News about Nanotechnology:
A longitudinal framing analysis of newspaper reporting on nanotechnology

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Abstract

Governments and businesses around the world have invested billions of pounds in nanotechnology research and development, and more than a thousand consumer products which manufacturers claim to involve nanotechnology are currently on the market. As such, the applications from this emerging field of science and technology have the potential for great impact on individuals and society, making it a recurring subject of news reporting worldwide. Scholars say mainstream news media are the primary places in which citizens learn about science and technology, therefore creating opportunities for democratic debate about these topics. This thesis explores the ways in which nanotechnology is reported in order to understand how journalists strive to make sense of it for their audiences. It analyses 759 articles from two opinion-leading newspapers – *The Guardian* and *The New York Times* – in order to address the following research questions: How do journalists frame nanotechnology for their audiences? How do the characteristic features of the framing processes change over time? And to what extent does the reporting open opportunities for meaningful, democratic discussion around nanotechnology? To answer these questions, the research evaluates literature around the reporting of science and technology, in particular nanotechnology. Using quantitative and qualitative approaches to framing, this thesis finds the coverage is overwhelmingly positive in its treatment of nanotechnology, suggesting it closely aligns with the business and government interests. Additionally, claims about the potential benefits of nanotechnology are prioritised over risk

claims in news articles, with the most common risk and benefit claims being those that are more likely to materialise decades into the future, if ever. Altogether, in failing to discuss applications and potential risks of nanotechnology without drawing on popular culture references limits the opportunity for meaningful, democratic discussion and debate.

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Chapter 1: Introduction

Nanotechnology – the science of the very small – is an up and coming area of science and technology. Broadly, it describes research and development at the scale of one to 100 nanometres. To put that size into context, “one nanometre is one billionth of a metre and is the width of approximately ten atoms” and “a sheet of paper is about 100,000 nanometres thick” (Esteban et al., 2008). This emerging science and technology is a contested area, which has received press attention. Amongst the more public controversies have been concerns raised by the potential risks and the many unknowns associated with nanotechnology from Bill Joy, a founder of Sun Microsystems, and Prince Charles, as well as organisations such as Which?, Green Peace, the ETC Group, and others.

Nanotechnology is perhaps not as hotly debated and therefore much less researched as other emerging science and technologies, such as stem cell research (see for example Williams and Henderson, 2003, Kitzinger and Williams, 2005, Liu and Priest, 2009, Nisbet, 2005, Nisbet et al., 2003) and genetically modified food (see for example Priest and Gillespie, 1999, Salleh, 2008, Marks and Kalaitzandonakes, 2001, Cook et al., 2006, Vilella-Vila and Costa-Font, 2008). Nor has it received as much attention as significant issues in society, such as climate change (see for example Antilla, 2005, Boykoff and Boykoff, 2007, Boykoff, 2007, Carvalho, 2007, Olausson, 2009, Rogers and Marres, 2000, Ward, 2008, Weingart et al., 2000). However, the debates around nanotechnology arguably deserve as much attention from the academy as these other issues given that governments and private industry around the world are investing heavily in nanotechnology (National Nanotechnology Initiative, 2011, Sargent, 2008, Rensselaer Lally School of Management and Technology, 2004) and more and more consumer products are being released on the market where manufacturers say use nanotechnology (Project on Emerging Nanotechnologies, 2010).

Proponents suggest nanotechnology holds the promise of the next “Industrial Revolution” with the opportunity for improved manufacturing of consumer goods, including to make them more cheaply and more efficiently (see for example Esteban et al., 2008, Cacciatore et al., 2009, Sargent, 2008). What makes nanotechnology special is that research and development at this tiny scale has found that materials demonstrate surprising properties that they do not exhibit at scales greater than 100 nanometres. For example silver at the nanoscale has antimicrobial properties, which means it can be used to kill bacteria (Rajeski, 2009). More than a thousand products that manufacturers claim involve nanotechnology in some way are on the market today globally. Most of those products are health and fitness related, including sun creams that use nanotechnology to make the cream transparent on the skin and razor blades coated in nanosilver to reduce the growth of micro-organisms (Project on Emerging Nanotechnologies, 2010).

At the same time, what fills nanotechnology with promise also holds the potential to be equally or more so harmful. The unexpected properties of materials at the nanoscale can pose risks and raises a variety of questions, including how these materials will react with tissues in the body or in the environment. For example, some research has shown that nano-sized particles, or nanoparticles, in the environment that result from the burning of fossil fuel is linked to respiratory problems and other related health effects (cited in Powell et al., 2008). Critics suggest that nanotechnology poses too many unanswered questions and more research around the potential implications of this emerging field is required in order to fully understand and appreciate the hazards (see for example Joy, 2000, Cacciatore et al., 2009, Sargent, 2008).

However, this thesis is not about the science and technology behind nanotechnology. Nor is it about whether nanotechnology is good or bad for society. Broadly speaking, this research is about the news reporting of nanotechnology. It considers how nanotechnology is represented and what the newspapers say about its potential impact on the planet, individuals' lives and society. The research agenda for the thesis centres on how two influential news organisations unpack complex issues such as nanotechnology for their audiences. It pays considerable attention to the concept of framing as a dynamic process of developing meaning(Gamson, 2001). It does so by examining news content that documents attempts by individuals and groups to establish a preferred definition of nanotechnology and a preferred way of thinking about nanotechnology. To explore the notion of framing as it relates to nanotechnology, the thesis asks: How do journalists frame nanotechnology for their audiences? How do the characteristic features of the framing processes change over time? And to what extent does the reporting open opportunities for meaningful, democratic discussion around nanotechnology?

In order to understand the defining and framing of nanotechnology, I have conducted an analysis of the reporting in two national newspapers that are influential in their respective countries – *The Guardian* and *The New York Times*. These publications are well known for their reporting and are read by opinion leaders. Both have tended to be amongst those publications researched when considering the national news reporting of each country for a variety of topics, including when studies have considered science reporting and framing of nanotechnology specifically (see for example Clark and Illman, 2006, Anderson et al., 2005, Stephens, 2005, Gorss and Lewenstein, 2005, Gaskell et al., 2005, Listerman, 2010). However, this study is unique in that it used these newspapers exclusively and conducted an exhaustive search of the print and online editions of them in order to understand the reporting of nanotechnology over an extended time period. The analysis catalogues all the reporting found through database searches in both publications that reference nanotechnology, nanoscience, and other iterations of 'nano' from 1986 to 2010. The decision to use these two newspapers and the collection of articles will be addressed in more detail later in this chapter and again in the methodology chapter, Chapter 4, when it is discussed in much more detail. Before that discussion, the thesis now turns to a review of nanotechnology in order to provide a sense of this emerging field of science and technology. Such background supports the remainder of the thesis by contextualising this emerging field and establishing its place in the news discourse.

Nanotechnology - a brief history & its place in the news media

Nanotechnology, which is sometimes referred to as nanoscience or nanotechnologies, is an interdisciplinary field, which draws on chemistry, biology, physics, engineering, and computer science (Chakrabarty, 2008, Turner, 2008, National Nanotechnology Initiative, 2011, Anderson et al., 2009b). It started as an idea from Prof. Richard P. Feynman in 1959 and is now being researched in universities and companies across the world. Feynman's lecture, "There's Plenty of Room at the Bottom", was a theoretical exploration of the potential for atomic-level fabrication, which more recently has been known as a "bottom-up approach" to nanotechnology. It is labelled as such because it involves the manipulation of atomic-scale material in order to build something from those individual molecules. The "top-down" approach to nanotechnology requires cutting or moulding materials to the nanoscale, which is limited by existing manufacturing processes and the ability for existing techniques to cut or mould ever smaller pieces (Turner, 2008). Feynman is one of the well-known figures in nanotechnology, although his contribution to the field was limited to his theoretical lectures about the potential for new research and development at a tiny scale.

The term "nanotechnology" was coined in 1974 by Japanese researcher Norio Taniguchi. At the time, the term described precision engineering with tolerances of a micron or less (Park, 2007). Another figure, Dr. K. Eric Drexler, is often credited with bringing the term "nanotechnology" into popular usage with the publication of his 1986 book *Engines of Creation*. As my findings chapters discuss, the review of his book is amongst the earliest articles found in the newspapers' coverage. Drexler played an important role in getting funding for nanotechnology research in the United States. He is, however, a polarising figure in nanotechnology research in part because his view of the field, which is almost exclusively centred on molecular manufacturing rather than broader senses of research and development at the molecular scale. In the end, he was not successful in defining this emerging science and technology in politics and society (Gasman, 2006). He is also criticised for some of his visions of the potential for nanotechnology, especially the idea of molecular self-assemblers - molecular devices that place molecules precisely to cause a chemical reaction (Schummer et al., 2006). This notion of molecular self-assemblers is amongst the more heated debates within nanotechnology research and is also featured in the reporting of nanotechnology.

Although the idea of nanotechnology has been discussed within the science and technology communities for several decades, it has only become part of mainstream news reporting and therefore been more accessible to the greater public more recently. Nanotechnology first began appearing in newspapers in the mid to late 1980s with very few articles each year being printed. The reporting grew over time, and in the early 2000s nanotechnology began to appear more frequently in the news (Stephens, 2005). How news organisations report on science and technology, especially emerging science and technology, is important to consider because mainstream news is the primary place for citizens to learn about science and developments within science (Friedman and Egolf, 2005, Gorss and Lewenstein, 2005, Boykoff and Boykoff, 2004). News organisations can play a vital role in drawing the public's attention to a topic in science and technology (Friedman and Egolf, 2005), which research says audiences know little about especially with regard to individual disciplines (see for example Lewenstein, 2005a). For new science and technology, the news media is an essential source for people's ideas about a particular topic and studying these innovations as they emerge in the press helps researchers understand the climate around an issue (Gorss and Lewenstein, 2005). These ideas and other important concepts related to the reporting of science and technology will be addressed in more detail in the conceptual background chapter, Chapter 2. Those ideas specifically related to nanotechnology will be discussed in the literature review, Chapter 3.

When researching nanotechnology and the reporting of nanotechnology, defining this field presents a number of challenges for scholars (see for example Anderson et al., 2009b, Lewenstein, 2005b). Anderson and her colleagues chose to refer to "nanotechnologies" because the singular "nanotechnology" fails to capture the interdisciplinary nature of nanotechnology and varied definitions that scientists use to characterise the field. They add that the term is further obscured by researchers who call their work "nanotechnology" in order to attract funding. Meanwhile, a variety of organisations appear to favour the term “nanotechnology,” ignoring the plurality of the field, as some of the definitions outlined below will demonstrate. “Nanotechnologies” is perhaps the more appropriate term to describe this field and capture the nuances and debates associated with research at the nanoscale; however, this thesis uses the term “nanotechnology” because of its apparent popularity in the wider discourse and particularly in news discourse. Chapter 5 of this thesis points out that in the two newspapers investigated, “nanotechnology” is the most common way of referring to the field with terms such as nanoscience rarely appearing as an alternative. “Nanotechnologies” appears very infrequently in the discourse, except as the title of a research institute or in a quotation from someone in the field of nanotechnology research. Therefore, to remain consistent throughout the study, particularly with the findings of the research, this thesis adopts the term “nanotechnology”.

The definition of nanotechnology at the outset of the chapter was very brief, providing limited context about this emerging field. Here, the thesis considers a few definitions that provide additional background and gives a sense of the complexity of the science and technology involved. The Royal Society (2011) defines nanoscience and nanotechnology together as:

> studying and working with matter on an ultra-small scale. One nanometre is one-millionth of a millimetre and a single human hair is around 80,000 nanometres in width. Nanoscience and

> nanotechnology encompass a range of techniques rather than a single discipline, and stretch across the whole spectrum of science, touching medicine, physics, engineering and chemistry.

The Royal Society and The Royal Academy of Engineering were commissioned by the British government to investigate nanotechnology, specifically considering some of the criticisms of the field and the concerns raised about potential hazards. The organisations reported back to the government in 2004 finding that nanotechnology has a number of potential benefits for society, but that steps need to be taken to ensure the uncertainties and risks of nanotechnology are appropriately mitigated (Royal Society and Royal Academy of Engineering, 2004).

The U.S. National Nanotechnology Initiative, which brings together government agencies involved in nanotechnology research, defines nanotechnology as "science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers" (National Nanotechnology Initiative, 2011). Additionally, it defines nanoscience and nanotechnology as:

> the study and application of extremely small things and can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering.
> Nanotechnology is not just a new field of science and engineering, but a new way of looking at and studying it.

The initiative was launched during President Bill Clinton's administration and is responsible for $16.5 billion in funding over the life of the initiative, including the 2012 budget for the programme.

As the two organisations' descriptions of nanotechnology above indicate, definitions of this emerging field vary to an extent, but offer a few areas of agreement. They tend to consider a size element; most often that nanotechnology is at the scale of 1 to 100 nanometres. As noted previously in the chapter, the upper threshold of 100 nanometres is linked to the special properties that materials display at that scale, which are different than at larger dimensions. Although the definitions above do not explicitly reference a synthetic element, some also define "nanotechnology" as involving a synthetic element; otherwise naturally occurring biomolecules and particles could be considered nanotechnology (Turner, 2008). As such, it would mean redefining chemistry and molecular biology. However, this is part of the contestation in that scholars in these fields have suggested that nanotechnology is nothing new, but rather an extension of existing science such as chemistry and molecular biology. Some definitions also call for a functional aspect to nanotechnology. In other words, only molecular manufacturing or machinery would be nanotechnology.

Additionally challenging the definition of nanotechnology is the notion of nanoscience and whether a clear distinction exists between nanoscience and nanotechnology. The definitions from the Royal Society and the National Nanotechnology Initiative cited above define the two terms together. Turner

(2008) draws the line between the two around functionality versus study. He defines nanoscience as the study of manipulation of matter at the molecular scale, but nanotechnology as the application of such research. This echoes definitions of science and technology more generally, which also make a distinction between study and application.

Put simply, science is the research and technology is the development (Bell, 2006). Although, such a simple distinction does not tell the whole story of defining either of these terms and the contested definitions of each that come from the philosophy of science, science and technology studies, sociology, and cultural studies, among other research traditions that would define these terms. Bell (2006) outlines a variety of explanations of each, primarily drawing on sociological and cultural studies traditions. Beginning with science, he explains this term is linked with the history, philosophy and sociology of science. Science is more or less what scientists do, but is also defined in the philosophy of positivism and the notion of falsification (Bell, 2006, Sismondo, 2010, Taylor, 1996). In other words, science is the process of observation that leads to truth (positivism) until it is proved or disproved (falsification). Turning to technology, Bell (2006) discusses a variety of definitions, which he simplifies by pointing out that most commonly technology refers to "artefacts or objects" and especially "gizmos" and "gadgets" because "technology" is also wrapped in a sense of newness (p. 43). "Technology" tends to be applied when a "gadget" is first introduced, but when it is normalised it is no longer considered part of "technology". Additionally, “technology” can also refer to processes and the skills used to develop these artefacts, he points out. Here again, the distinction between science and technology appears to lie in the study of a phenomenon being science and the application of what's learned through that study is called technology.

While it is important to keep in mind the debates around the terms science and technology and also nanotechnology, nanoscience, and nanotechnologies, this thesis most often uses the term nanotechnology because it is the most common way of referring to the field in the news discourse, as was noted previously. When it comes to science and technology, most often the terms are discussed together as they relate to nanotechnology because the science and technology of the field are to an extent mingled. That means "nanotechnology," as it is discussed in the thesis, includes both research at the molecular scale, as well as the development of products and manufacturing processes/skills used for molecular manufacturing. As the findings in Chapter 5 discuss, the term nanotechnology is the most commonly cited way of talking about this field. Therefore, adopting "nanotechnology" early on in the thesis avoids a mixing of terms. In addition to discussing the frequency of terms used to discuss nanotechnology, Chapter 5 also revisits definitions of nanotechnology, but specifically as they are provided in the news content and how these news organisations define nanotechnology in the reporting. Now the chapter will provide a summary of the research project and its development before discussing the newspapers studied in more detail and closing with a roadmap of the remainder of the document.

This research - the research agenda & the newspapers

As discussed previously, this research focuses on the representation of nanotechnology in two well-known newspapers - *The Guardian* and *The New York Times*. More specifically, it examines how nanotechnology is framed by these two news organisations since the mid-1980s, primarily looking at the print editions, in order to understand the extent to which the reporting opens opportunities for democratic discussion around nanotechnology. Where it considers 24 years of reporting in these two publications, I have called it a longitudinal study. Longitudinal studies tend to have one thing in common; they are looking at trending over a period of time, which is also true of this thesis. From there, longitudinal studies of news content vary in the approach, including the length of time studied and whether a census of content within that time frame or a sample of content within that time frame is gathered (see for example Clark and Illman, 2006, Greer and Mensing, 2006, Kepplinger et al., 1989, Vliegenthart and Walgrave, 2008). For those cited, the length of time varied from seven to 20 years of news reporting, or in some cases the studies examined journal articles over a period of time to understand trends in research around news reporting. Additionally, they adopted different sampling techniques to gather the content they were studying.

This thesis, as the methodology chapter will discuss, reviews a census of the content in the chosen newspapers through 2010. The earliest date that an article appeared in searches of the Factiva and LexisNexis databases was 1986; therefore that was chosen as the starting point. Analysing such a long time frame allowed for the research to document the contest over framing in the news over the life of the story to date and allowed for identifying trends across more than two decades of reporting. Broadly speaking, it identified how journalists perform a mediation of nanotechnology and tracks the news discourses around nanotechnology. Such a longitudinal approach is useful for exploring frames and the process of framing as it allowed me to see the rise and fall of frames and how frames take shape across decades, which is an important element in understanding and exploring the potential of framing theory in this context.

While framing is discussed in more detail at the outset of Chapter 4, it is important to discuss the concept here to help ground the project and understand the research agenda. Put simply, framing refers to how journalists organise news stories and make sense of complex topics for their audiences (Reese et al., 2001, Allan, 2004, Marks and Kalaitzandonakes, 2001). Framing does not have a unified theory, nor does a singular approach to framing research exist. Scholars such as Entman (1993) and Scheufele (1999) have drawn attention to the array of definitions in research and identify it as an area of weakness in the theory. On the other hand, Hertog and McLeod (2001) believe the variety of approaches provides an opportunity for creativity in the design of research and allows for approaches to framing research that have otherwise not been considered. This research has adopted a less traditional view of framing in that it considered where framing can happen anywhere in an article, including within phrases. More traditionally, researchers have considered headlines, leads, and closing paragraphs as the primary place to find frames for a topic (see for example

Trumbo, 1996, de Vreese, 2005, Zaharopoulos, 2007). These elements of articles are very significant in terms of the power to frame an issue because they help set the tone of a story and, when it comes to headlines and leads in particular, may be the only parts of a story that audience members read. However, articles can arguably provide a more dynamic and perhaps conflicted sense of an issue in later paragraphs. Additionally, where an issue is raised in part of a story about something else, then it may be framed in a few words or sentences. As Nisbet and Scheufele (2009) pointed out, science and technology when reported in other parts of the newspaper can bring new audiences to an issue. Therefore, the framing of that issue within those articles can help shape the audience perception of that issue. Also, considering the framing beyond the elements more traditionally reviewed for frames can provide a more detailed and dynamic sense of the contest over framing that exists. This issue will be revisited in much more detail in Chapter 4, but now the chapter continues to discuss some of the nuances of the research carried out for this thesis.

Returning to the content investigated in this thesis, the study reviews 759 newspaper articles from *The Guardian* and *The New York Times* to understand the reporting of nanotechnology. Where it considered such a volume of articles, a quantitative approach was adopted in the form of content analysis. The quantitative content analysis was the primary method of investigation and therefore many of the findings are based around the quantitative elements of the research. However, where framing is such a dynamic concept the study also includes qualitative analysis as a secondary method, especially as it relates to analysing the definitions of nanotechnology as they appeared in the newspapers. Using both quantitative and qualitative measures aims to provide a deeper sense of the issues associated with the framing of nanotechnology in the news. As Halloran (1998) points out, social science research problems are complex in nature and often require a mixed-method approach in order to more fully engage with the issues.

Meanwhile, both of the news organisations investigated have a strong web presence, which offers an additional avenue for framing nanotechnology. As such, this research reviewed articles gathered from the two news websites to compare them with the newspaper reporting. Where *The Guardian* and *The New York Times* are both known for their reporting on the web and their innovation in that regard, especially *The Guardian*, the online element of the study was originally intended to be a much larger focus of the research at the outset of the project. However, Chapter 5 discusses how the online reporting of nanotechnology is largely a replication of the print editions' reporting and therefore is much less a focus of the findings of this research.

As noted above, this research draws on quantitative and qualitative methods in order to understand the reporting of nanotechnology from a variety of angles. Where the quantitative method of content analysis is the primary form of investigation, it could suggest that this research assumes that the news reporting of nanotechnology reflects some reality that is easily observed and measured, stemming from a more positivist philosophy (Hart, 2007, Hughes and Sharrock, 1997, Johnson and Onwuegbuzie, 2004, Johnson et al., 2007). However, as noted previously, social science problems are complex and can benefit from multiple forms of enquiry (Halloran, 1998, Priest, 1996, Deacon et al., 1999). Therefore the decision to prioritise a quantitative method was driven by the research agenda and the volume of news articles identified in the database searches, rather than a particular epistemology of research.

Looking now to the organisations studied, *The Guardian* and *The New York Times* are influential newspapers in their own countries and abroad, as noted above. They are often the subject of research alongside other national newspapers, including when it comes to understanding science reporting at a national level. Here, I discuss the two news organisations and why they were chosen for this particular study.

The New York Times is a highly influential newspaper which is often used to understand the reporting of science (Clark and Illman, 2006). It has a distinguished history of science reporting and has received several Pulitzer Prizes and other awards for its reporting, including the coverage of science and medicine (New York Times Co., 2011). *The New York Times* is considered the "gold standard" in science reporting (Russell, 2006). While other news organisations are cutting science journalists, *The New York Times* continues to invest in its science staff. Since 1978, the newspaper has included a weekly "Science Times" section devoted to issues of science and medicine (Wilford, 2003) and it also runs a weekly podcast on its website dedicated to science reporting. Furthermore, the newspaper more generally is read by opinion leaders and interested publics for science (Clark and Illman, 2006, Fursich and Lester, 1996). It is credited with influencing science reporting at other newspapers (Clark and Illman, 2006). *The Guardian*'s editor Alan Rusbridger (2003) cited *The New York Times* science reporting as having influenced the establishment of the Science Weekly section in *The Guardian* in 2003*.*

Although *The Guardian*'s science section was established more recently, the publication has a long history of science reporting, as evidenced by the study of correspondence between an editor at the *Manchester Guardian*, as it was previously called, in the 1930s (Hughes, 2007) . When studying science journalism in the UK, *The Guardian* is amongst the broadsheet or quality newspapers that scholars have considered a solid source for science and technology news (Clayton et al., 1993) and tends to be figured amongst the national publications studied when looking at news reporting generally and as it relates to science. While the science reporting in *The Guardian* is strong, the newspaper was originally chosen for the thesis because online news was initially expected to figure more significantly in the study. As such, *The Guardian* was a natural choice because it is regarded as leading the way in rethinking of the role of a newspaper and has taken a more web-centred approach to news. Run by the Scott Trust, the Guardian News and Media owns *The Guardian*, *The Observer* (for the purposes of this research it will be considered the Sunday edition of *The Guardian*) and guardian.co.uk.

The suite of websites had been called Guardian Unlimited, but the newspaper changed the website title a few years ago to guardian.co.uk. According to Mintel (2011), despite facing similar financial challenges to other UK news organisations in the 2009-10 financial year, it is the only one that did not reduce staffing in order to handle the economic pressures.

In summary, these two newspapers are well respected and well read, especially amongst elites. They were chosen as a result of that position within society and because they can be influential to other news publications. Also, the online element of the study, although less prominent than anticipated, was an important factor to consider at the outset of the project and played a role in determining what news organisations would help identify trends in online reporting of nanotechnology. Although these newspapers are very influential, it is impossible to speculate about the broader reach of their reporting on nanotechnology to suggest that what and how they report on nanotechnology represents the reporting of nanotechnology more broadly in the two countries. Therefore, this thesis does not suggest that the findings are representative of news reporting on nanotechnology in the broader news discourse of the United Kingdom or the United States. Such national comparisons are not the focus of the research. Instead, the longitudinal element and gathering as complete a collection of articles as possible was the priority for the research. Doing so aimed at identifying macro and micro trends in the reporting over more than two decades.

Conclusion

In summary, this chapter has discussed nanotechnology as an important area of emerging science and technology, which has seen a growing attention in the mainstream news since 1986. Defining nanotechnology from the broader societal context and describing some of the science and technology behind it aimed to provide a background that would ensure the discussion around the reporting of nanotechnology is meaningful and useful. Overall, this introduction has aimed to provide a foundation for the rest of the research project. Here, I set out a road map of the remainder of the thesis, which provides a sense of what readers can expect as they review each chapter.

Chapter 2 moves to a discussion of literature on science and technology journalism and some of the important factors in the reporting of these topics as they relate to nanotechnology. In particular, what makes science and technology newsworthy and some of the professional norms of science and technology journalism are explored. These topics and notions of risk and uncertainty underpin some of the key elements of the findings. Risk in particular is an important concept in the literature around nanotechnology reporting and has received considerable attention in previous research.

As with the reporting of risk, other elements discussed in the conceptual background chapter helps contextualise the discussions around research into the reporting of nanotechnology, which forms the basis for discussion in Chapter 3. The literature reviewed in that chapter includes content, production and audience research as it relates to news about nanotechnology. The content studies are most closely linked to this research, but the production and audience research explored in the chapter helps contextualise the content research. The chapter discusses how significant research has centred on the audience reception of nanotechnology and much less attention has been paid to production research. While this thesis is not a production study, it draws on the content for textual clues as to the production and concentrates on the content as the moment between production and reception.

Chapter 4 discusses the methodology and the research approach adopted in this project. The chapter begins with a review of framing theory, which includes an examination of the contested definitions and methodological challenges of conducting a framing study. It then goes on to discuss content analysis as a method and its use in news research. It briefly discusses textual analysis, which was used in the study but to a lesser degree than the quantitative measure. It concludes by reviewing how this project was carried out and the procedures involved in conducting the research in order to provide a transparent view of how the research was carried out.

The findings of the research are addressed in Chapters 5 and 6. Chapter 5 provides an overview of the content studied. Specifically the chapter explores the trends in which sections of each newspaper nanotechnology articles appeared, what made the science and technology in the stories newsworthy; and what news hooks or news pegs, if any, prompted the articles. It also considers when nanotechnology was the subject of stories (in other words, when articles were primarily about nanotechnology) and when nanotechnology was a secondary subject of stories (in other words, when articles were primarily about something else, but discussed nanotechnology). The chapter also reviews how these news organisations define nanotechnology for the audience through phrases or short paragraphs that introduce the topic to the audience and answer the question, what is nanotechnology? This introduction has provided definitions of nanotechnology and established how it is operationalised in the study. However, definitions provided in the wider discourse, including by government bodies/programmes such as the US National Nanotechnology Initiative and prominent science bodies such as the Royal Society in the UK are not necessarily the way that news organisations define this field of science and technology for their audiences. The definitions provided by the news organisations are a way of framing nanotechnology for the audience, although perhaps the most diffuse conception of nanotechnology.

Moving from the definitions of nanotechnology, Chapter 6 concentrates on the framing of nanotechnology, which is central to the research questions outlined above. It begins by discussing the tone of articles toward nanotechnology, which draws heavily on claims about the benefits and risks of nanotechnology that are discussed in the articles. Following the discussion of reported risks and benefits of nanotechnology, the chapter discusses the individual frames represented in the reporting of nanotechnology. That review describes the individual frames and identifies the prominence of frames in each newspaper. It outlines how individual frames are unequal and at times some frames prevail over others in the news reporting. The findings of this chapter are contextualised within previous research, drawing in large part on the studies discussed in the literature review.

Finally, Chapter 7 discusses the key findings from the thesis and how they relate to the research questions identified in this introduction. It also reviews how this research contributes to broader conversations about the reporting of nanotechnology, science journalism and framing theory. It also reviews the strengths and limitations of this study, as well as opportunities for future research.

Chapter 2: News about science and technology: a conceptual background

The way in which mainstream news organisations report on science and technology is an important area of study because the mass media is the primary place for adults to gain information about these topics (Schafer, 2010). This is especially true of emerging areas of science and technology (Friedman and Egolf, 2005, Gorss and Lewenstein, 2005, Boykoff and Boykoff, 2004). News organisations play a vital role in drawing the public's attention to a topic (Friedman and Egolf, 2005), which audiences know little about (see for example Lewenstein, 2005a). For new science and technology like nanotechnology, where the news media is an essential source for people's ideas about a particular topic, studying these innovations as they emerge in the press helps researchers understand the climate around an issue (Gorss and Lewenstein, 2005). Therefore the reporting around science and technology is an important factor to study, however, also important is to consider the notion of science journalism as a discreet specialty or whether it is more appropriate to consider news about science and technology more generally.

Reporting about science and technology can be found throughout the news and includes new developments in research to human-interest stories to breaking news to policy and political reporting. As such, the reporting of science and technology is not exclusively on the science pages of newspapers, but it can be found in political reporting when it comes to funding research and policy decisions; education pages in discussions about science education such as debates around what should and should not be taught in schools; business pages when science is the subject of investment and the opportunity for job growth or decline; and so on.

Additionally, the reporting is not done exclusively by specialist journalists. Reporters across the newsroom cover science, including general assignment staff. Science and technology may make news as a result of discoveries, but science and technology might also be included in stories about pollution, politics and breaking news (Allan, 2008, Hansen, 2009, Weigold, 2001). When science and technology are reported beyond the specialty pages of newspapers, it can bring new audiences to an issue that might otherwise not be familiar with the topic. Also, where the journalists writing the stories may not come from science and technology backgrounds, they may interpret the science differently from a specialist journalist and introduce new voices and ideas to the coverage of a topic (Nisbet and Scheufele, 2009). This type of reporting is often called “science journalism,” but it is perhaps more appropriate to consider reporting around science and technology more broadly because these topics appear throughout the news and are covered by journalists on various beats and with different degrees of speciality in/knowledge of science. Hansen (2009) points out that focusing research exclusively on the news content that is centred around science would mean ignoring "some of the most powerful images of science and its social role" (p. 107). In taking a broader view of science and technology reporting, that means researchers can have a fuller picture of how these issues are communicated and framed to a variety of audiences.

The notion of the audience for science and technology is a concept that has evolved in the research literature. Studies of news reporting around science and technology have moved from a conception of a homogeneous audience to a more nuanced view of who pays attention to science and technology in the media (Hansen, 2009). Evans and Priest (1995) argue it is important for research to hold such a nuanced view of the audience because when it comes to science and technology content, the audience varies by class, gender, and other relevant features, especially depending on the content of individual articles. That is arguably also true when considering where the articles appear in a particular newspaper(Nisbet and Scheufele, 2009).

Weigold (2001) documented the variety of ways that researchers consider the audience for science communication from those that take a more normative approach and believe that news about science is for the general public to those that segment the audience based on a hierarchy of their knowledge and engagement with science. This hierarchy ranges from policy decision makers on top that require a lot of scientific literacy to a non-attentive public who are challenging to engage and it is unknown as to what they want from news about science and technology (p. 175). Bauer and Bucchi (2007) suggest that it is not for a mass audience at all, rather those that read science and technology news are "non-specialists scientists, policy makers, and investment brokers" (p. 7), although that is arguably for the specialised reporting rather than when science and technology appears in sections other than the specialty pages of newspapers. It is also a more elitist view of who reads the science news. In the end, these debates about the audience for news about science and technology suggest that journalists speak to a wide audience with a variety of needs for information and news about science. This is amongst the challenges that science and technology presents to journalists in the course of producing the news. This thesis tends toward a more normative view of the audience for news about science and technology because of the role that journalism plays in society and enabling the audience to make informed decision as citizens and consumers (Calhoun, 1992, Curran, 1991, Dahlgren and Sparks, 1991, McNair, 2000, Schudson, 1992).

This discussion about the audience links to broader issues of the relationship between science and the public and the role that the media plays in connecting the two. The public's awareness and understanding of science became an important discourse in science communication research, especially in the 1960s and 1970s (Hansen, 2009). Hansen (2009), outlining a brief history of the research around science communication in Britain, discusses how the focus on the public understanding of science stemmed from a concern around a lack of scientific literacy and the public's growing scepticism around scientific and technological developments.

The public understanding of science is also known as the scientific literacy model and the deficit model (Friedman et al., 1999), and has also been popular in science communication research in the US (Weigold, 2001, Schafer, 2009, Nisbet and Goidel, 2007). Studies within this tradition suggest that the public needs more understanding of basic science in order to function well within society (Nisbet and Scheufele, 2009). Additionally, the model assumes that more information about science in the public would also improve attitudes toward science, which scientific institutions need in order to obtain funding. The deficit model links with the more linear media reception/effects models that have been challenged in social science for decades (Hansen, 2009). However, this view of a passive audience for science and technology can also alienate the audience thereby exacerbating the very issues it aims to correct (Nisbet and Scheufele, 2009). Social science research in this area has since moved to a more nuanced view of the audience and often refers to engaging the public in science (Hansen, 2009, Weigold, 2001), but as Hansen points out that official reports tend to reflect these more linear media effects models.

The engagement model, which is more popular today, is more robust in its conception of the relationship between the public and science because it goes beyond increasing knowledge as a way of increasing acceptance (Delgado et al., 2010, Priest, 2006, Schafer, 2009). It is more about the involvement of the public in the “socio-technical trajectories” of science and technology (Delgado et al., 2010, p. 2). Therefore, the connection between the public and science and technology is not simply about gaining acceptance, but is meant to be about opening the process of dialogue and debate around science and technology. Also, the engagement model goes beyond a simple linking of individuals' knowledge of science and technology with their attitude and considers that individuals' values and beliefs also play a role in their views on science and technology (Priest, 2006). However, as Delgado and her colleagues point out, the way the engagement model is operationalised has been, to an extent, a new form of the deficit model. Public outreach exercises, for example, are designed to address scepticism and opposition to science and technology and reproduce the assumptions of the deficit model.

The literature above underlines the importance of researching the reporting around science and technology through a discussion of the ways in which scholars have viewed the audience for science journalism and the ways in which research has viewed the relationship between science and the public, particularly as it relates to the role of the media in facilitating that relationship. Overall, as was discussed previously, this research takes a normative view of the audience and the role of news in communicating science to the public. In other words, journalism plays an important role in society in that it helps communicate to citizens and consumers to facilitate participation in society. Where science and technology may be reported in a variety of sections within a newspaper, this thesis understands that news may communicate science and technology to a variety of audiences. This means that the reporting can facilitate discussion and debate amongst citizens and consumers that might otherwise not engage in these debates if science and technology were only reported on specialist pages.

With the above in mind, the chapter moves on to discuss literature around what makes science and technology newsworthy, the professional practice of the reporting of science and technology, and the reporting of uncertainty and risk. These are important topics for understanding the production of news about science and technology and support the literature review, which centres on research around all aspects of the reporting of nanotechnology. They also provide a foundation for some of the ways in which the data was collected and the findings of this thesis, which are explored in later chapters.

Newsworthiness of science and technology

The literature surveyed above discussed what is science and technology journalism and who is it for, but did not review what makes science a newsworthy item for journalists to report. That is where this section of the chapter begins. Looking at what is covered and how journalists select what to report, science news is both “selective” and “uniform” (Hansen, 1994). As Hansen explains, it is selective in that some areas of science are more often covered than others, such as medicine, and uniform in that there tends to be agreement about what counts as news when it comes to science, which are "news values." For science and technology to be newsworthy, it often requires an element of newness, controversy, and/or human interest (see for example Lewenstein, 2005a, Allan, 2008, Weigold, 2001, Priest, 2001, Carvalho, 2007). That’s not surprising in light of decades of research into news values more generally, which have pointed out in a variety of contexts that in order for something to be news it has to be new, often includes an element of conflict, and should be relevant to audience members' lives (see for example Galtung and Ruge, 1999, Harcup and O'Neill, 2001, Livingston and Bennett, 2003, White, 1999).

These studies have also highlighted the subjective nature of deciding what is news. Part of what makes it subjective is that journalists' sense of the audience and what the audience wants to know plays a part in determining what topics to cover. Among the studies that have illustrated this issue is one where Hughes (2007) analysed the content of letters and memos between editors and a science correspondent at the *Manchester Guardian* in the 1930s. In the letters to the science correspondent, the editors outline what they think the audience wants – stories about eels and the physical effects of labour, for example – and assign those stories and stories like it to the correspondent. While now 80 years old, this study, when taken with the more recent studies cited above, points out where continuities exist in news values around science and technology. The stories *Guardian* editors assigned related to human-interest topics and, especially with regard to the story on the physical effects of labour, had relation to the audience members' lives, which was specifically stated in the letters as a reason for the assignment.

Drawing on interviews with British journalists, Hansen (1994) finds a set of news values that are shared amongst the journalists in his research. These news values are how journalists decide what counts as news out of the potential stories that come to them by way of press releases, letters, phone calls and other communications they receive daily. The news values he identified are "relevance to daily life" or those stories that have a “human angle” to them; "weird and wacky” stories; “breakthrough”; “controversy”; “proximity”; and social, political and economic relevance (p. 115-116).

The “relevance to daily life” and “weird and wacky” news values were highlighted as the top news values identified by the journalists. As Hansen notes, the focus of journalists on finding news that is relevant to their readers is part of the reason why medical and health-related news tend to be dominant subjects for the news reporting. Breakthroughs in science are less common because of the pace of science and the development of science, but these are identified as newsworthy because they are new. However, Hansen found that the tight time pressures that journalists face can sometimes mean they rely on scientists to identify when breakthroughs are significant. Controversy, as discussed above, is a news value that is echoed throughout news more generally, so is not surprisingly an important news value for science. Similarly, proximity was identified by the journalists in Hansen’s study as an important news value. That is true too in the broader conceptions of news values the closeness of news events to the readership is also a way of linking it to the relevance to the audience (see for example Galtung and Ruge, 1999, Harcup and O'Neill, 2001, Livingston and Bennett, 2003, White, 1999). Finally for Hansen's news values, science becomes news when it crosses social and political boundaries. In other words, when science is discussed in the context of politics and economics, it becomes news. This collection of news values will be revisited in the methodology chapter as it was used to identify when news about nanotechnology became newsworthy.

In addition to news values, journalists also routinely decide what is news based on the importance of the stories, which is determined by the number of lives who are affected, for example, and the timeliness of the story (Weigold, 2001). Events, press releases and journal publications of research can help provide a timely link for journalists to publish the stories (Weigold, 2001, Dunwoody, 1999). This is sometimes referred to as a "news peg" or “news hook” because it helps identify what makes the news relevant now (Kitzinger et al., 2003). Although Williams and Clifford (2009) did not specifically identify it as a "news peg" or “news hook” in such terms, their research on the state of journalism in Britain highlighted how journalists are increasingly reporting about conferences, press releases, and science journals. These types of events help bring a timely element to stories, which is why they can be considered news hooks or news pegs. The publication of journals and the issuing of a press release becomes an event because articles can therefore say scientists "announced" a development, making the issue relevant now.

News production and journalistic practice

Meanwhile, production practices also influence story choice and the reporting of science and technology more generally. It is common for science and technology to be covered by a specialist reporter at larger news organisations like *The New York Times* and *The Guardian* because they view these areas as niche areas of reporting (Weigold, 2001). At smaller publications, general assignment reporters or wire services would more commonly cover these areas. However, as the discussion above outlined, science is also reported by general assignment staff and other specialists, such as business/finance reporters, as science becomes newsworthy for a variety of reasons. Additionally, sources play an important role in the production of news, as the following paragraphs address.

Since World War II, science journalism in Britain has shifted from a media-led to a more source-led environment (Bauer & Gregory in: Bauer and Bucchi, 2007). The competition for stories has contributed to a reliance on public relations to fill the news hole. Bauer and Gregory rightly argue that where science communication is increasingly driven by public relations a significant challenge is posed to democracy and public discussion around science because it lacks the independent critical evaluation that democracies require. The trend toward a reliance on public relations and sources in news reporting more generally, as a number of studies have documented (see for example Franklin, 1997, Lewis et al., 2008, Moloney, 2006). However, the work of Bauer and Gregory (2007) in the UK and Bucchi and Mazzolini (2007) in Italy, points to such a trend in science journalism beginning as early as post-World War II. While troubling in many respects, Bucchi and Mazzolini point out that source involvement does have a benefit. The direct involvement of science sources, including writing articles for the newspapers, combats the notion that science journalism is often inadequate because it is written by non-specialists. Although referring to science in post-war Italian newspapers, Bucchi and Mazzolini's remark would still be true in other national contexts. Even still, the threats to public discourse due to the lack of independent, critical evaluation are arguably paramount.

Recent research on the state of science reporting in the UK has indicated that in the last few decades, news organisations have dedicated more staff and space to science and technology topics (Williams & Clifford, 2009). Despite recent job losses in the news industry, including on science and technology beats, Williams and Clifford point out that by the numbers, science and technology has far more dedicated journalists today than decades ago. However, these journalists are faced with increased pressures to produce more copy, in part to support the web presence of their newspapers or broadcasters. As a result, these journalists are turning to "diary" stories, which include conferences, press releases, and science journals, to compensate. Williams and Clifford's research points out that journalists are also increasingly reliant on public relations for story ideas and copy. All this has meant journalists have less opportunity to engage in original reporting, which is problematic because an overreliance on public relations and other ready-made articles can mean less critical reporting. This research was conducted by surveying British journalists covering science, health and the environment, as well as to interview some of those individuals. The result is a reflection on science and technology news today versus years ago from the perspective of those that practice it. The research echoes studies conducted by others into how science and technology journalism is increasingly becoming "desk work" and dependent on public relations (see for example Trench, 2009, Trumbo et al., 2001). Part of Trench's study was focused on the way that the internet is changing science and technology reporting, which will be revisited in detail later in this section.

Looking to the US, the picture of science journalism is that of shrinking science sections and fewer specialist journalists. Although news organisations once had a number of flourishing specialist science sections that were filled with stories from specialist reporters, Russell (2006) documented a decline in the number and size of dedicated science sections and the number of science journalists that work there. In the course of her study, Russell documented that of the 2,400 members of the National Association of Science Writers only 6 per cent, or about 144 journalists, were staff at newspapers, popular magazines, radio and television. Another 9 per cent were staff at specialist magazines, 40 per cent were freelance staff, and 42 per cent worked in universities and other organisations. Most of the 2,400 members were medical and health specialists, she noted. Of the science sections that continue, Russell noted that most have turned their attention to the reporting of "news you can use." In other words, the reporting of science is focused on medicine and health, especially as it relates to consumer health issues. While Williams and Clifford's (2009) research concentrated on the state of science journalism in the UK, some of the journalists they interviewed also remarked on the lack of US specialist journalists they encountered when covering stories in the US. They also feared that the situation of cutting specialists in the US would be replicated in the UK.

Meanwhile, the internet has influenced the practice of science journalism, as well as the opportunity for engaging the audience in science reporting differently. The internet is increasingly playing an important role in science journalism for journalists, sources and the audience. For journalists and sources, the internet is an important communication tool (Trench, 2009), which has been documented from the 1990s (Trumbo et al., 2001). Trench points out that the internet offers resource-starved journalists access to information at their fingertips, which can be a double-edged sword. Although it enables quick access to information and sources through e-mail, it also means science journalism is increasingly becoming a desk job. Trench also discusses the use of press releases and the use of embargoed material, but with more of a focus on the way the internet facilitates and exacerbates the use of these tools. He says science journals like *Nature* and *Science* are using such devices as public relations tools because it turns scientific research – conducted over long periods of time – into events, thereby making the "release" of a study’s conclusions something newsworthy. The implications is a trend toward repackaging information from these press releases and journals, which can mean a sameness of coverage across science journalism that Allan (2008) also points out.

In journalism more widely, scholars have discussed the implications of online news for expanded opportunities for people to express their opinions beyond letters to the editor and vox pops (Allan, 2006). Proponents of online news rightly cite the potential for immediacy, depth, and interactivity as some of the benefits. As journalists are realising the web’s possibilities, academics have considered their potential impact in a broader context. Cottle (2006) says the increased opportunities for audience participation helps democratise journalism by bringing in more views and voices. Others, including Matheson (2004) and Allan (2006), have considered Web publication an opportunity for news organisations to regain the public trust by improving transparency. It is important for the public to consider news agencies a trusted source of information in order to support democracy and foster debate around topics, including science. For the audience, it is growing in its prominence as the place for people to learn about science (Allan, 2008).

Finally, professional norms of objectivity, balance, and fairness are also important in the reporting of science. Although her research was more focused on the news production habits of journalists covering cloning, Priest (2001) discussed issues of objectivity, balance and fairness which have applications well beyond the reporting of cloning. Specifically she says:

> Scientific facts, once "discovered," are unlikely to be the subject of much real dispute, but when such disputes nevertheless emerge, journalism strives to remain "objective" by "balancing" opposing points of view uncritically.

Objectivity has been problematic when a consensus within the scientific community exists, but minority opinions contradict the consensus. In that case, as scholars have highlighted in the case of climate change (see for example Carvalho, 2007, Boykoff and Boykoff, 2004, Boykoff and Boykoff, 2007, Boykoff, 2007, Antilla, 2005), the norm of objectivity can be misapplied in that journalists seek to balance unequal positions (Priest, 2001).

Notions of objectivity are problematic in journalism studies as they relate to science and more widely. As Allan (2004) says, journalists use objectivity as a means of getting to the “truth” – the key principle of news coverage. He observes determining what the truth is and who determines it is a challenge, which is why journalists attempt to balance conflicting sources or ideas. In his writings on the environment, he also notes that journalists turn to competing sources as a matter of balance and to address opposing truth claims (Allan, 2002). Miller and Riechert (2000) argue that journalists use objectivity in environment stories to stand in for fact checking. The norm of objectivity, balance and fairness also links to the notion of the social construction of news. These ideas cannot be objectively measured because they rely on the personal perspectives of the journalist who wrote the story and the audience member who interprets the story, among others (Hansen, 2010).

This section reviewed literature that addresses production practices and influences on the production of science and technology news. When it comes to the reporting of science and technology, research has demonstrated the increasing role of public relations and public relations tactics in journalism. Amongst these tactics are the embargo of content from journals, issuing press releases, and announcing the results of a study. This has also contributed to the desk-natured work of science and technology reporting, as has the internet. Finally, this section discussed literature as it relates to objectivity, which is an important professional norm for journalism more generally and science journalism. These elements all play an important role in the findings of the research, as do those addressed in the following section.

Uncertainty and Risk

The last topics that this chapter considers are those of uncertainty and risk. Scholars have paid considerable attention to these topics as they relate to science and technology reporting. For this research, they are important to consider because, as the introduction discussed, nanotechnology carries potential risks, so understanding these concepts and the reporting of them in science and technology news will provide an important background for the rest of the research. The following chapter will consider risk again as it relates to the reporting of nanotechnology because several content studies have focused on the reporting of risk, or really the lack of reporting that addresses risk.

Beginning with the concept of uncertainty, scientists create uncertainty while trying to create new knowledge by poking holes in previous work and inviting the reader to agree that further investigation is required (Zehr, 1999). Early studies of news around science and technology assumed that scientific authority was reduced if uncertainty is reported, so looked for where scientists downplay uncertainty in the public image of science. However, more recent work, Zehr notes, has considered how uncertainty is managed in very particular ways, including to delay policy decisions because policymakers can claim more research is needed to reduce uncertainty. It can be used to appear objective and authoritative because scientists themselves appear to claim a limit or incomplete knowledge. Also, uncertainty can arise from scientists debating different theoretical positions and research interests; however, news reports do not tend to engage with theoretical issues, which therefore leaves the science community looking divided. Climate change can again be used as an example of this, as was noted above.

Where controversy exists around a topic, the reporting of it can exacerbate uncertainty by juxtaposing experts on either side of a debate making the science appear more uncertain than the scientific community might believe it to be (Dunwoody, 1999, Stocking, 1999). This links back to the professional norms of balance and objectivity, which was discussed earlier in the chapter. Journalists balance conflicting ideas in the news reporting in order to be objective in the way they cover the news. Stocking also points out that news articles can reduce uncertainty by reporting science and technology without addressing the limits of knowledge that are communicated by scientists through caveats in the scientific literature. Stocking argues that uncertainty is socially constructed in that it is rhetorically managed and influenced by social pressures, which is what Dunwoody describes in more detail.

Dunwoody (1999) refers to the process of negotiating the meaning of science and technology in the news as a "complicated dance between scientists and journalists, both trying to cast the story in a way that makes sense to them" (p. 59). However, it is an unequal power struggle in that journalists maintain narrative control, but scientists are often successful in determining the meaning of the science and technology being reported. When the science is new and controversial, journalists, within the parameters of professional norms of balance and objectivity, often rely more heavily on the experts to help understand the meaning. However, the power in these circumstances lies with the journalists who select the voices that appear in the narrative. Meanwhile, Dunwoody points out that one-source articles are common in the reporting of science and technology. Closely linked to the concept of uncertainty, is that of risk. Risk is the potential for hazards based on what we know about science and technology, but also what we don't know. This is an important issue for this research as the following chapter discusses the limited extent of risk reporting in the news about nanotechnology, which has been a significant focus of the research in this area to date.

Risks are threats, hazards and insecurities arising out of the development of modern society (Caplan, 2000). Beck (1995, 1999, 2006) is a key scholar in the area of risk as he has written extensively on the topic and many scholars use his work as a foundation for discussions around risk in society. An important thing to note is that risk is not something that has happened or is happening, rather risks are things that might happen (Adam et al., 2000). They are not only associated with developments in science and technology (Beck, 2009), but the focus here will be on those that stem from science and technology. As with uncertainty, the concept of risk is closely associated with the theory of the social construction of reality in that risks are constructed through the development of science and technology and in making sense of the potential threats associated with the scientific and technological development. In other words, risk is not an objective entity that happens; it is rhetorically constructed/managed. That's not to say that these risks are imagined, but rather they are "revealed" through the process of social construction (Adam et al., 2000, p. 2).

Defining risks and the process of determining what counts as "acceptable" levels of risk are contested processes. Risks are defined by key social actors, including politicians, scientists and journalists (Beck, 1999, Beck, 2009, Adam et al., 2000, Caplan, 2000). This process politicizes risks and can mean normalising and underestimating them because acceptable levels of risk are set. Of scientific claims, Beck suggests that accepting scientific claims without exploring the potential risks results in ignoring people and society. In other words, without a discussion of the risks associated with science and technology, people cannot adequately participate in the debates around the potential hazards and therefore fully engage in discussions around science and technology as citizens. This is an important issue for the reporting of nanotechnology because many studies so far have argued that risks of nanotechnology are rarely reported in the news, which the following chapter will discuss.

Overall, in today's "risk society" we are blind to the threats we face (Beck, 1999). Risks often cannot be seen with the naked eye, but can cause threats so large that we cannot understand them. Beck's writings on risk form an important beginning for understanding the role of news discourse in defining risks. However, as Cottle (2006) notes, Beck's insights cannot be the end of the discussion. Cottle argues these ideas need to be refined through research to help gain insights into how public and news agendas are built and mobilised over time. This thesis attempts to explore risk - both as a result of what we know and do not know/are uncertain about - as it relates to nanotechnology. These issues, risk in particular, will be discussed in more detail in the next chapter, specifically focusing on the reporting of nanotechnology.

Conclusion

This chapter began by discussing the importance of science and technology journalism and providing a brief overview of some of the ways in which research has treated the audience and conceived of the role of the media in connecting the audience to the science and technology communities. From there, I reviewed how news around science and technology is reported, including what makes science newsworthy. Finally, the literature around uncertainty and risk was discussed as they are important elements of science communication research. The topics discussed here support the next chapter, which focuses on the reporting of nanotechnology. This chapter and Chapter 3 provide a foundation for the remainder of the thesis and were key in determining how and what data to collect, which is addressed in the methodology chapter (Chapter 4). In particular, what makes science newsworthy and when (the news hook or news peg) are explored in the findings as it relates to how nanotechnology comes to be a newsworthy topic for the newspapers investigated. Also, uncertainty and risk are explored in this research as it relates to when and how these issues are raised in the reporting of nanotechnology. As such, understanding the context around these concepts and how they have been developed through research and discussion amongst scholars over time is useful for contextualising this thesis within the wider landscape of research.

The following chapter reviews research into how nanotechnology has been reported and its influence on the way in which the broader public understands this new science and technology. It begins with a discussion of content studies and follows with research into journalists' and scientists' opinions of the reporting. It ends with a review of literature on audience studies as they relate to nanotechnology reporting because, after all, the audience is the intended recipient of these news stories. The research around the content of nanotechnology reporting is the most relevant to this thesis, which is also a content study. However, the production and audience studies add meaning to the content research because the content represents the moment between the production of news and the reception of it. Therefore considering the literature around that moment helps contextualise the content research.

Chapter 3: Nanotechnology & the news: mapping the literature

As the introduction discussed in greater depth, nanotechnology can simply be defined as the science and technology of the very small. It is considered a defining technology for the 21st Century as it is expected to have fundamental impacts on science and society (Arnall and Parr, 2005). It is considered a disruptive technology in that it has the potential to displace older science and technology and allow for new technology and manufacturing processes that will be used well into the future. It is also considered an enabling technology like electricity because it can have far-reaching implications for the way in which we live our lives. As such, the stakes are high when it comes to this new science and technology. It has an overwhelming potential, but as the introduction chapter set out, it also is filled with questions about the potential risks and hazards that can come from such a potentially revolutionary science and technology.

Debates around this new field of science and technology envision the far-reaching impacts of nanotechnology most often in diametrically opposed ways (Wilsdon, 2004, Arnall and Parr, 2005). Those who are described as nano-optimists describe nanotechnology with excitement because it could reduce the cost of manufacturing and therefore the sale of goods and services, improve computer technology significantly, and provide innovations in medical technology that would bring a "virtual end to illness, aging and death" (Arnall and Parr, 2005, p. 24). Alternatively, those described as nanopessimists imagine it will exacerbate social inequalities that exist globally because wealthy countries will benefit disproportionately from nanotechnology. Additionally, threats include the threat of self-replicating nanobots drawing on raw atomic materials, also known as "grey goo". However, that public debate around nanotechnology is centred around these utopian and dystopian views is an oversimplification of the potential - both positive and negative - of nanotechnology (Macnaghten et al., 2005). Focusing so intently on utopian and dystopian images of nanotechnology arguably limits the possible engagement the public may have around nanotechnology and can obscure the potential for this new field both in terms of its expected benefits and threats. In other words, these views of nanotechnology can make any future of the field sound out of reach, fantastical, incredible, and perhaps unlikely. Therefore the public debate around nanotechnology becomes less meaningful and loses sight of the impact of this field today.

When debates turn to the ethical, legal and social implications of this emerging field of science and technology, nanotechnology is often likened to the debates around genetically modified organisms and biotechnology (Wilsdon, 2004, Schummer, 2004, Sandler and Kay, 2006). The analogy tends to be invoked in order to encourage more public engagement in debates around the implications of nanotechnology, but Sandler and Kay (2006) argue it is not a helpful analogy because it then is dismissive of the engagement process. They say it treats the engagement process as shallow, instead making it more about gaining public acceptance of nanotechnology rather than a true engagement in an important debate. Meanwhile, the way in which the news media covers these debates is important in that it makes science and technology accessible for citizens (Schummer, 2004).

As the previous chapter also addressed, the news media is the primary place for citizens to access news and information about science and technology. That is especially important when considering emerging science and technology like nanotechnology because the media can “contribute to individuals’ awareness, knowledge, opinions, and even behaviors related to such issues” (Dudo et al., 2011, p. 56). News reporting also identifies such issues as important for the audience because as agenda-setting theory points out that exposure to media messages can increase the audience’s perception of whether something is important (McCombs and Shaw, 1999, Bakir, 2006, Dudo et al., 2011). That said, a number of studies have discussed a lack of knowledge on the part of British and US audiences when it comes to nanotechnology (see for example Dudo et al., 2011, Wilsdon, 2004), which will be discussed again later in this chapter when reviewing audience studies.

Looking at the reporting of nanotechnology in the mainstream news, this new field of science and technology has been reported in the mainstream media as early as the mid to late 1980s (Stephens, 2005, Faber et al., 2005, Dudo et al., 2011). Where it is such a new topic in news reporting, research into how the news is produced, the content, and the audience effects is by and large in its infancy. Therefore the research into this area is limited, but what exists has centred on content and audience studies. This chapter discusses those studies, focusing on the studies that consider the UK and US news because they are most relevant to this thesis. Audiences for nanotechnology news have received the most attention from scholars with many studies looking at what audiences know about nanotechnology and what they think about it. The content has been the second most studied area of nanotechnology news reporting with a particular emphasis on the early part of the 2000s. The content is the first topic that this chapter addresses before moving on to studies of the attitudes of sources and journalists about that reporting, which has received marginal attention with only a few studies. The chapter closes with a review of the audience studies because although this research is not an audience study, it is important to understand what research tells us about the ways in which the audience interprets the media messages they receive.

Representation and Framing Nanotechnology in the News

Research into how nanotechnology has been reported has largely focused on press representations of this field and centred on how the risks of nanotechnology are framed. Studies that consider the early days of press reporting on the topic have found that it began in the 1980s with few articles appearing each year (Stephens, 2005, Faber et al., 2005, Dudo et al., 2011). Studies have pointed out that overall the reporting is intermittent, but a 2005 study indicated that from the early part of the 2000s nanotechnology began appearing more frequently in the press than previously (Friedman and Egolf, 2005), which researchers have argued can indicate a growing salience of the topic on the news and public agendas. However, a more recent study of US reporting by Dudo and his colleagues (2011) has suggested that the reporting of nanotechnology may be in decline. That decline, they propose, may be the result of a reduction in science reporting overall as news organisations shed jobs in the tough economic times. Additionally, few events associated with nanotechnology have occurred in the last several years, which given the discussion on news hooks means nanotechnology has lacked the timely element required to make it newsworthy.

That study of US news considered the reporting of nanotechnology from 1988 to 2009 in 21 daily newspapers (Dudo et al., 2011). The research found that business and health appeared as the most common themes – rather than frames – of the reporting and that national security and the environment were far less common as content themes. The study defines themes as a topic that associates nanotechnology broadly with another aspect of society, and chose themes based on the US National Nanotechnology Initiative's implementation plan. The authors made a distinction between their study on themes and framing research because they believe, and I would agree, a frame is much more than a thematic label instead a frame guides the audience regarding a particular meaning. "Themes can set the stage for a frame but do not qualify as frames themselves" (p. 60). Framing theory is discussed in more detail in the following chapter. The study also considered "conceptual themes", which they define as a theme that tracks a more specific meaning related to nanotechnology and its applications. The "research" theme was the most commonly found theme reported in the study, where the "uncertainty" and "regulation" themes appeared far less often. The authors called for more research that considers some of the issues that they address, but goes further into identifying how the media portrayal of nanotechnology links these themes to positive and negative tones in the reporting. This thesis addresses that request to an extent in that it considers frames, which are more nuanced than themes, and the tone of articles toward nanotechnology as it relates to the frames, among other things.

Schummer (2004) conducted a small content analysis of news on nanotechnology as part of a study that called for social science researchers to consider nanotechnology's social and ethical implications in order to engage in debates around these issues. The study, which considered 160 articles published from December 2003 to June 2004 primarily from US newspapers and magazines, found that business, politics and grants for research were the primary topics covered by these news organisations, but that the ethical, legal and social implications of the new science and technology appeared rarely in the reporting. He assumes that the levels of reporting on each topic reflect the levels of interest by Americans in nanotechnology, but this is a problematic conclusion. As Nisbet and Scheufele (2009) point out, news reporting can set the parameters of debate, but it cannot predict public opinion. Setting aside that Schummer implies that news content predicts public opinion, he rightly concludes that absent a discussion of the implications of nanotechnology in the news, it is likely that the average American would struggle to engage in debates around these issues.

Another study that considered Canadian and US news reporting of nanotechnology in 2004 found that nanotechnology appeared in reporting about once each month and was largely discussed in terms of new technologies, societal risks and benefits, and business and market news (Laing, 2005). The author identified those topics as “broad news frames”, however, the description of the content within each “frame” was similar to the way the Dudo and his colleagues defined “themes”. For example the new technologies frame was described as containing stories that profiled new technologies and applications for nanotechnology, which connotes limited meaning beyond the topic or theme of the reporting. The study also highlighted three minor “frames” for nanotechnology, which included profiles of institutes or facilities involved in nanotechnology, economic investment in nanotechnology, and the regulatory, legal and patent issues arising from nanotechnology.

Other studies that refer to their research as framing research have found that the reporting most often frames nanotechnology in a positive light. Faber and his colleagues (2005) go so far as to say North American reporting from 1986 to 2000 was uniformly positive and few articles addressed risks and implications of nanotechnology for society, the environment, or health and safety. They point out that nanoscience and nanotechnology are represented as an elite field that is coming out of well-known universities and research centres and that the work is most closely affiliated with computer research and medical and electronic applications. In this case, the notion of framing is concentrated around the tone of articles toward nanotechnology, which arguably fails to reflect the nuances of framing theory in that it does not adequately address how frames promote a particular meaning and help set the boundaries for debate around a topic. However, it is a useful starting point for understanding the context in which nanotechnology is being reported and identifying the tone of articles toward nanotechnology can be a useful addition to framing research.

Looking more globally, Stephens (2005) surveyed 350 articles in 93 news outlets worldwide to identify how nanotechnology is framed from 1988 to mid-July 2004. In this case, I believe the research draws on framing theory in a more precise and nuanced way because the frames used in the study go beyond thematic description and identification of the tone toward nanotechnology. Specifically the study found that many of the news outlets that reported on nanotechnology, especially those with higher levels of reporting, came from the UK and US, which includes the reporting by *The New York Times* and *The Guardian* as part of the sample of national news organisations for their respective countries. Stephens' research finds that scientific discoveries and specific projects involving nanotechnology are a significant focus of the reporting. Ethical, legal and social implications of nanotechnology appear less frequently and the business of nanotechnology was the third most prominent frame he identified. When the implications of nanotechnology were reported, the stories tended to lean toward benefits outweighing the risks. However, stories that focused on the risks outweighing benefits tended to be on the front page or main news pages of the newspapers, which can mean that these stories are more widely read than the stories that tend toward benefits outweighing risks. Of the studies outlined so far, this, to my mind, has most usefully contributed to the conversation about the framing of nanotechnology because it takes a more sophisticated view of framing. However, it is worth revisiting the framing outlined in this study and others to be discussed in the remainder of this section in order to evaluate the framing of nanotechnology several years on and with a more comprehensive sample of news reporting in a smaller number of newspapers.

A British press framing study, or more appropriately series of studies, that focused on the reporting of 2003 and 2004, found that science discovery and science fiction/popular culture are prominent frames for nanotechnology reporting (Anderson et al., 2005, Anderson et al., 2009a). Science discovery is likely seen as newsworthy because of its “new” character, which reflects the idea that what is new is news, as was discussed earlier in this conceptual background chapter. Meanwhile, Anderson and her colleagues (2005) find the prominence of the science fiction and popular culture frame problematic as it suggests nanotechnology is difficult to define as science or science fiction. The financial and business applications of nanotechnology were also highlighted as a prominent frame in news reporting, which they note indicates that the economics of nanotechnology is also of significant interest. Similar to other framing studies, Anderson and her colleagues (2005) find that the British press seems largely optimistic about the science and technology, with a couple of exceptions where risks and benefits of nanotechnology were treated more evenly in the reporting. Following on from this study, the authors (2009a) considered the implications of the framing of nanotechnology on public discourse. They consider it problematic for public debate that nanotechnology is largely framed around benefits and that little discussion of the implications and risks of nanotechnology appear in the reporting. They do, however, go on to say that framing nanotechnology around science fiction can indicate a growing receptivity to discuss nanotechnology applications and impacts of nanotechnology. Meanwhile, they point out that public discourse around nanotechnology may be limited because the coverage is centred in the elite press and nanotechnology is framed so positively. As with the Stephens study, these studies take a more sophisticated view of the framing of nanotechnology, focusing exclusively on a British context. It provides a useful context for discussion around these issues, especially for the two year period that they consider. As with the Stephens study, it would be helpful to update this research, but consider a wider number of years, including the most recent history to see how nanotechnology framing has developed since that time.

Looking at the prevalence of science fiction in the public discourse, Lopez (2004) considers references to science fiction in discussion about nanotechnology as positive. Specifically, he finds it useful in that the science fiction discourse can help illuminate the potential of nanotechnology in a way that is not possible at the moment because many of the potential applications for this emerging science and technology are some time away. Lopez was speaking about the public discourse more generally, rather than specifically focusing on news discourse, but it is an interesting perspective to consider alongside that of Anderson and her colleagues regarding risks, as noted above. Lopez and Anderson and her colleagues see the role of science fiction in the discourses as potentially positive. While that is true to an extent, Lopez's ideas of the visionary elements of science fiction being a way to bridge the gap between nanotechnology today and nanotechnology's potential can also arguably obscure the debate. The visionary discussion around nanotechnology, especially as it relates to far-reaching potential benefits, could then lead to linking nanotechnology with fantastical imagery that is too out of reach for meaningful debate.

Moving to a US focused study on how nanotechnology is framed, Gorss and Lewenstein (2005) surveyed American press coverage from 1986 to 2004 that focuses on how much attention the American press has paid to nanotechnology and what key arguments were articulated at the time. Much of their research is consistent with the UK studies. Not surprisingly, the two determined that nanotechnology is event driven rather than issue driven. As the previous chapter discussed, such a finding is consistent with science journalism research that has documented the importance of conferences and release of new studies in journals and studies of news in general. The Gross and Lewenstein study also finds that how nanotechnology can be applied and the financial implications of the coverage are dominant in the news. The researchers point out the overwhelmingly positive tone of nanotechnology reporting and its characterisation as revolutionary can exacerbate negative coverage if a problem arises in future. The reporting of nanotechnology, they say, leaves open the question of risk. Gorss and Lewenstein (2005) point out that news reporting should cover concerns such as lab safety; potential privacy issues with the opportunity for nanocameras, for example; environmental impacts, and political questions such as funding and who will benefit from that funding. As with some of the studies discussed earlier, this particular study prioritises the tone of articles toward nanotechnology as framing, which is limited in its contribution to discussions around framing nanotechnology. However, this study also reviews how the US newspapers report on the potential applications for nanotechnology, which can contribute to the discussion of framing in that it indicates the meaning of nanotechnology is to an extent tied to how it can be used.

A more recent US study considered nanotechnology frames in reporting within the last several years (Weaver et al., 2009). The study reviews coverage of major US newspapers from 1999 to 2008 and finds that nanotechnology is often framed around progress and that although risk is also featured in the reporting; it is most often generic risks rather than specific risks that are cited. The research echoes some of the research previously discussed, however, the authors found that regulatory responsibility has become a more prominent frame since 2007. This study, however, considered four frames - regulation, generic risk, conflict and progress. Therefore it is not surprising where other studies considered a broader spectrum of frames that these specific frames were less salient or absent (as is the case of regulation) from other studies. With that in mind, a regulation frame is useful in that it highlights the ways in which nanotechnology is made meaningful through the political process of regulating how nanotechnology is used in consumer goods, agriculture, and other potential applications. The way Weaver and his colleagues operationalised the frame, however, would include news reporting that addresses specific risks of nanotechnology in that those would be identified as needing to be regulated to prevent. The generic risk frame was used to identify when risks were reported in the news, but did not specifically address regulation or a need for regulation. That raises the question about how the claims about risks of nanotechnology are reported in the news and to what extent they are specific or generic risks because the way in which Weaver and his colleagues addressed these issues do not make that clear.

Another study looking at the framing of nanotechnology pointed out the prominence of a public accountability frame and a social progress frame (Nisbet and Scheufele, 2009). In particular, risks are used as "framing devices" within a wider frame of public accountability. For example, asbestos and the problems associated with asbestos are part of the “public accountability” frame because it links to a lack of regulation around asbestos. It is also part of a “Pandora’s box” frame where the risks of nanotechnology are unknown and will be learned over the long term. References to nanotechnology as being natural or having natural roots is a framing device that is part of the frame of "social progress" in that proponents of nanotechnology try to naturalise synthetic nanotechnology. This study draws on a set of frames that are identified as common in science reporting more generally, which is useful to make comparisons for the reporting of nanotechnology against other fields of study. However, it does not consider how nanotechnology is made meaningful for the audience without being compared to other fields in science and technology.

Looking specifically at how claims about risk are reported, Friedman and Egolf (2005) conducted a study that considered how the UK and US reporting differed. It focused on newspaper and wire copy from 2000 to 2004 that addressed environmental and health risks in particular. When it comes to reporting on risk, the authors expected to find a negative framing of nanotechnology. However, the authors found that stories included positive references to nanotechnology and a number of neutral paragraphs, which indicates a balanced approach to the reporting. That said, they pointed out that headlines were often negative and did not always match the stories they topped, which is problematic when considering that readers may scan headlines and not read the stories. Looking at the reported risks themselves, Friedman and Egolf's research finds that risks discussed were general risks and most often were non-specific health risks. Overall, the authors found that reporting on nanotechnology risks were similar in both countries with two subtle differences: the UK articles were slightly more negative than US stories and the UK articles included higher levels of concern about the effects of nanotechnology on society. When it comes to claims about nanotechnology risks, this study is useful for its contribution to the discussion around health and environmental risks, but where it is so focused on such risks it is limited in wider conversations about the claims associated with nanotechnology.

Overall, the literature reviewed on content studies of nanotechnology in the US and UK has found a rise and perhaps a more recent decline in the reporting of nanotechnology over the last few decades. When nanotechnology has been reported, the risks of nanotechnology rarely feature in the content, but when it does they are often outweighed by the benefits that nanotechnology could bring. This particular finding from research is often linked to the tone of reporting on nanotechnology rather than explicit empirical evidence, however. When it comes to the framing of nanotechnology, the news reporting tends to discuss nanotechnology in terms of scientific discovery and the breakthroughs in the field or frame nanotechnology around science fiction. As such, the picture of nanotechnology in the news thus far has been that it is a beneficial area of science and technology that is bringing about breakthroughs in those fields that are unimaginable except in terms of science fiction. These conversations serve as a backdrop to the following sections of the chapter, especially the section on production and sources because in many cases the study participants are responding to the content. The news reporting of nanotechnology is also important in the final section of the literature review because it considers what the audience knows/understands about nanotechnology and how they feel about it, in part because of what they read/see about it in the news.

Production of news about nanotechnology

Now this literature review moves to studies that consider how journalists and sources, specifically scientists, feel about the reporting. Petersen and his colleagues (2009) point out that scientists are likely to be concerned about news reporting of nanotechnology because of the implications to their work and specifically to policy makers' support of it. They are likely to be especially interested when it comes to how claims about the benefits and risks are reported. The researchers surveyed and interviewed scientists to gain insight into their attitudes and opinions about the reporting on nanotechnology. The scientists they surveyed were largely dissatisfied with the reporting of nanotechnology and thought it detrimental to science. Specifically, half of the 37 scientists thought reporting on nanotechnology were inaccurate and three-quarters considered it sensational. The scientists involved in the study were wary about interacting with the media, although a number of them had been interviewed by journalists and had a "satisfactory" experience. The scientists acknowledged some of the challenges for journalists covering nanotechnology, including a lack of consensus on a definition for nanotechnology and some scientists labelling other fields of work nanotechnology in order to get funding. They also acknowledged that they may play a role in the problem in that they could be more effective in the way they communicate with journalists. The researchers argue that scientists do not sufficiently understand how the news is produced and their role in that production, but should if they want to play a part in enriching public discussion on nanotechnology especially when it comes to reporting on the implications of nanotechnology. This study draws attention to the often conflicted relationship between scientists and journalists, which has been documented more widely in the study of science journalism. It is useful for this thesis in that it specifically addresses issues associated with reporting nanotechnology and identifies some of the challenges - defining nanotechnology, for example - that journalists face when attempting to make sense of this new field of science and technology for the audience.

Specific to the implications of nanotechnology and how it is reported, Wilkinson and her colleagues (2007a) interviewed scientists and journalists about their opinions of the reporting. Both scientists and journalists agreed that reporting on risks and other implications of nanotechnology was lacking. Some of the journalists interviewed believed the news media was taking a measured approach to nanotechnology and did not want to amplify risks, while one in particular pointed out that so much uncertainty around nanotechnology exists that it makes it a complex topic to report. The journalists' views on the reporting further highlights some of the challenges of reporting this complex topic and provides a behind-the-scenes look at news production and the decisions about how nanotechnology is reported. When risk is reported, however, the scientists interviewed thought it was sensational. The scientists notions of the reporting echoes some of the struggles outlined in the study above when it comes to the scientific community and journalists negotiating the way to make sense of nanotechnology for the audience.

Another study that considers the production of news around nanotechnology is one focused especially on the financial reporting of nanotechnology (Ebeling, 2008). The author interviewed professionals in financial and science journalism, public relations and marketing, nanoscience, and private equity investing in order to explore the mediation of uncertainty around the financial risks of nanotechnology. While all of the various perspectives are useful for understanding the complexity of the topic, the most appropriate for this thesis is that of the journalists. In that case, the journalists interviewed reportedly struggled with the definition of nanotechnology and chose to avoid an overuse of the term that would otherwise obscure its meaning. As the introduction set out, sometimes scientists and companies are applying the word “nanotechnology” whenever dealing with something small, therefore it makes the definition of nanotechnology less clear. The journalists also reported a backlash from investors when they covered financial risks and uncertainty around nanotechnology. Where this research is so intensely focused on the financial reporting around nanotechnology, its use for this thesis is limited in that my project considers specialist and non-specialist reporting as it relates to nanotechnology. However, it provides an insight into some of the challenges financial journalists in particular have faced in reporting nanotechnology for their audiences.

In summary, the scientists and journalists who have participated in the few news production focused research projects believe the news about nanotechnology can be better reported, especially with regard to claims about risk. These studies not only highlight a dissatisfaction about the reporting of nanotechnology, but also document the challenges that journalists and scientists face in communicating nanotechnology - even defining it - because it is such a complex subject. As such, it underlines the difficulty that journalists have in reporting on the field of nanotechnology for their audiences.

The audience and news about nanotechnology

Finally, this literature review turns to some of the audience studies. To put it simply, research has pointed out that few people know much about nanotechnology, but they are largely optimistic about the field (see for example Besley et al., 2008, Gaskell et al., 2005, Dudo et al., 2011, Wilsdon, 2004, Lee et al., 2005, Sheetz et al., 2005). A variety of factors influence people's attitudes toward nanotechnology, and science and technology more generally, but the media representations can play a role in developing individuals' ideas about technology, as this section discusses in detail.

A 2005 study pointed out that people form their opinions about nanotechnology by drawing on their general knowledge of science and technology, and absent specific knowledge about nanotechnology they will take cues from the news media, among other places, to form their ideas (Lee et al., 2005). Drawing on a telephone sample of 706 people in the US, the researchers concluded people use their knowledge about science in general in order to evaluate the risks and benefits of nanotechnology and decide whether to support it. Also, heuristic cues from the media and emotional variables, such as a trust in scientists more generally, will also play a role in influencing the attitudes of the public toward nanotechnology. Overall, the study found that although increased knowledge about nanotechnology might influence people's attitudes toward nanotechnology, more heuristic and emotional cues can be stronger at times. As such, the models of science communication that focus on the media's function in improving scientific literacy are not adequate because it oversimplifies the ways in which people evaluate science and technology. The study highlights how news reporting can be an influential source for people's attitudes toward nanotechnology therefore emphasising the role that news plays. However, it also points out the shortfalls of linear models of media effects, which were also addressed in the early part of Chapter 2.

Another study (Scheufele and Lewenstein, 2005) drawing on a telephone survey of people in the US about their attitudes toward nanotechnology focused more heavily on how the media influences these attitudes. This study may have drawn on the same survey of 706 people as noted above; Scheufele was involved in both research papers and the survey was conducted at the same time of year (autumn 2004) and using the same methodology. Where that may be the case, it is not surprising that this study also concluded that people in the US do not have a lot of knowledge about nanotechnology, but are primarily positive about the potential of nanotechnology. Setting that aside, Scheufele and Lewenstein delved deeper into the role that the media plays/potentially plays in the formation of those attitudes. While only 16 per cent of participants reported having knowledge of nanotechnology, all demonstrated some knowledge, including that nanotechnology was expected to make an economic impact. The authors attribute that to the focus of news reporting on nanotechnology's benefits, especially as it relates to the economy. They also found that those who reported they paid attention to media around science and technology were more likely to hold positive attitudes toward nanotechnology. This demonstrates a more nuanced sense of the influence of media on audiences by focusing on the more subtle ways in which the news may affect the audience. Specifically, it found that individuals' knowledge of nanotechnology reflects some of the themes that content studies have identified as the primary ways in which nanotechnology has been reported.

A third study carried out by Lee and Scheufele (2006), also drawing on a survey of 706 people in the US using the same methodology as the two previous studies, elaborated on the specific media channels individuals used and the potential influence it has on their attitudes toward nanotechnology. Specifically, the authors looked at ways in which the news media – newspaper, web and television - influenced individuals' attitudes toward nanotechnology and more generally their deference toward science and scientists. They concluded that overall, individuals' use of the media – all three channels – had a positive influence on their attitudes toward nanotechnology. Newspaper and web reporting of science had a stronger connection to an increase in knowledge about nanotechnology than did television. That increase in knowledge, particularly as it relates to reading about science and technology in the newspaper, positively influences people's attitudes toward nanotechnology. With that in mind, the authors point out that overall the news reporting of nanotechnology has been primarily positive, as this literature review has already indicated, which might also influence the overall positive tendency toward those individuals' who participated in the study. The two conclude that as nanotechnology continues to be reported in the news, the framing of nanotechnology may become more nuanced and therefore the audience will be exposed to more complex information about nanotechnology. Where the three studies above appear to be drawn from the same survey of 706 individuals, the individual contributions of each are more limited. They are useful, however, in indicating the more subtle ways in which the reporting of nanotechnology might be reflected in the knowledge and attitudes of the public toward the topic.

Looking specifically at how framing affects public opinion, Cobb (2005) studied the results of a nationally representative phone survey conducted in the United States to determine how the framing of a story on nanotechnology influences the opinion of individuals polled. He concludes that negative frames are more influential than positive ones within limits. When stories are more balanced between the risks and benefits, they did not tend to change the respondents' opinions. His study suggests that public opinion is malleable within limits. Cobb concludes that despite a lack of knowledge about nanotechnology, Americans tend to have a largely positive view of nanotechnology that remains relatively constant even in light of negatively framed stories. Where this study tests how the change in tone of an article might influence the audience differently, it provides a very limited definition of framing around positive, neutral and negative terms. Setting that aside, like the other studies cited here provides a useful context for the ways in which the audience interprets news around nanotechnology.

More recently, a US study reviewed audience perceptions of nanotechnology with an eye toward the applications for nanotechnology (Cacciatore et al., 2009). Specifically, it looked at whether individuals' attitudes toward nanotechnology were influenced by associating nanotechnology with particular fields, such as medicine, consumer products or the military. The study suggests that previous studies' work identifying how risks influence individuals' perceptions of the field are simplistic. Instead, the researchers argue, that in forming their attitudes toward nanotechnology, individuals might consider risks more if they associate nanotechnology with a particular application, such as medicine. Therefore, the study further highlights the complexity of the ways in which people form attitudes about science and technology and simple, linear ways of thinking about the media's role in influencing attitudes are inappropriate.

Overall, the audience research has indicated that people know little about nanotechnology, but appear to hold positive attitudes toward it. Some research suggests that the news provides heuristic cues for the audience, which is why they hold the attitudes that they do. Also, that the audience perhaps know more about nanotechnology than they think because they are exposed to media messages and participants in one study reportedly knew about nanotechnology's potential economic benefits. However, most agree that when it comes to forming individual attitudes, a linear understanding of media effects is inappropriate. These studies together underline the importance of studying news about nanotechnology, but serve as a caution that content studies are not predictive in what attitudes individuals will hold as a result of the reporting.

Conclusion

In conclusion, this literature review discussed research into how nanotechnology has been reported with an emphasis on framing. Overall, that research has begun to identify how nanotechnology is reported in newspapers, however, framing studies have by and large focused on whether reporting is more positive or negative with a few exceptions. A more nuanced approach to how nanotechnology is framed is appropriate, and to consider how that framing has changed over these last few decades would also be beneficial in further understanding the reporting of nanotechnology. Additionally, many of the news reporting studies have centred on a shorter period of time - especially in the early 2000s. The studies that have considered a longer time frame have provided a good overview of the reporting, but many are several years old now. Additional studies can contribute to the conversation by investigating not only a long period of time, but also to consider a variety of elements of the reporting from framing to claims about risks to benefits and so on. Regarding scientists' and journalists' opinions of reporting, studies indicate they are concerned about a lack of reporting with regard to risks and implications of nanotechnology.

However, more study in this particular area is needed to help close the gap between the volume of audience and content research that exists. Finally, the literature review pointed out that the reporting of nanotechnology, including its framing, can influence how the public perceives the topic. This illustrates the importance of understanding how nanotechnology is reported in the mainstream press. Now this report turns to a brief discussion of the methodology I intend to use to carry out my research. It begins with a review of framing literature in detail because, as this chapter has illustrated, it is a complex idea that is interpreted in a variety of ways.

Chapter 4: Framing theory and its approaches: an exploration of methodology

With the background provided in Chapters 2 and 3 in mind, this chapter begins to discuss the methodology employed in order to explore the definitions and frames for nanotechnology in the two newspapers under investigation. To address the research questions set out in the introduction, I intend to carry out a framing analysis that will employ both quantitative and qualitative traditions of content analysis. Doing so seeks to more fully explore how nanotechnology has been framed over these last few decades. Quantitative and qualitative methods can be used to complement and balance the individual methods by addressing the blind spots in both. It follows from the idea that social science research benefits from multiple methods and address the complexity of issues explored in this type of research (see for example Hansen et al., 1998, Stokes, 2003, Kracauer, 1952-1953). Additionally, by studying how more than two decades of news content frames nanotechnology, it is arguably necessary to draw on quantitative and qualitative research methods to identify trends in the reporting and explore certain aspects of the content more deeply. Stokes (2003) says using two or more methods helps add more "texture and understanding" of a research problem (p. 27). Hansen and his colleagues (1998) also offer that social science research, because it studies multidimensional problems, requires a complex and multifaceted approach.

Before discussing the methods individually, it is necessary to define framing conceptually and discuss what makes it useful in research terms. It is a popular theory to draw on for research, including for research into the reporting of nanotechnology, as the literature review discussed, and other science and technology issues (see for example Connolly-Ahern, 2008, Reis, 2008, Listerman, 2010, Grimm, 2009). That said, the literature review chapter began to highlight some of the challenges to the theory of framing, which includes an array of definitions and conceptual understandings of what exactly it is, what it entails, and how it is carried out (see for example Scheufele, 1999, Entman, 1993, Druckman, 2001, Koenig, 2006). Hertog and McLeod (2001) consider it a “blessing” (p. 140). They say it offers the opportunity for creative analysis, but note that in such a situation researchers must therefore outline their approach in great detail so that scholars can choose the best of the approaches. That kind of transparency and rigorous attention to defining and describing the research approach is also important for reliability and validity in content analysis, which will be discussed later in this chapter.

Returning to definitions previously cited in this research, framing refers to journalists’ process of organising topics to make sense of complex stories for audiences. Framing analyses seek out textual evidence of the choices journalists make, specifically looking for elements that are included in the reporting and by extension identify what might not be included (Allan, 2004, Reese, 2001, Gamson, 2003). Entman (2003) says framing involves choosing and highlighting certain aspects of an issue or event over others and drawing connections amongst those aspects in order to promote a particular way of thinking about the issue or event. His definition points to issues of power in the process of meaning making as he suggests that meaning is constructed discursively through the interactions between sources and journalists. Specifically, he says, the two exert influence over each other in order to promote certain interpretations. In doing so, other interpretations are marginalised.

Similarly, Gitlin (cited in Reese et al., 2001) defines it as “principles of selection, emphasis, and presentation” that represent “tacit little theories about what exists, what happens and what matters” (p. 114). In short, frames help journalists determine how best to organise the news and package it for the audience. Allan (2004) points out the once a frame is chosen, it helps the journalist choose the relevant facts, sources and information to include. Additionally, echoing Entman’s point that frames develop through conflict and struggle, Miller and Riechert (2000), point out the implications for winning the struggle over how to frame an issue. They say the struggle to frame an issue is tied to an attempt to influence public opinion and the policy-making process by setting a preferred interpretation of an issue. It can be particularly influential, they say, because it brings a particular position to the fore and can also mean some ideas are not expressed publicly. Therefore the audience is exposed to a limited number of meanings, which then limits the potential for discussion. Miller and Riechert (2000) talked about framing as it relates to environmental issues, but their discussion around framing applies to other contexts as their discussion centres around the decisions that journalists make.

Also discussing the decisions that journalists make, Marks and Kalaitzandonakes (2001) point out that journalists adjust frames based on their understanding on a particular topic, style of reporting, and the practical limitations of their work. In writing on science and technology, journalists can frame a topic in a way that emphasises facts, health and environmental risks, and broader social implications. They also point out that when it comes to framing risks, the news media have the opportunity to direct the public's attention to a particular area of concern thereby influencing what topics or elements of a particular topic the public thinks about.

D'Angelo (2002) offers helpful ways of thinking about frames, including what they mean and how they function. Synthesising decades of framing research, he outlines four conceptualisations for frames that broadly deal with how frames are constructed and interpreted. First, he describes them as themes within news stories that are "ontologically distinct" from the topic itself (p. 873). Put simply, frames can set an issue into another context or draw on elements of a context that is otherwise unrelated to the topic. It does so by drawing on certain language and images that might not be directly related to the topic. A common example of such an idea is the "War on Drugs", which sets the issue of the illegal drug use and trafficking in the context of war. As such, the language of war and military brings meaning that otherwise would not have been present in the discussion of illegal drug use and trafficking should another context have been provided. Secondly, D'Angelo says frames are powerful cues that can influence the ways in which people think and the way that public opinion is formed. Thirdly, frames “exist as prior knowledge” and help individuals and groups make sense of a news story quickly and efficiently. At the same time, these individual frames serve as reference points for frames encountered in the media, so individuals weigh media frames against their prior knowledge. Finally, news frames are particularly powerful and important because they have the potential to influence public debate. D’Angelo points out that framing researchers tend to view journalism in normative ways and consider the role of journalism to inform citizens in a democracy.

Additionally, framing offers an alternative to notions of "objectivity and bias" and differs from such ideas in important ways, according to Tankard (2001). He rightly points out that it goes beyond whether an article portrays an issue in favourable and unfavourable ways or positive and negative ways because it adds possibilities of “additional, more complex emotional responses and also adds a cognitive dimension (beliefs about objects as well as attitudes)” (p. 96, parentheses in original). Tankard goes on to say that the media’s presentation of a topic defines it and the issues associated with it, as such setting the terms of debate. Further, it gives researchers the opportunity to examine media hegemony, which he suggests is when one frame is so dominant that people accept it without question. He rightly notes that the power of framing comes from “its ability to define the terms of debate without the audience realizing it is taking place” (p. 97).

Tankard offers three approaches to an empirical investigation largely focused on quantitative analysis, including setting out a list of frames that are defined before examining the articles in the sample. Of the approaches he sets out, the list approach most appropriately describes the approach adopted for this thesis, which is discussed in more detail in the research approach section of this chapter. No matter what type of quantitative investigation of frames is used, Tankard says researchers must clearly define the frame and frame indicators, but cautions that naming a frame is an act of framing in itself however unavoidable.

Looking at framing in science news, Nisbet and Scheufele (2009) explain that framing theory allows for “rich explanation for how various actors in society define science-related issues in politically strategic ways, how journalists from various beats selectively cover these issues, and how diverse publics differentially perceive, understand, and participate in these debates”. This is a particularly useful way of thinking about framing as it relates to science and technology because it identifies how sources attempt to set a preferred meaning for a topic and the role of journalists in choosing a preferred meaning, as well as the role of the audience in interpreting the frame. This considers framing from the three perspectives, which scholars such as Philo (2007) argue is necessary for good research around media reporting of individual issues. While it is useful to consider all three perspectives, it is not always possible or appropriate given the research questions of a project.

The individual frames themselves are neutral in that they can be mobilised in a number of ways. The devices within those frames are not. Nisbet (2010) offers the example of the "morality/ethics" frame in debates around embryonic stem cell research. Both sides of the argument use this particular frame, but they inflect it differently. Critics argue that using human embryos in research is morally wrong because it involves taking a life. Proponents argue it is morally wrong to prevent research because it prolongs someone's suffering that might otherwise be cured in and through the research.

The above discussion illustrates the power of framing and the value of framing research. In particular, it identified that frames are more than the positive, neutral and negative representations of a particular topic. Instead, they are ways of making sense of complex topics for the audience. Journalists have a particular role in selecting frames, but sources are also key in identifying frames for journalists. The literature around framing, in short, identifies the contested nature of establishing a preferred meaning for a topic, in which this thesis is most interested. In order to carry out the framing analysis, the study employs quantitative and qualitative content analysis methods. Quantitative content analysis, which is the primary method of investigation, allows for the identification of trends in the reporting. Alternatively, the qualitative analysis allows for a close examination of the texts and a deeper sense of certain aspects of the reporting. Where the quantitative study is the primary focus of the thesis, the following section describes content analysis as a method, including an outline of the benefits and drawbacks of the method. Following on from there, the chapter discusses textual analysis, the qualitative tradition of content analysis, before detailing the research approach specific to this thesis.

Content Analysis

To begin, content analysis is a “technique for making inferences by systematically and objectively identifying special characteristics of messages” (Berg, 2001). It is a flexible method that enables researchers to analyse large volumes of texts, which is amongst the reasons it is appropriate for this particular project. Berg’s definition uses the word "objective’" to describe the method, but I focus more so on the systematic nature of the process because choosing the research elements to be counted is in itself a subjective activity (Hansen, 1998), and as the previous section points out there are qualitative aspects to identifying frames and so to call it "objective" could be misleading.

Before discussing the method and its relative benefits and drawbacks, it is useful to set out some historical perspective on this technique. Analysis of content, which by definition includes newspaper articles, is something researchers have done for centuries, including research in theological studies in the 17th Century that analysed newspaper content (Krippendorff, 2004). Krippendorff suggests the research carried out in the 1600s contributed little to the development of the method we know today, but criticisms of an 18th Century study of Swedish hymns of unknown authorship contributed many of the ideas that are now part of the method and stimulated debates about methodology that continue today (p. 4). The hymns, called *Songs of Zion*, spurred debate about whether they undermined the Swedish state church clergy. That discussion included literary scholars on both sides who analysed symbols in the song and came to different conclusions, sparking questions about interpretation (Krippendorff, 2004).

Specifically looking at newspapers, the early 20th Century saw the development of quantitative newspaper analysis, which was borne out of the emergence of journalism schools in the United States and a desire for empirical enquiry into the field of journalism. Studies at the time, measured column inches devoted to particular topics as a way of illustrating the state of journalism and measuring the volume of content on certain subject matters is still part of many studies conducted today, according to Krippendorff. The method has been used extensively to analyse the content of a variety of mass communications media, including print, radio and television (Hansen, 1998). Hansen (1998), outlining a brief history of the method, notes it was developed as a formal method during World Wars I and II to address concerns about how media messages contributed to social upheaval, as well as a desire to make social science research more systematic.

In media studies, content analysis has more often been used to examine how news, drama, advertisements and entertainment reflect social and cultural issues and values. It has also been used as a means of studying media organisations, professionals, sources, production and other matters

(Riffe and Freitag, 1997). A number of the studies highlighted in the literature review were conducted using content analysis, including several that helped me develop this thesis and formulate the coding schedule that is an important element of a quantitative content analysis. The specific contributions to the formulation of this research are discussed in the research approach section at the end of this chapter.

Returning to the definition of content analysis cited earlier in this section, scholars focus on the systematic and methodical processes involved in making inferences from a text. In order to be systematic, the method requires researchers to establish rules for identifying the content to be analysed and explicitly defining what elements of the content will be recorded for analysis, all based on the research problem and constructed within a theoretical framework (Krippendorff, 2004, Hansen, 1998, Deacon et al., 1999). Krippendorff (2004) defines it as “a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use” (p. 18). He places emphasis on the replicability of the research, arguing that different researchers applying the method to the same data should arrive at the same results. He describes it as the “most important form of reliability” (p. 18). He goes on to say that content analyses must also be valid, which means it must be open for scrutiny and its claims upheld through independent review.

Potter and Levine-Donnerstein (1999) consider the theoretical underpinnings of the content analysis as key to reliability and validity. In other words, if the coding scheme is derived using academic literature, then the researchers designing the study are “on solid ground to create a valid coding scheme” (p. 282). Absent adequate scholarship, they recommend pilot testing the coding scheme, although arguably a pilot test is important no matter how much scholarship is used to develop a study. Also important to Potter and Levine-Donnerstein’s notion of reliability and validity is the replicability of a study. They pay particular attention to the use of multiple researchers to carry out the coding and evaluating the inter-coder reliability to ensure the coding schedule is applied reliably. However, where this thesis is part of a PhD study, a single coder was used and therefore other procedures for ensuring reliability were used and will be discussed in detail in the research approach section.

Criticising the notion that reliability derives solely from replicability, Gunter (2000) says that strictly focusing on reproducibility of content analyses assumes that “textual meaning is fixed and quantifiable,” but some aspects of content that researchers seek to explore cannot be fixed and the researchers’ personal attitudes are important (p. 82). Therefore, part of establishing reliability and validity is through the careful discussion of the processes of carrying out the research and a reflection on that process. This is especially true for a content analysis such as this thesis in part because some of the content under investigation is decades old and therefore is analysed with the benefit of many years of development of nanotechnology. It was not gathered and analysed as it unfolded, with the exception of some of the most recent reporting. Therefore, that perspective can colour the analysis. Additionally, some of the elements of this study draw on qualitative distinctions, such as identifying news content as meeting a particular frame, which required a clear set of definitions for each frame that helped guide the coding. Additional discussion around self-reflection on this thesis is taken up in the last section of this chapter.

Moving on to the benefits and drawbacks of the method, content analysis is unobtrusive and can cope with large volumes of unstructured data (Krippendorff, 2004). It also enables researchers to describe and analyse characteristics of communication and offer textual evidence of the production of texts (McMillan, 2000). It is especially adept at helping researchers develop a "big picture" on a given topic by "delineating trends, patterns and absences" over a period of time (Deacon et al., 1999), which is useful for my research as it is a longitudinal study. At the same time, content analysis faces a variety of criticisms, including that it simplifies meaning in texts, can be too descriptive, and fails to capture the complexity of communication. In response, Gunter (2000) suggests that the counting and quantifying in content analysis can be supplemented by interpretive procedures that help dig deeper and consider the social implications of what is being counted. Hansen (1998) also points out that if content analysis research is grounded in theory it illustrates the "social significance and meaning of what is being counted" (p. 96). It is often combined with qualitative methods of analysis to help address some of those criticisms, which brings me to the qualitative analysis of the texts.

Textual analysis

Textual analysis, sometimes described interchangeably as discourse analysis and critical discourse analysis, works well with content analysis because it adds depth to the quantitative content analysis by exploring the news reporting in more detail. It does so through close, interpretive reading of texts to gain deeper insights into meaning and how meaning is constructed in these texts. Newspaper articles are amongst the many elements that would be defined as a text in textual analysis because they allows us to derive meaning from the articles (Fairclough, 2003). Before discussing textual analysis in terms of its use as a research method and the benefits and limits of the method, it should be noted that this study drew on textual analysis in a very limited way, prioritising the quantitative content analysis. As such, the discussion here is also limited.

Textual analysis explores the way "language is deployed, how images, sounds and statistics are organised and presented, and, where relevant, how these various elements are combined" (Deacon et al., 1999, p. 17). It draws on semiotics and linguistic analysis, among other approaches, in order to explore how meaning is constructed and does so at the smallest level – individual words – through to the whole text. Although interpretative by nature, Deacon and his colleagues point out that researchers employing textual analysis should attempt to be systematic in conducting their analysis by applying explicit methodological principles. They also point out that textual analysis does not allow researchers to "make clear assertions about the intentions of a text's producer, nor can it validly infer the impact of the text on readers, viewers or listeners” (p. 182). In other words, a textual analysis of news content cannot assume that journalists intended a particular reading of the text, nor can it assume that audiences would interpret the text in the same ways. This particular limitation is more a caution against abuse of the method or really an overstatement of the implications of findings from an analysis of text. As such, they encourage researchers to reflect on their methodology and the extent to which their findings are applicable. Additionally, textual analysis considers that texts written or laid out in different ways mean different things and enables analysis in levels from individual words through to the text on the whole (Richardson, 2007a).

Looking briefly at its beginnings and some of the approaches to it, textual analysis is an interdisciplinary method of studying texts that stems from disciplines within humanities and the social sciences (Van Dijk, 1988). It was developed in the 1960s and 1970s, but has roots in classical rhetoric, as van Dijk points out. In discussing the historical perspective and development of the methodology, van Dijk includes a variety of approaches to discourse and textual analysis such as conversational analysis and text linguistics. The approaches to discourse analysis range from more abstract analysis of text that pay little attention to the linguistic elements in texts to those more intimately focused on the linguistic elements (Fairclough, 2003). In the cases of Fairclough and van Dijk's methods of discourse analysis, as Philo (2007) explains, the texts and the discourses represented within them are linked to power and social interests. Discourses represent "aspects of the world" and different discourses represent different perspectives (Fairclough, 2003). As such, they carry power and can be used to establish, maintain and/or change social relations. In other words, exploring these discourses can help researchers to understand the dynamics of power within society.

This method allows researchers to explore the latent and implicit meanings of a text and discern patterns within the texts and across texts (Fürsich, 2009). The textual analysis is carried out in a variety of ways, including by following more prescribed rules and systems for interpretation like those by Fairclough and van Dijk to the more interpretive and humanistic in nature. The latter are sometimes referred to as thematic analyses. Van Dijk's (1980, 1988) work also includes discussions around themes or topics within news discourse and also how they relate to wider discourses, but as Fürsich points out his method is grounded in rules for analysis more so than those more interpretive and humanistic approaches. According to Richardson (2007a, 2007b), textual analysis, or critical discourse analysis as he refers to it most often, allows researchers to interpret the different ways in which texts written or laid out can mean different things. Also, he believes that through analysing the different levels of texts - individual words through to the text on the whole - helps researchers understand how discourses convey meanings, including more subtle meanings, through word choice, sentence structure and presupposition.

As with content analysis, textual analysis is an unobtrusive method that allows for the close scrutiny of news content, as in the case of this thesis. It has been used by a variety of scholars in examining news content for a number of years. As discussed briefly above, this method does not allow for making inferences about the production of the texts or the reception of the texts, which is amongst the criticisms it faces (Philo, 2007). While Philo's point is not unwarranted, Fürsich (2009) points out studies that adopt textual analysis on its own are useful in that they help explore that moment between production and reception. Further she notes that Philo's approach, and that of the Glasgow Media Group more widely, tends to prioritise those readings of the text that agree with the journalists' interviews and the audience reactions to the content. As such, the text itself and the close readings of it are delegitimized. Further, for those studies that consider texts historically, as this thesis does with the longitudinal strategy taken, the Glasgow Media Group's methodological approach would be limited by the recollections of the journalists interviewed and the reactions of the audience long after the content is published.

This section focused on conceptual discussions around textual analysis, including the benefits and limitations of the methods and some of the historical background on each method. It is employed in this research in a limited way, primarily used to analyse the definitions of nanotechnology as provided by the news organisations, and therefore the engagement here has been limited. However, the discussion outlined that textual analyses are operationalised in a variety of ways and focus on individual words to whole texts. In the case of this project, as the following section discusses, the textual analysis primarily considered the phrases and short paragraphs used to define what nanotechnology means. This was part of the overall strategy of the research, which drew heavily on the quantitative analysis of texts. The ways in which these methods were employed are addressed in detail in the following section of this chapter.

Research approach

Following on from the conceptual review of methodology, this discussion describes how this research was carried out and reflects on the benefits and drawbacks of the decisions made while conducting the investigation. It begins with a discussion of how the news articles have been gathered before outlining how the quantitative and qualitative methods were employed. In the interest of self-reflexivity, this section also discusses the problems that arose in carrying out the study and the extent to which these issues could be mitigated.

This thesis attempted to analyse all stories written in *The Guardian* and *The New York Times* that address nanotechnology in some explicit way. The study included where nanotechnology was the subject of news reporting and when it was the object of news about something else (in other words, when nanotechnology appeared in news that was primarily about another topic). This strategy was adopted to understand how nanotechnology is represented, defined, and framed in the news in both obvious and subtle ways. It also drew on a longitudinal strategy in order to explore how the complex process of framing unfolded over time.

The articles were gathered using a keyword search in the Factiva and LexisNexis databases of news. The keywords for the research were chosen based on the readings outlined in the literature review, especially Anderson and her colleagues (2009b) and Weaver and his colleagues (2009). Specifically, the chosen words were: nano; nanotechnology; nanoscience; nanobot; and nanorobot. This aimed to gather as broad a collection of news stories as possible to meet the aim of this research. The same keywords were used in both databases; however, I had to make some minor changes to the searches to accommodate for the differences in how these databases operate. While searching the Factiva database, I was able to exclude results for "Tata Nano" and "iPod Nano", which helped reduce the number of irrelevant responses as a result of the "nano" keyword. I also tried to use "nano!" in order to capture derivatives of nano, such as nanoscale. However, more results were reached by using "nano" as a keyword in this particular database. The LexisNexis search did not allow for the exclusion of "Tata Nano" and "iPod Nano", so the number for irrelevant responses was much higher in the results. The use of "nano!" appeared more successful than in the case of the Factiva search, which allowed for capturing that discussed "nanoscale engineering", for example, which might otherwise not have been included in the results.

The Factiva database results served as the primary collection of articles. The LexisNexis database results were used to cross reference those found from Factiva and fill in gaps. I reviewed each of the articles to determine their suitability for the research. Both databases had a number of articles in common and in such cases the article was coded only once. Also, irrelevant articles were removed from the collection. A total of 759 articles spanning a period of August 1986 to December 2010 were coded.

Articles were considered irrelevant and removed from the collection for the following reasons:

- Nano was a proper name, for example former Albanian Prime Minister Fatos Nano and iPod Nano,
- Generic references to anything small, for example “nano-dab of makeup”,
- Listings that include “nanotechnology” or “nanoscience”, but where nanotechnology is not discussed as part of the story. For example radio and television programme schedules or university course listings,
- “Nanotechnology” or “nanoscience” is only part of an author credit and not addressed in the article, for example Ed Regis wrote several book reviews and the final line of stories he wrote notes that he is the author of *Nano: The Emerging Science of Nanotechnology*.

In the first two instances, the stories are not about nanotechnology and are therefore not relevant to the study. In the other cases, analysing articles where nanotechnology is only mentioned as part of a listing of radio and television programmes or university courses, as well as in individuals’ titles or describing information about an individual, would provide little useful data for this research. If the latter were included in the study it could obscure the results on framing and defining nanotechnology, so removing them from the content collection was the most appropriate action. For each article that was removed, I gathered information about what news organisation it was taken from, the date of publication, and the reason it was removed [see Appendix A for the full list of Factiva articles that were removed and the reasons for removing each article].

For the online news collection, I primarily consulted the individual websites for *The Guardian* and *The New York Times*. I used the same keyword searches for the online search as the newspaper databases. Using those archives presents a variety of problems, which are unfortunately unavoidable. As with the Factiva and LexisNexis databases, I cannot say definitively that the web archives of the individual newspapers' sites represent all nanotechnology reporting done by these news organisations. Additionally, *The Guardian* online archive is only available through 1999, which is the year the newspaper began publishing online. According to information from the archives office at *The Guardian*, Guardian Unlimited, which was the former name of the newspaper's website, launched in 1999 and the only reporting before then that appeared online was specific to individual topics, including major sporting events. What is available through the online archives of the website is the only public record of the online reporting of *The Guardian* (personal communication).

Alternatively, *The New York Times* online archives includes reporting that goes back before the launch of the newspaper's online edition, which began in 1996 (Greer and Mensing, 2006). Therefore the online content of *The New York* Times now includes articles that once appeared only in the print edition of the newspaper. For example, articles from the late 1980s and early 1990s can be found in the online archive, but where the website was not launched until 1996 it is reasonable to assume that articles that predate the website were available only in the print edition. Despite the limitations of gathering content online, this research found 845 articles from the individual websites.

I gathered the online content by saving each article from the news organisations' web archives using Paparazzi!, a Mac-based software that takes a colour snapshot of the article at the time of download and allowed me to save the full page (see Appendix B for an example page). That said, it provides a static view of the pages and removes all interactive elements, which is a limitation of the research. However, the content of the articles was the primary focus of investigation and although it would have been an added benefit to be able to follow hyperlinks and play video and audio elements after the articles were downloaded, what was gathered provides important data that was analysed in reference to the specific research questions of this project. The online and print articles were compared electronically using a database called Devonthink to remove articles that were at least 95 per cent similar in the print and online reporting. Those remaining after the electronic comparison were reviewed individually to confirm they were relevant to the study and identify where presentation differences between print and online editions made articles appear to be unique to the website when they were not. This will be discussed in more detail in Chapter 5 when the findings of the online news analysis are reviewed.

Moving on to how the content analysis was developed and conducted, I began with qualitative exploratory readings of the newspaper articles to help establish a better understanding of the news content across both publications and the nearly 25 years that was researched. Those early readings of the content together with the literature review supported the design of the coding sheet, which was used to analyse the 759 articles in the newspaper content (see Appendix C for the coding sheet).

The coding sheet captured identifying information for each article, including the headline, news organisation, date of publication, and section or desk that the story came from. Also, the page number, word count and author were documented. This type of information is routinely gathered in content analyses because it helps set up the remainder of the analysis. Other elements of the coding schedule are discussed in detail in the following paragraphs.

As was noted in the conceptual background chapter (Chapter 2), news reporting needs a timely link or news hook/peg, including when covering science and technology. To help understand what events appeared to prompt each article, I included the "news peg" in my coding sheet. The elements used for this section of the coding sheet were drawn from research carried out by Williams and Clifford (2009) and Kitzinger and her colleagues

(2003), which identified the prevalence of "diary" stories for the journalists who cover science and the types of events that tend to prompt stories that relate to science. The news pegs that were coded for are: speech or press conference, press release or announcement, policy or advisory report, journal publication, government proceedings, academic conference, industry proceedings, other, and none.

Also relevant to this research is what makes science newsworthy and when stories are primarily about nanotechnology, what makes nanotechnology newsworthy. Hansen's (1994) news values for science journalism was used to establish the list of news values for the coding sheet, with the addition of an "other" category. His list of news values draws on interviews with British science journalists and, although somewhat similar to news values identified in journalism studies research more widely, is especially useful here as it specifically addresses reporting on science and was gathered from science journalists. The news values in the coding schedule are: human angle or relevance to daily life, weird and wacky, breakthrough, conflict or controversy, proximity, link to politics, link to economics, link to other social context, and other. The news peg and news values section support the identification of the frame as they help identify why nanotechnology was first reported and arguably contributes to the framing of nanotechnology.

Where this research is seeking to understand how nanotechnology is defined and framed in the news, I have chosen to analyse all stories that address nanotechnology in some explicit way. That means stories that mention nanotechnology in only a phrase or short paragraph or a few paragraphs were still included in the content collection. As such, the coding sheet includes a section on the article's topic to account for stories where nanotechnology is only part of the story. In such cases the remaining aspects of the coding sheet that I discuss below only refer to the discussions, descriptions and definitions of nanotechnology specifically. Doing so attempts to ensure that the data collected using this coding schedule meets the needs of this research, which is entirely focused on how nanotechnology is defined and framed.

Following the identification of the story topic, the coding sheet documents where nanotechnology is first referenced: headline, lead, first quarter through fourth quarter. Doing so helps identify whether nanotechnology is becoming more prominent in the news. Each story was divided into quarters based on the number of paragraphs in the article, which means stories with fewer than four paragraphs could not be quartered.

To address the research question on how nanotechnology is defined by these news organisations, the coding schedule captured whether it is referred to as nanotechnology, nanoscience or in some other way and allowed for the full definition to be documented. Reviewing how often it is referred to as nanotechnology versus nanoscience or something else altogether will be an important element of this research and can help tease out to what extent the science of nanotechnology is a feature in the reporting.

Additionally, the definitions of nanotechnology were analysed qualitatively, which is discussed later in this chapter.

Specific to the framing of nanotechnology, the coding sheet draws on previous research on nanotechnology framing, especially Stephens (2005), Anderson and her colleagues (2009b), and Weaver and his colleagues (2009). However, a frame around nature was added as a result of the qualitative readings of the articles undertaken before the content analysis. Nature and biology appeared in a number of articles, including references to learning from nature and nature as a nanotechnologist. As such, it was included in the list of frames to identify the extent to which nanotechnology is framed in such a way. In circumstances where more than one frame could be applied to an article, I identified all possible frames and highlighted a primary frame, if such was evident. In all cases, keywords and phrases used to support the selection of frames were also documented in order to be able to reflect on the choice of frame. Below are descriptions of the frames used in this research. In all cases, these apply to how nanotechnology, as well as debates around these topics, are defined, described and discussed in terms of:

- Discovery/project – scientific discovery and the process of scientific discovery.
- Risk/social implications – risk, ethics and social implications of nanotechnology.
- Business/economy – impacts to business and local/national/international economies.

- Funding/investment – government and business spending on nanotechnology or a need for such.
- Science fiction/popular culture – the language of science fiction or popular culture and discussion of science fiction or popular culture.
- Policy/regulation –regulation or policy around nanotechnology and the language of regulation and policy.
- Visionary/far future – developments/possibilities that are futuristic in nature (both good and bad).
- History – its history or the history of science.
- Celebrities – Celebrities' responses to or discussions about nanotechnology in both positive and negative terms.
- Natural – nature as proof nanotechnology works, nature as a nanotechnologist, and learning from nature.
- Other – where the above categories do not apply.

Again, for each article, I took notes on keywords and phrases that support the selection of a frame or frames for nanotechnology (see Appendix D for an example of a completed coding sheet).

Moving on to how nanotechnology can be used, this section of the coding sheet documented what each article says about nanotechnology's possible uses and were identified through the exploratory readings conducted before undertaking the analysis. The uses include: computers, military and security, medical, manufacturing, none specified, and other. The other category proved useful in circumstances where a specific use was identified, but do not otherwise fit neatly in the other uses described above.

While framing is more nuanced than whether a topic is addressed in positive or negative ways, it remains useful to identify whether articles are primarily positive, negative, or neither in their orientation toward the topic because it can provide context for other areas of the analysis and give a flavour of how nanotechnology, in this case, is treated in the reporting. As such, my coding sheet identifies the tone of the article specific to nanotechnology as positive, balanced or measured, or negative.

Moving on to some of the references included in the reporting, the coding sheet documents where science fiction and other fiction sources are referred to in the reporting. Previous research, as was discussed in the conceptual background and literature review chapters, has indicated that references to science fiction are a regular feature in the reporting of science, including nanotechnology. Nanotechnology also frequently appears in science fiction literature and films, which are regularly reviewed in the news. Initial readings of the reporting for this particular research indicated that science fiction and fiction references are an element of the reporting by these two news organisations. As such, I was interested in documenting the role of science fiction in reporting about nanotechnology, and added this category to help identify the frequency with which these references appear and to what extent it is the technology of science fiction or whether specific references are included. Also references to nature and nanotechnology as natural appeared repeatedly in the exploratory readings of the articles, and I wanted to document the extent to which this is a feature in the reporting.

Other studies of nanotechnology reporting have focused considerable attention on the risks of nanotechnology, although in many cases the timeframe for study was quite limited or the focus on risk was limited to specific risks, for example environmental implications of nanotechnology. Additionally, previous research has not empirically documented what types of risks appear in the news reporting, and in doing so this thesis can contribute such evidence to the conversation about nanotechnology risk claims. Also, as this study is longitudinal in nature, it can help identify whether risk reporting has grown over time, as well as document the types of risk that are reported in different time periods. The categories on the coding sheet were identified from a number of the studies on nanotechnology reporting identified in the literature review, as well as risks that were found in the qualitative readings of the reporting.

Alternatively, documenting the benefits of nanotechnology that are reported can also be an opportunity for insight, but have not received as much attention by researchers. None so far in my review of the literature has documented specific benefit claims as are reported in the news, but it appeared through the exploratory readings of the content that the same benefits were regularly reported. As such, I wanted to document what benefits of nanotechnology are reported and how frequently these benefits are discussed.

Also useful to documenting how nanotechnology is defined and framed is identifying who is said to be involved in nanotechnology research and how they are characterised. Where nanotechnology is an interdisciplinary field, I wanted to document the extent to which scientists, engineers, technicians, nanotechnologists and others are said to be involved in the research. Also, through the exploratory readings of the content I found regular references to nanotechnology researchers as playing or tinkering; visionary or pioneering; and serious or practical, so thought it would be useful to identify where the researchers are characterised to further support the framing of nanotechnology.

After coding each article using the coding schedule, I entered data into PASW, formerly called SPSS, to help analyse it statistically. Where many of the elements identified in the coding sheet are considered "nominal variables" in statistical analysis, the opportunity for complex statistical analysis is limited (Pallant, 2010). Nominal variables are those containing categorical data, such as the identification of newspapers. Numbers were assigned to the two newspapers - *The Guardian* and *Observer* were 1 and *The New York Times* was 2 - in order to identify them in the database. However, the numbers themselves are meaningless. Therefore, averages and more complex statistical calculations are not possible for most of the research. As such, the analysis of data in this research project is descriptive in nature, which is useful for the research questions set out at the beginning of this study. The descriptive nature of the statistics in my project helps tell a story of the reporting of nanotechnology over the 24 years studied.

Once the quantitative analysis was complete, the definitions identified on each of the coding sheets was analysed for trends in the way nanotechnology was explained to the audience. Each coding sheet was scanned to a PDF, which allowed for archiving of all the coding sheets, but also enabled the use of the Nvivo software package that allows for management of qualitative data and assists in qualitative analysis. The definition of nanotechnology, nanoscience or other ways of referring to "nano" was then qualitatively coded for words and phrases that represent larger themes. The codes were then reviewed to identify trends in the themes across the news reporting. Chapter 5 discusses these definitions, which will provide a clearer picture of how the analysis was conducted.

Regarding the organisation of the findings, the newspaper content serves as the primary focus of this investigation in part because the findings of the online news provided little fodder for discussion. As such, the newspaper findings are prioritised in the findings chapters - Chapters 5 and 6. Overall, the chapters are divided around the two central questions in the research - how is nanotechnology defined and how is nanotechnology framed in these two newspapers? Chapter 5 primarily considers how nanotechnology is identified in the reporting (nanotechnology versus nanoscience or other terms), how it is defined, what makes it newsworthy, and what events prompt the reporting. The discussion of online news is addressed in toward the end of Chapter 5 and is primarily focused on the extent to which the reporting was unique to the web and the presentation of the news content in the online edition. Chapter 6 follows with a focus on the framing of nanotechnology and a discussion of the overall tone of the reporting toward nanotechnology, as well as the benefits and risks identified in the reporting. As has been discussed, the tone of articles has been considered "framing" in previous studies of nanotechnology, but I believe this is a very limited way of looking at framing theory. As such, it is a beginning point for understanding the framing of nanotechnology, rather than the framing in itself. Chapter 6 explores this issue in more detail and focuses on the framing of nanotechnology in the news reporting.

In summary, this chapter reviewed framing conceptually, including highlighting some of the challenges of defining and carrying out such a study. It also discussed the approach adopted for this thesis - the list of frames approach - before reviewing the quantitative and qualitative approaches to content analysis. In discussing the two methods chosen for this research, the chapter reviewed the benefits and drawbacks of each, as well as how they can be used together in complementary ways to enhance the research. Finally it reviewed the research approach adopted in the thesis, including gave a detailed account of how the content and textual analyses were carried out. Now, this research turns to the findings and analysis of the news articles. The chapter explores the content of the newspaper articles, including the frequency of reporting on nanotechnology, the news values associated with stories that discuss nanotechnology, and the events that make nanotechnology a timely topic to discuss. It then goes on to revisit the discussion on defining nanotechnology, but focuses on how *The Guardian* and *The New York Times* define it for their audiences.

Chapter 5: Findings & Analysis - The Content Over Time & the Newspaper Definitions of Nanotechnology

Moving on from methodology, this chapter outlines the findings of the analysis of 759 newspaper articles. It starts by describing trends within the reporting to help understand how nanotechnology has been covered by these two news organisations over the 24 years studied. The findings begin with how frequently nanotechnology has been reported, why it is newsworthy, and whether it is the primary topic of a story or is part of a story about something else (a secondary subject). It then leads to a discussion about defining nanotechnology, which is a more diffuse conception of framing. The chapter reviews the definitions each newspaper uses to help identify what is nanotechnology in short paragraphs or phrases. That discussion includes a review of how these newspapers identify nanotechnology - whether it is nanotechnology, nanoscience, or something else - and the explicit descriptions each provides for the chosen terms, which were explored qualitatively. Finally, the chapter examines how the newspapers say nanotechnology can be used, which also contributes to defining nanotechnology for the audience. From there, the thesis turns to Chapter 6, which discusses the framing of nanotechnology in more detail these news articles and some of the factors that contribute to the framing of nanotechnology, such as the reporting of nanotechnology's claimed risks and benefits. Throughout the findings chapters I contextualise the research in terms of literature covered earlier in the thesis.

To begin, reporting on nanotechnology promises a lot – nanobots exploring our bodies to repair damaged cells, computer drives the size of a sugar cube that contain the Library of Congress's entire collection, and an elevator with cables made so strong using nanotechnology that it can travel to space. Nanotechnology allows these things because it stems from the manipulation of matter at such a small scale, therefore providing researchers with the opportunity to do almost anything in our imaginations. Scientists and engineers will be able to solve the problem of climate change, cure people of diseases like cancer, and make our computers smaller and faster while storing more information – all thanks to nanotechnology. These are some examples of the possibilities of nanotechnology as has been reported in *The Guardian* and *The New York Times* since the mid-1980s. To the extent that it is possible to discern, the overarching narrative in the reporting by both organisations is one of possibility and promise. In my reading of the newspaper content, which these findings reflect, the newspapers have focused significantly on the potential for nanotechnology in overwhelmingly positive terms. It considers what nanotechnology will allow in the future, however, the reporting points out that these particular benefits may be quite some time off and in some cases question the possibility that the more fantastical applications will happen at all.

Claims about risks associated with nanotechnology are also reported in these two newspapers, including that critics worry about nanobots that would self-replicate and even evolve so that people are one day outnumbered and overtaken by these nanobots (often referred to as grey goo). Other concerns highlighted include the potential for misuse and turning good technologies against people so that the lifesaving nanotechnology described above instead attacks the body. Finally, nanotechnology is also subject to social and ethical dilemmas, which has been raised in the reporting including moral arguments about exporting nanotechnology to developing countries because it has the potential to make manufacturing of certain products cheaper and more energy efficient. Discussions also include the risks associated with nanotechnology and questions about how these tiny particles might be dangerous to people and the planet. Although this appears in the reporting, as this thesis will discuss in Chapter 6, claims about risks of nanotechnology are far less prominent in the reporting than claims about benefits over the whole study period and are much less salient in the reporting at times. That said, in certain periods, risk claims are very prominent in the coverage, as will be addressed in more detail later.

Before delving into these deeper issues, however, it is important to consider some of the more descriptive aspects of the content studied. As previously noted, this research considered 759 newspaper articles from *The Guardian*, *The Observer*, and *The New York Times*. As the chart below illustrates (see Figure 1), articles that discussed nanotechnology appeared most in *The Guardian* with a total of 367 articles, representing 48 per cent of all of the coverage. When including *The Observer* as the Sunday edition of *The Guardian* that adds 57 articles to *The Guardian* reporting overall, which makes its total proportion of the reporting 56 per cent. *The New York Times* reporting comprised 335 articles, or 44 per cent of the reporting in this study.

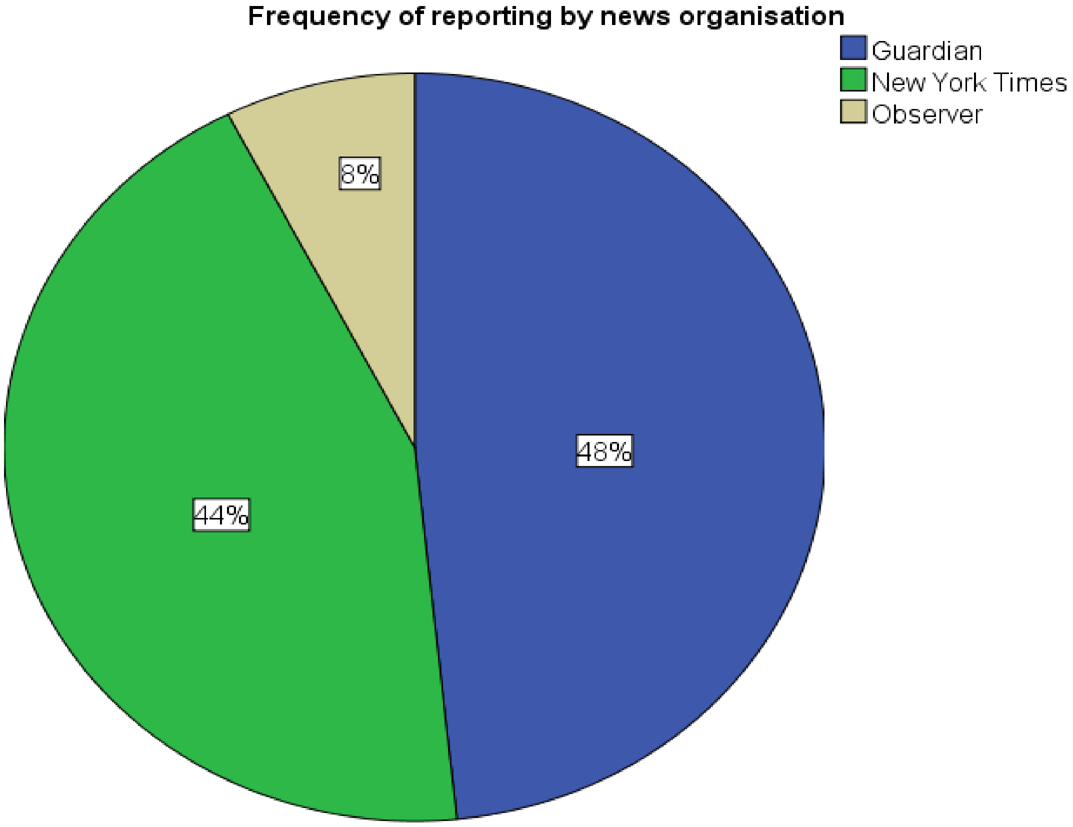

Figure 1: Per cent of news reporting by each news organisation.

The chart above illustrates that *The Guardian* and *The Observer* included nanotechnology in a total of 424 articles or 56 per cent of the reporting. That compares to the 335 articles from *The New York Times,* which represents 44 per cent of the reporting in this study.

Moving on to how the reporting was spread across the study period (see Figure 2 below), the first explicit references to nanotechnology came in 1986, based on the keyword searches conducted in the Factiva and LexisNexis databases of news articles. This is also supported by earlier studies, including Stephens (2005). In those early days, reporting was scarce with fewer than five stories reported each year from 1986 through 1994. Long lapses between stories were a common occurrence in the reporting. In 1987 and 1989, for example, no stories mentioning nanotechnology, nanoscience or other iterations of nano appeared in the reporting based on the searches in the databases. In 1995 to 1999, the reporting fluctuates between 11 and 20 stories each year before rising to a peak in 2003 with a total of 96 stories. Coincidentally, the same number of articles was reported in 2004, after which the reporting appears to decline through 2010. There was a slight increase in reporting in 2008 to 59 stories, but it has since declined again to only 36 in 2010.

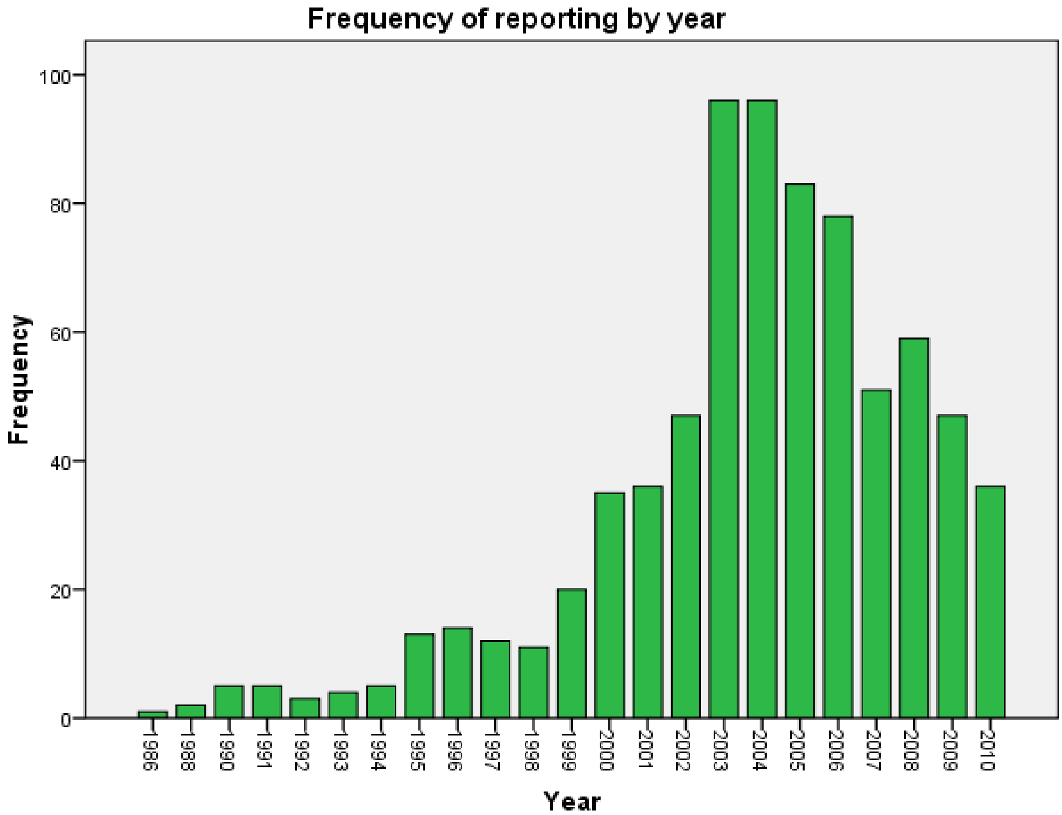

Figure 2: Reporting by year

The chart above illustrates the limited reporting in the early days of nanotechnology coverage and the rise before a peak in 2003 and 2004. The number of news articles then decline through 2010, with the exception of a minor increase in reporting in 2008.

Although some scholars expected nanotechnology reporting to rise, this study, as does the most recently published study (Dudo et al., 2011), indicates an overall decline in the reporting. Despite the recent decline, the levels of reporting more recently remains higher than the initial reporting of nanotechnology and the reporting continues to be covered at levels equal to or higher than the period leading up to the peak. If the frequency of reporting continues to decline that could indicate that nanotechnology is losing its salience as a newsworthy topic. However, at this stage and given the volume of reporting documented in this study, it could indicate that the reporting is instead stabilising, which may mean that nanotechnology has become an accepted science in terms of its value as a news story. Additionally, as Dudo and his colleagues observed, there have been few events involving nanotechnology that would have made it newsworthy. The earlier period of the reporting included events in both the US and UK, which contribute to the newsworthiness of the topic. These events include the 1997 awarding of a Nobel Prize for the discovery of buckyballs (a carbon molecule that resembles a football), the publication of Michael Crichton's book *Prey* in 2002, the announcement of the National Nanotechnology Initiative in 2000 and its launch in fiscal year 2001, and the release of the report by the Royal Society and Royal Academy of Engineering regarding nanotechnology implications in 2004.

The New York Times was first to report on nanotechnology with a book review of K. Eric Drexler's *Engines of Creation* on 10 August 1986. The article introduces a number of the facets of nanotechnology reporting that will be discussed in these findings, including the promises to fix any and all problems of the modern day and that nanotechnology is a natural entity more so than something conducted by researchers in a lab. It discusses the potential for nanotechnology to fight infection and lengthen our lives, as well as ensure limitless food supplies for the world because we would be able to build nanomachines to do everything. The article includes some scepticism, however. It points out that previous scientific discoveries have promised great things, but disappointed. Despite that disappointment, Drexler is quoted as saying nanotechnology is the “greatest technological breakthrough” yet to come. Additionally, the story states that “serious” scientists are considering nanotechnology’s possibilities. The story cites life itself as evidence of nanotechnology and why those serious scientists now consider it important to research. “Enzymes, after all, are merely nanomachines controlled by simple nanocomputers called genes,” the story states. Some of these ideas will be revisited in more detail later in this and the following findings chapter as it relates to framing nanotechnology.

The New York Times may have been first to report on nanotechnology, but over the years *The Guardian* consistently covered nanotechnology more frequently with a few exceptions (see Figure 3 below). In 2000 and 2002, *The New York Times* had slightly higher numbers of articles which mention nanotechnology. In 2000, *The New York Times* reported 21 articles that discussed nanotechnology to *The Guardian*'s 14. In 2002, *The New York Times* reported 26 articles to *The Guardian*'s 21. The rise in 2000 could be attributed to President Clinton’s announcement of the National

Nanotechnology Initiative, which, as the introduction discussed, aimed to coordinate government funding of research initiatives around nanotechnology. The initiative was mentioned frequently in the reporting that year and the years that followed. As the section on the newsworthiness of nanotechnology will discuss later in this chapter, the announcement of the initiative and various rounds of funding provides a timely link for journalists, which contributes to the newsworthiness of the subject. Additionally, it connects with news values for science in that it links science with politics and the actions of government, which is also an important element of what makes it news worthy in journalistic terms.

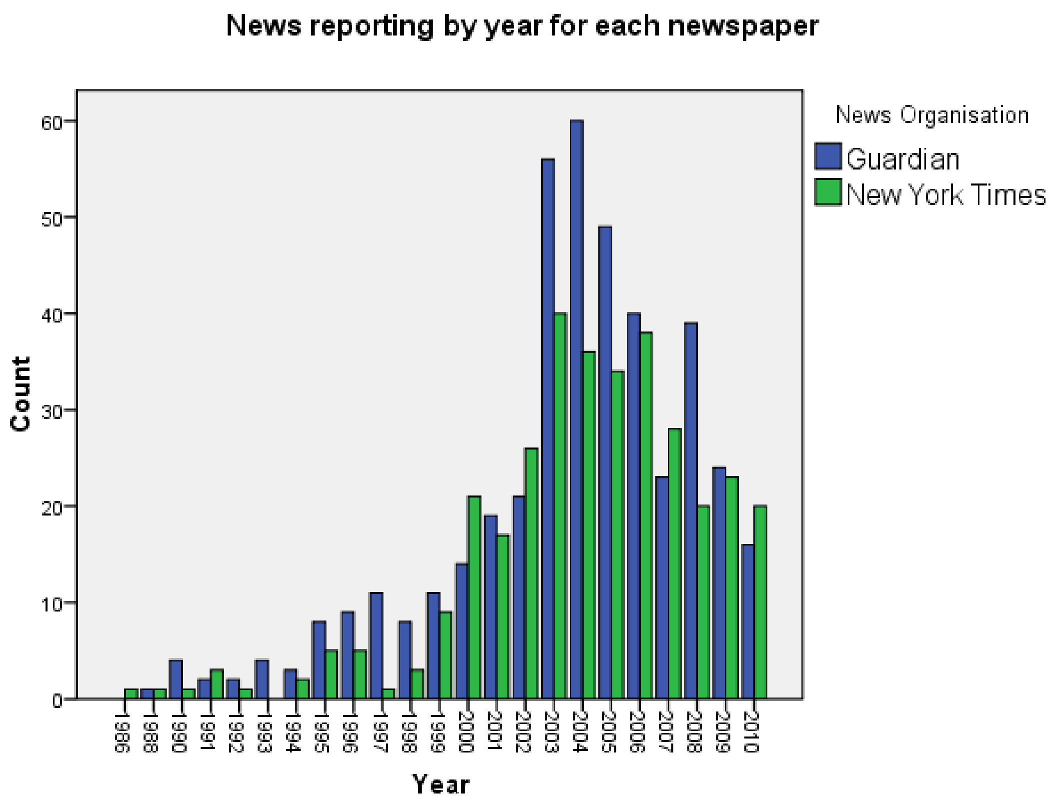

Figure 3: News reporting by year for each newspaper.

The chart above illustrates the sporadic reporting by both newspapers in the early part of the study period and highlights the significant increase in reporting by *The Guardian*, in particular, in 2003 and 2004.

Looking at *The Guardian*, nanotechnology appears to have first been mentioned in 1988 with a story about government funding for research in areas such as genetic engineering and information technologies. In that case, nanotechnology was only discussed briefly as one of the areas to receive funding from the government. The story was largely about the problem of government bureaucracy and its preventing the creation of "new wealth and new jobs." Nanotechnology was not discussed in any great detail except to say that it dealt with "microscopic accuracy in machining work." The issue of government funding of nanotechnology returns later in the reporting, but with a special emphasis on how Britain is falling behind other countries in nanotechnology research.

Like *The New York Times*, *The Guardian* wrote an article reviewing Drexler's *Engines of Creation* in 1990 when it was released in the UK and again in 1996 when it went to paperback. *The Guardian* review was less enthusiastic than *The New York Times* article a few years earlier. *The Guardian* story pointed out some of the problems of proposed medical applications of nanotechnology, including the moral and ethical implications of fixing people and extending our lives is a concern given an already overcrowded planet.

The Guardian saw a dramatic increase in reporting in 2003 with a near doubling of the reporting from the 26 articles published in 2002 to 40 articles in 2003. The rise could be attributed, in part, to Prince Charles making a statement to the Royal Society asking for research into the potential dangers of nanotechnology. His speech to this famous institution of scientists was cited in a number of stories that year and the following year when the Royal Society and Royal Academy of Engineering issued its report. The initial reporting of his comments took him more seriously than later comments, which were often treated with humour and derision (Anderson et al., 2005). In some cases, his comments around nanotechnology were linked to other statements he made regarding alternative medicine for cancer treatment, including coffee enemas. His statements about both nanotechnology and cancer treatment were referred to in stories reported years after the statements were made, including in stories with little to nothing to do with the Prince's views on science. Amongst those is a story in 2005 regarding the announcement that Prince Charles and Camilla, now Duchess of Cornwall, would be married. Also, the study the Royal Society and Royal Academy of Engineering that followed the Prince's original statements was a regular feature in the news reporting.

Meanwhile, nanotechnology was more likely to appear in a story about something else than to appear as the primary subject of the story (see Figure 4 below). In nearly every year studied, nanotechnology was a secondary subject within the news (in other words, part of a story primarily about something else) more often than it was the topic of a story. Examples of where nanotechnology was reported in other stories, include when nanotechnology was discussed in an article about the economy in a region of New York State (*New York Times*, 19 Oct. 2003) and the impact of the restructuring university departments in some prominent UK higher education institutions (*Guardian*, 4 Dec. 2004). It was useful to document when nanotechnology was the primary subject of a story and also when it was mentioned as part of a story because it helps highlight some of the nuances of the reporting, particularly its influence on the framing of nanotechnology.

Early on in the reporting, nanotechnology rarely appeared as the primary subject of a story. For example, in 1986, 1991, 1992, and 1994, only one article was published each year in either newspaper where nanotechnology was the subject of the story. However, overall, as was discussed previously, nanotechnology received limited attention in the very early days of reporting. In 2003, the number of stories primarily about nanotechnology peaked with 39 stories. That represents approximately a third of the overall stories that mention nanotechnology that year. The following year saw slightly fewer stories about nanotechnology with 34 articles, but a sharp decline followed from there with the exception of 2008 when there was a rise to 18 articles (in 2007 and 2009 only 14 articles appeared in the newspapers where nanotechnology was the subject of the story). However, in 2010 nanotechnology was the primary topic of the story in only 4 of the 32 articles reported that year. That is similar to the early 1990s reporting where few articles were centred on nanotechnology. Overall, nanotechnology tends to be reported at higher levels when it is included in stories about something else, than it is to be the primary subject of articles on its own. Therefore ignoring articles where nanotechnology is only part of the story would mean ignoring most of the reporting on nanotechnology.

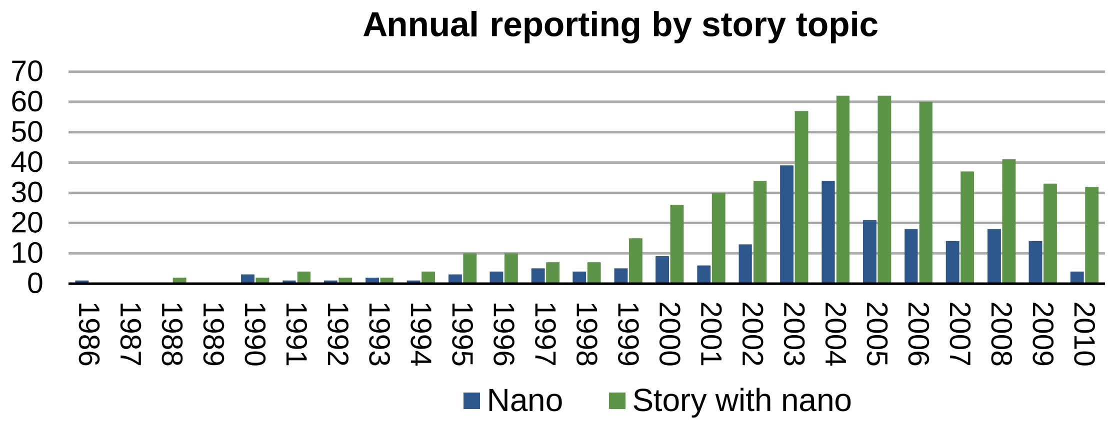

Figure 4: Annual news reporting by story topic.

The chart above shows the extent to which nanotechnology is newsworthy in its own terms and how much it is part of larger issues. Overall, nanotechnology is most often part of news about something else. That said, in 2003 and 2004, the reporting of stories primarily about nanotechnology increased, but declined after that to a low of four stories in 2010.

Individually, the newspapers broadly followed similar patterns with low levels of reporting in the 1980s and 1990s and an increase in the early part of the 2000s until a decline after 2004. Looking more closely at the reporting of stories where nanotechnology is the primary subject in each newspaper offers a slightly different picture. *The Guardian*'s reporting dramatically increased between 2002 and 2003 (see Figure 5 below). In 2002, the newspaper published three stories that were primarily about nanotechnology. The following year it reported 22 nanotechnology stories. As noted above, that increase can be attributed, at least in part, to Prince Charles's statements about nanotechnology and the reporting that followed. Reporting on nanotechnology continued to be high in 2004 with 21 stories where nanotechnology was the subject of the news. Amongst the stories about nanotechnology that year was the report from the Royal Society and Royal Academy of Engineering, which stated that nanotechnology has tremendous potential but the risks and implications of it need more exploration (Royal

Society and Royal Academy of Engineering, 2004). After that, nanotechnology reporting declines, as with the trend for reporting overall. The number of nanotechnology stories fell each year, except the period between 2006 and 2009 where the reporting fluctuated. From 2005 to 2010 the number of stories reporting about nanotechnology ranged from a high of 14 in 2008 to only one in 2010. As noted previously, few significant events have happened to thrust nanotechnology into the news in the most recent period, which can explain the decline in reporting since initial concerns about nanotechnology were raised by individuals and organisations in the early part of the 2000s.

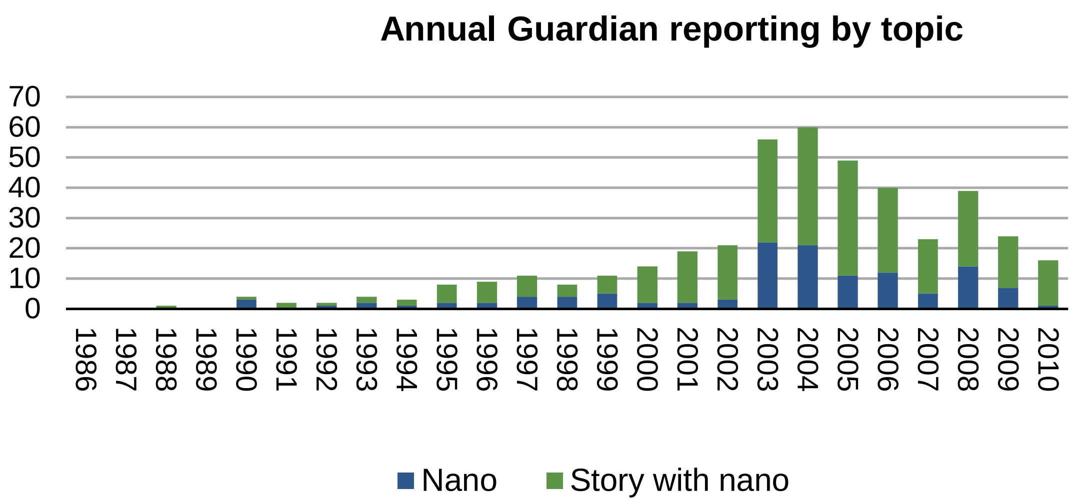

Figure 5: *Guardian* reporting by topic each year

The bar graph above illustrates *The Guardian's* reporting on nanotechnology as a newsworthy topic on its own against reporting that included nanotechnology in some way. It shows the scant reporting in the early days on nanotechnology as its own story, as well as the dramatic increase in reporting between 2002 and 2003. Following that peak in reporting, nanotechnology stories dropped the following years with the exception of 2008. After a slight increase that year, the reporting dropped again until 2010 with only one story primarily about nanotechnology.

The New York Times reporting illustrated similar patterns, especially in the early years (see Figure 6 below). Like *The Guardian*, *The New York Times* reporting on nanotechnology was limited in the early days and some years there were no stories (1988, 1987, 1989, 1992, 1994, 1998, and 1999) where nanotechnology was the subject. Overall, the reporting in that period that focused on nanotechnology ranged from no stories (as noted above) to one story in 1986, 1991, 1995, and 1997 to two in 1996. The rise in reporting appeared a bit earlier for *The New York Times*, which happened from 2000. As noted previously, that year the Clinton Administration announced a new initiative to support this emerging field and aimed at coordinating government funding of various nanotechnology research projects. In total, 7 stories about nanotechnology were published that year. In the years that followed, the reporting primarily about nanotechnology fluctuated with 4 and 10 articles in 2001 and 2002, respectively.

The frequency of reporting on nanotechnology rose again in 2003 to 13 stories. In addition to Prince Charles's warnings, which were covered in by the *Times* (*New York Times*, 19 May 2003), other warnings were reported in the news. Amongst them was a report from the Canadian watchdog ETC Group that cautioned on the risks of allowing businesses to use nanotechnology in consumer products without adequate testing and regulation in the area (*New York Times*, 3 Feb. 2003). Other stories that year included the development of a nanotechnology office within government (*New York Times*, 20 Nov. 2003) and research into the military applications for nanotechnology (*New York Times*, 8 April 2003). From then the reporting of nanotechnology as its own story began to decline with 13, 10, and 6 articles in 2004, 2005 and 2006, respectively. The frequency of articles fluctuated from 2007 to 2010 with 9 articles in 2007, 4 in 2008, 7 in 2009 and 3 in 2010. Overall, as the chart below illustrates, there was minimal reporting where nanotechnology was the primary subject of news in the early days and a rise in the early 2000s until it began to drop again more recently. The reporting about other topics, but that includes some discussion of nanotechnology (in other words when nanotechnology was a secondary subject of news) tended to follow a similar pattern but with many more stories than when nanotechnology was the subject.

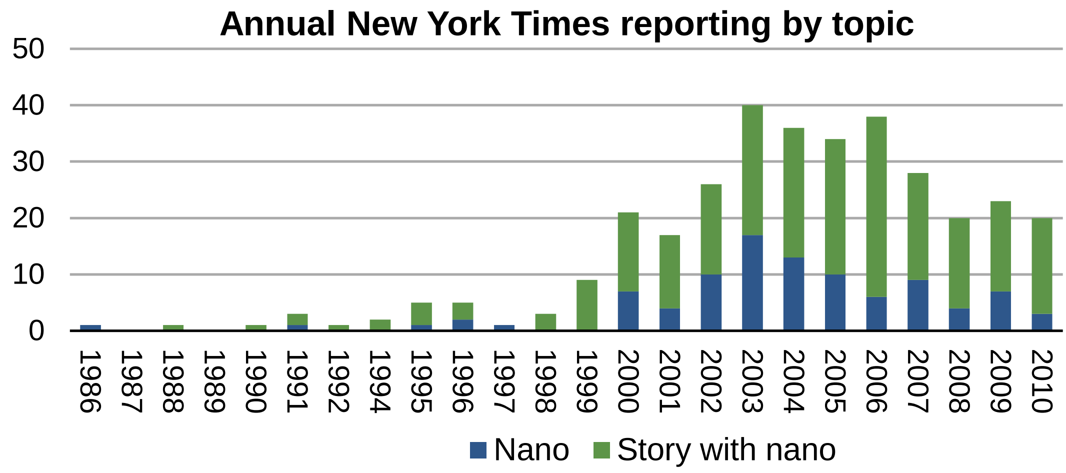

Figure 6: New York Times reporting by topic each year

The graph above illustrates how *The New York Times* covered nanotechnology as a story on its own and as part of other stories. In the early years, the reporting was sporadic, including some years where nanotechnology did not make the news as the focus of a story. In 2000, it gained some purchase, although numbers decreased in 2001 and gradually rose again for a few years before declining overall.

Nanotechnology stories and stories that include nanotechnology primarily appeared in the news, science and technology, and business and finance sections (see Figure 7 below). However, contrary to expectations, it also appeared in the food, travel, style and culture, automotive, and society sections; however, the numbers of articles in those sections were relatively low. Before discussing some of the details regarding where these stories appeared, it should be noted that in the case of approximately 14 per cent of the content studied (106 articles) the databases used to gather the sample did not indicate where in the newspaper these stories were published. So, the figures offered here are based on the majority of articles which did provide such information.

With that in mind, 4 per cent of the reporting, or 26 articles, appeared on the front page and another 17.2 per cent, or 112 stories, appeared in the news pages. Taken together, that means approximately 21.2 per cent of the articles were news stories rather than part of specialty pages. By reporting nanotechnology in these sections suggests that audiences that might otherwise not read about nanotechnology are being exposed to the topic, as Nisbet and Scheufele (2009) suggested about science reporting more generally.

The second most common sections for these articles to appear were the science and technology sections, which represent about 18.8 per cent of the reporting or 123 articles in the study. Stories where nanotechnology is the subject of news and stories that included nanotechnology also appeared prominently in the business and finance sections of the newspapers, which included 17.9 per cent of the reporting on this topic or 117 articles. This helps illustrate the economic links of science and this field of science in particular. A total of 61 articles, or 9 per cent of the reporting, appeared in the opinion and comment sections of the papers, which includes 11 letters to the editor. Reviews of books, theatre events, and films also comprised a significant portion of the reporting also with a total of 61 articles, or 9 per cent. That includes reviews of science fiction books that mention nanotechnology, including the often cited Michael Crichton novel *Prey*. Also, the education pages of the newspapers included stories that mention nanotechnology for a total of 37 articles or nearly 6 per cent of the reporting.

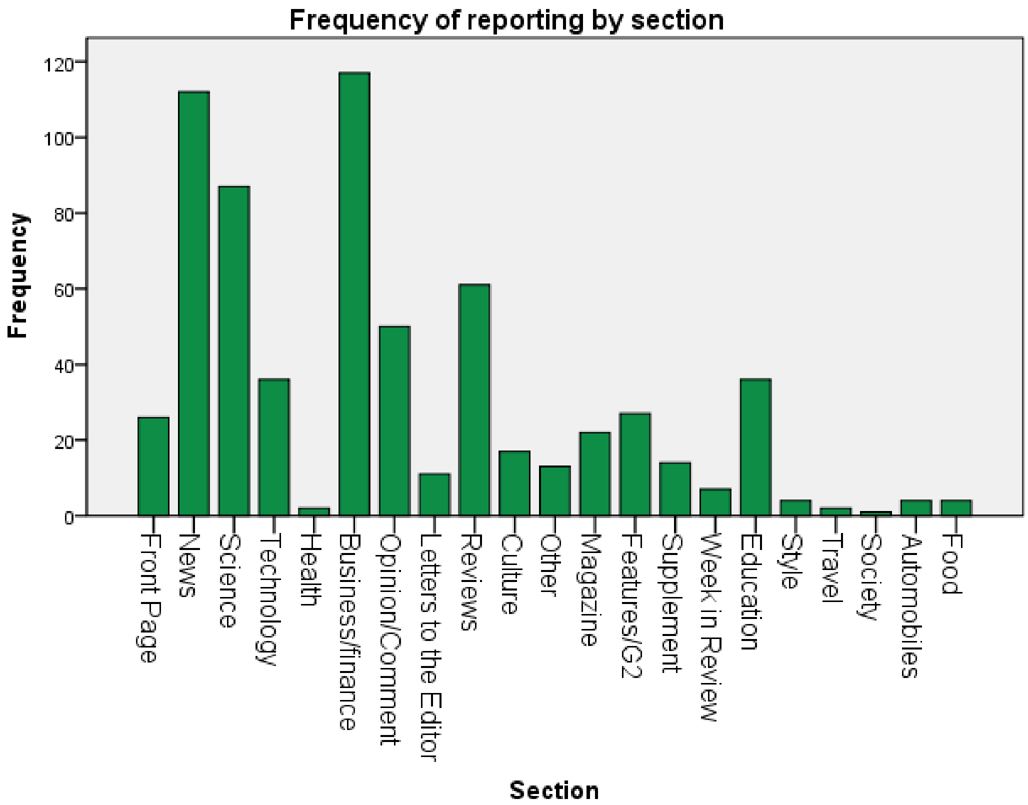

Figure 7: Frequency of reporting by section

The chart above illustrates the frequency of reporting on nanotechnology within each section. For 106 of the 759 articles in the content collection, the databases did not provide a section that the reporting appeared in. However, where sections were reported, the front page and news sections, taken together, were the most common place to find stories about nanotechnology or that mention nanotechnology. The science and technology sections were second most common, and the business and finance sections were the third most common place to find the reporting.

The most prominent place for an article to appear is obviously the front page. A total of 26 stories appeared on the front page of the two newspapers.

These stories were primarily stories that mentioned nanotechnology rather than being focused on nanotechnology. They included a feature on the office of the future as envisioned by researchers at Xerox Corporation's Palo Alto (California) Research Centre (*New York Times*, 6 Nov. 1991) and a decision by Tessa Jowell, the culture secretary at the time, to "snub" Prince Charles by refusing to list London's Smithfield Market (*Observer*, 18 July 2004). The latter story mentioned Prince Charles's "dire warnings about nanotechnology and the recommendation of coffee enemas and carrot juice as alternative cancer treatments." Additionally, at least 61 stories about or that mention nanotechnology were also on the front of sections in *The New York Times* and *Guardian*, which is also a prominent placement for stories. It should be noted that most of those were *New York Times* stories, as *The Guardian* structures its newspaper with fewer sections than *The New York Times*.

When considering stories that focused on nanotechnology, the results are somewhat different. Stories primarily about nanotechnology were very likely to appear in the science and technology sections for a total of 32.2 per cent of the reporting in the study or 59 articles. The business and finance sections of these newspapers included 24.6 per cent of the reporting, or 45 articles that focused on nanotechnology. When it comes to the news section and front page combined, it is similar to the proportion of the entire study at a rate of 21.3 per cent of nanotechnology reporting, or 39 articles, appearing in the news sections. However, when it comes to the front page on its own, only three of those articles about nanotechnology appeared on the most prominent page of either newspaper. These included: a *Guardian* story about the development of nanotechnology as a new field with a particular emphasis on molecular machinery (*Guardian*, 22 Feb. 2001), a development by IBM in computer technology that uses carbon nanotubes to develop smaller, more powerful microchips (*New York Times*, 27 April 2001), and a similar story in 2010 about a development by Rice University and Hewlett Packard to shrink computer memory, which has been limited when using silicon in more traditional ways (*New York Times*, 31 Aug. 2010). What is interesting is that in the case of these stories, nanotechnology was alluded to in the early parts of the story, but not explicitly mentioned for several paragraphs. Instead, early on the stories referred to work at the molecular scale or more precise machining because of new developments in technology. This also appears to contradict findings of an earlier study, which suggested that stories on the front page of newspapers tended to focus on the risks of nanotechnology (Stephens, 2005). That was not the case of the three articles cited here.

When it came to letters to the editor although there were only 11 in the whole study, most of them were primarily about nanotechnology. It should be noted that if multiple letters were included in the article, only those that address nanotechnology were coded. The letters focused on nanotechnology were all published in *The Guardian*, and were authored by people from around the world. All responded to articles that had been published in the paper a short time before the letter appeared. Amongst them were two letters published in 1998 in response to a story about NASA's research to arrange individual atoms of carbon to create diamond substances for a variety of purposes, one from an academic pointing out that similar work was done creating diamond substances at the slightly larger scale (micro-scale) and another letter pointing out a challenge of nano-scale engineering (*Guardian*, 12 Feb. 1998). In 1999, a letter from someone in Bangkok, Thailand responded to a G2 article on nanotechnology where the letter writer argued the potential for nanotechnology was in making the human impact on the environment smaller (*Guardian*, 4 Nov. 1999).

In 2004, three letters appeared at different times responding to various articles in the newspaper. One came from a doctor in the US responding to one of many stories published about Prince Charles's statements regarding nanotechnology. The letter writer called the statements "at best uninformed" and at worst "dangerous" for a technology the author considers to carry tremendous benefits (*Guardian*, 17 July 2004). Later that year, a researcher at Oxford University responded to an article in *The Guardian* that outlined the potential risks of nanotechnology where the letter writer believed the newspaper "put a negative spin" on nanotechnology and was sensational in its reporting (*Guardian*, 5 Aug. 2004). Also in 2004, Prof. Ann Dowling, then chair of a working group on nanotechnologies by the Royal Society and the Royal Academy of Engineering, clarified the report the working group issued that was covered in a *Guardian* article the day before (*Guardian*, 20 Aug. 2004). She points out that report called for additional discussion and debate around nanotechnology before decisions are made regarding regulation and before polarised positions become apparent.

In 2006, the newspaper published a one-sentence blog entry as a letter to the editor. In it, the author raises concerns about privacy and security of private information in discussing a government initiative to use nanotechnology to embed fingerprints in passports (*Guardian*, 23 Nov. 2006). The most recent letter came in 2009 and was written by Emma Hockridge of the Soil Association, who challenged an article for its lack of information on the health risks of nanotechnology, citing a study in China of manufacturing workers who were hospitalised and two who died where nanoparticles were found in their lungs (*Guardian*, 1 Sept. 2009).

Overall, the research found that the published letters identified through the database search all responded to the reporting of *The Guardian* of which several criticised the reporting itself, rather than nanotechnology. When letters discussed issues related to nanotechnology itself, rather than the reporting of it, the few letters identified through the search raised concerns about ethical, legal, and social implications of nanotechnology (specifically, potential invasions of privacy) and an opportunity for reduced environmental impact if certain benefit claims regarding nanotechnology materialise. It was surprising that the database search for nanotechnology reporting in *The New York Times* did not reveal any letters to the editor that mention nanotechnology.

Stories ranged in length from very short pieces of fewer than 100 words, which include a short story that announced the decision of a UK panel of citizens charged with sharing their thoughts and concerns regarding nanotechnology (*Guardian*, 22 Sep. 2005) and a brief announcing the US National Science Foundation's decision to open three nanotechnology research centres in New York (*New York Times*, 26 Sep. 2001). The longest article was a *New York Times* magazine piece of more than 8000 words that focused on the development of China and technology in China that briefly discussed funding for nanotechnology research. *Guardian* stories tended to be shorter with an average article length of 883 words. *The New York Times* average word count was 1254 words.

Overall, the section above outlines the contours of the research and helps set the scene for the remainder of the findings in this and the following chapters. In particular, it points out that nanotechnology reporting has risen over the years, but more recently appears to be declining in its salience perhaps because of a lack of newsworthy events about nanotechnology. It also draws attention to the volume of reporting on nanotechnology that has otherwise been ignored by previous research – stories where nanotechnology is part of news articles about something else (or the object, rather than the subject of news). The reporting of nanotechnology as the primary subject of news appears most often in the science and technology sections of the newspapers, as the evidence above illustrates. However, when taken with articles that mention nanotechnology, the reporting spreads across the publication and therefore potentially introduces this topic to other audiences that might not read the science and technology sections of newspapers. The findings above are more descriptive in nature and provide a foundation for the remaining findings identified through this thesis. How often nanotechnology appears in the publications and in what sections, which is what has been described thus far, links to findings on the newsworthiness of nanotechnology, specifically that of news hooks/pegs and news values. These issues will be addressed in the following section and support the broader discussion around how nanotechnology is framed in the news. It does so because what makes nanotechnology news in journalistic terms helps establish a context for nanotechnology and begins to set the parameters of what is relevant for individual articles.

Newsworthiness of nanotechnology

As the conceptual background chapter discussed (Chapter 2), events, press releases and journal articles about new research help provide a timely link for journalists to publish individual stories. This is sometimes referred to as a "news peg" or “news hook” because it helps identify what makes the news relevant now (Kitzinger et al., 2003). Looking at the reporting of nanotechnology, this thesis finds that in most cases, an article was prompted by such a news hook, which can be described as an event of sorts. This indicates that when it comes to stories about nanotechnology or stories that refer to nanotechnology there is an event-driven element to the news. The coding schedule developed the list of news pegs/hooks from Williams and Clifford (2009) and Kitzinger and her colleagues (2003), which was outlined in the methodology chapter. In order to be counted as a news hook, it had to be explicitly referred to in the article. Otherwise, it was identified as not having a clear news peg to avoid assumptions about whether and what hooks/pegs may have prompted individual stories.

There was no clear news peg in nearly 35 per cent of cases or 262 articles, leaving approximately 66 per cent of the reporting, or 497 articles, where an event of some kind was linked to the story (see Figure 8 below). A press release or announcement was the most often cited news peg with nearly 19 per cent of the reporting, or 94 articles, making reference to an announcement of some kind. The next most commonly cited event was the release of a new book, which includes fiction and non-fiction books that were reviewed or discussed in 16.5 per cent of the reporting, or 82 articles. Following that, the appearance of an article in a journal or other publication prompted 17.3 per cent of the reporting, or 86 stories. That includes the publication of new findings of a study, for example. In addition to the indication that news of this subject is event drive, the frequency with which press releases/announcements and journal publications are cited in articles as the news hook suggests that the public relations tactics and desk-driven nature of science news is also salient in the reporting of nanotechnology (Trench, 2009, Williams and Clifford, 2009, Bauer and Gregory, 2007, Bucchi and Mazzolini, 2007).

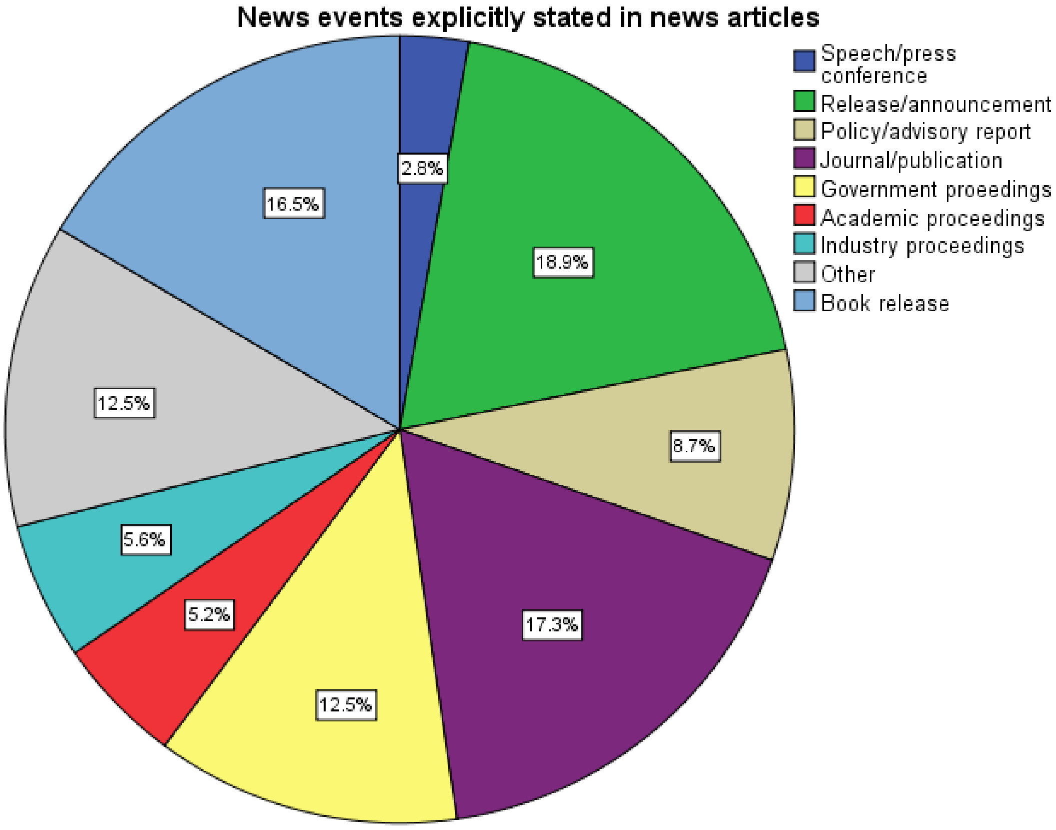

Figure 8: News events explicitly stated in news articles

The chart above illustrates the news pegs that appear to have prompted the articles in the study. A press release or announcement was the top event cited in stories in 18.9 per cent of cases; second to that was publication of an article in a journal or other magazine in 17.3 per cent of cases; and thirdly a new book release at 16.5 per cent of cases.

With articles primarily about nanotechnology, journal and other publications are amongst the most often cited news peg/hook with 31 per cent of the reporting, or 45 articles (see Figure 9 below). In this case, the stories tended to link to results from studies published in journals or trade publications or magazines for their newness. This links to news values, which are discussed a little later in this chapter. The second most commonly cited news peg for nanotechnology stories was a release or announcement, which was cited in nearly 21 per cent of the reporting, or 30 articles. Policy or advisory reports were referenced in 12.5 per cent of the reporting, or 18 articles, about nanotechnology. Policy or advisory reports include reports from nongovernment organisations like Which? and ETC Group, both of which cautioned against the potential risks of nanotechnology. Book releases were cited much less frequently than in the reporting overall at a rate of 4.2 per cent of the reporting, or 6 articles. That means most of the articles about book releases mentioned nanotechnology rather than being primarily about nanotechnology. As with the complete collection of articles, stories primarily about nanotechnology are most often reported due to journal publications and press/releases announcements, with most stemming from journal publications. This reflects broader trends in science reporting and news in general (Trench, 2009, Williams and Clifford, 2009, Bauer and Gregory, 2007, Bucchi and Mazzolini, 2007), which was discussed in more detail above.

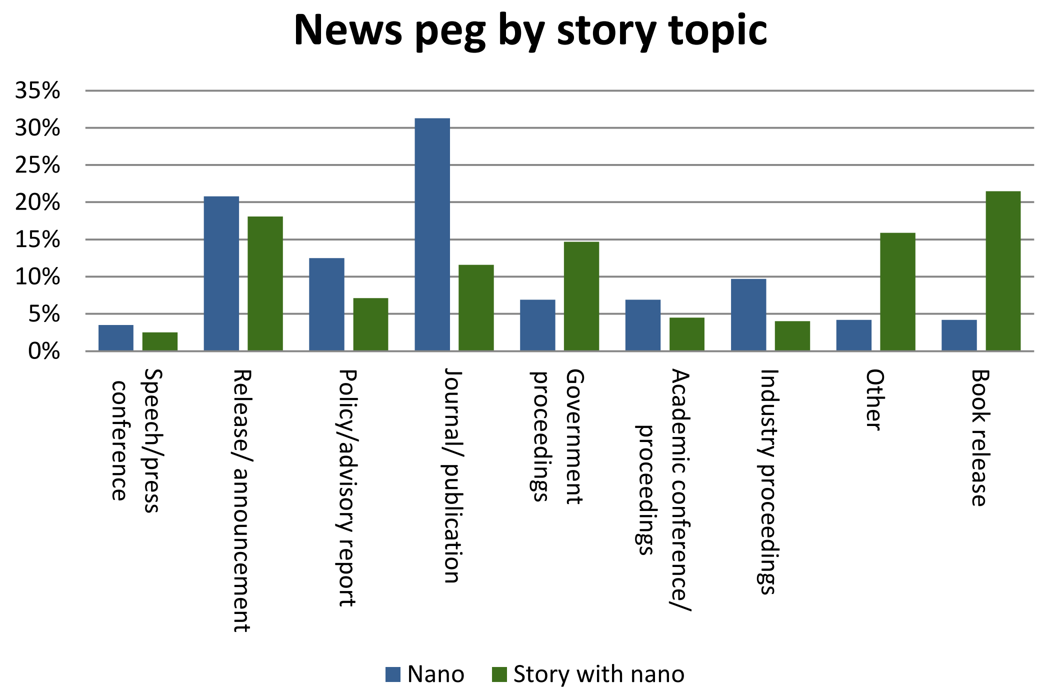

Figure 9: News peg by story topic

The bar chart above illustrates how often the chosen news pegs are cited in stories about nanotechnology and stories that include nanotechnology. It shows that for stories about nanotechnology, publications including journal articles are the primary news peg. Press releases and other announcements were also frequently cited in stories that focused on nanotechnology.

Looking at the news pegs/hooks that prompted nanotechnology stories in each newspaper, the two have similar patterns of news pegs appearing in stories with a few exceptions. As with the most often cited news pegs for nanotechnology stories discussed above, the same is true when considering the individual publications, which again links to the prevalence of PR tactics and the desk driven nature of science reporting as previous studies in science journalism and news more widely has indicated (Trench, 2009, Williams and Clifford, 2009, Bauer and Gregory, 2007, Bucchi and Mazzolini, 2007).

Both publications had similar proportions of articles that attribute the story to an article that had been recently published in a journal or other publications - 29.9 per cent of *The Guardian* nanotechnology reporting, or 23 articles, and 32.8 per cent of *The New York Times* reporting, or 22 articles (see Figure 10 below). They exhibit slight differences when it comes to press releases or announcements with 16.9 per cent of *The Guardian* reporting, or 13 articles, and 25.4 per cent of *The New York Times* reporting, or 17 articles, making reference to a statement of some kind. Policy and advisory reports were cited at similar proportions for both publications - 13 per cent (10 articles) of the *Guardian* nanotechnology reporting and 11.9 per cent (8 articles) of *The New York Times*. The newspapers' reporting differed when it came to citing academic and government proceedings. *The New York Times* cited government proceedings more often as the hook that prompted articles with a total of 11.9 per cent of the reporting, or 8 articles. These included votes in Congress, committee meetings of government bodies or agencies, and other similar events. *The Guardian* reporting cited government proceedings in only 2 articles, or 2.6 per cent of its reporting. Alternatively, *The Guardian* was more likely than *The New York Times* to cite an academic conference or other such event as instigating a story. In total, *The Guardian* cited academic conferences in 9 articles, or 11.7 per cent of the reporting. *The New York Times,* on the other hand, cited academic conferences in only one article or 1.5 per cent of the new hooks cited in articles. These differences also link to the news values and frames that are discussed later in this chapter and the following chapter respectively.

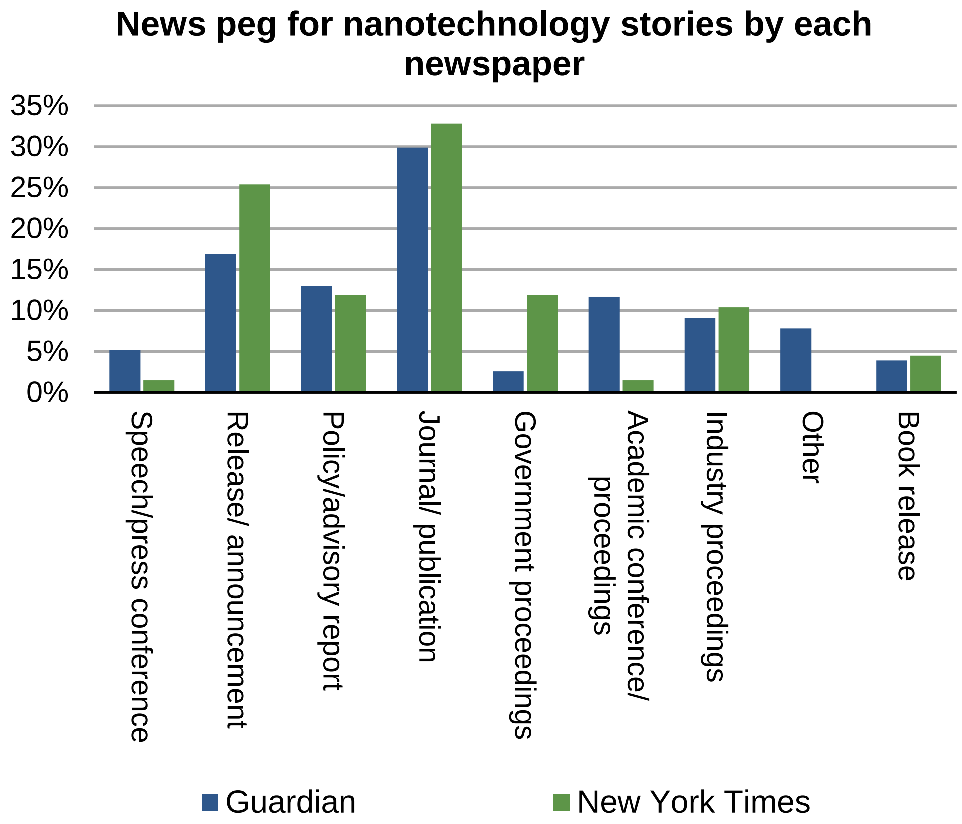

Figure 10: News pegs cited in nanotechnology stories by each newspaper

The bar chart above illustrates that both newspapers cited the same three news pegs most often for articles about nanotechnology. Where they differed was with regard to government and academic proceedings.

Moving on to news values, the conceptual background chapter discussed how in order to be newsworthy science and technology often requires an element of newness, controversy, and/or human interest (Lewenstein, 2005a, Allan, 2008, Weigold, 2001, Priest, 2001). This study drew on Hansen’s (1994) news values in order to evaluate what makes nanotechnology newsworthy - both when it comes to stories about nanotechnology and stories that mention nanotechnology. In other words, what makes the science in these stories something that journalists would want to cover? For the most part, Hansen’s news values worked well in this study, but the social contexts that he described were primarily focused on politics and economics. Through the qualitative readings of the news articles done before the quantitative analysis, it appeared that other social contexts may be relevant, including education. As such, I added a value for "link to other social context" to account for such circumstances when education was discussed without a political overtone. In the "other" category, which was added to accommodate news values that did not readily fit in Hansen's list, book, film, and game reviews were identified as a news value of "entertainment", which if categorised elsewhere may have unduly influenced results regarding the news values of science.

In the interest of self-reflexivity, determining what made a story newsworthy arguably requires some judgement on the part of the researcher, especially where more than one news value could apply to a given story. As the methodology chapter discussed, I set out clear definitions of each news value based on the work of Hansen and referred to these definitions frequently while coding. Additionally, I regularly returned to articles coded earlier to ensure that my coding of articles was consistent after becoming more adept at applying the coding schedule.

Overall, the most prominent news values coded were breakthroughs, link to politics and link to economics for all stories in the study (see Figure 11 below). In 16.2 per cent of the reporting, or 123 articles, science was newsworthy because of some breakthrough or development that was announced. Stories that were coded as such included a *New York Times* article from 2009 that reported that scientists discovered how to create nanoparticles that mimic "good" cholesterol in the blood (*New York Times*, 22 November 2009).

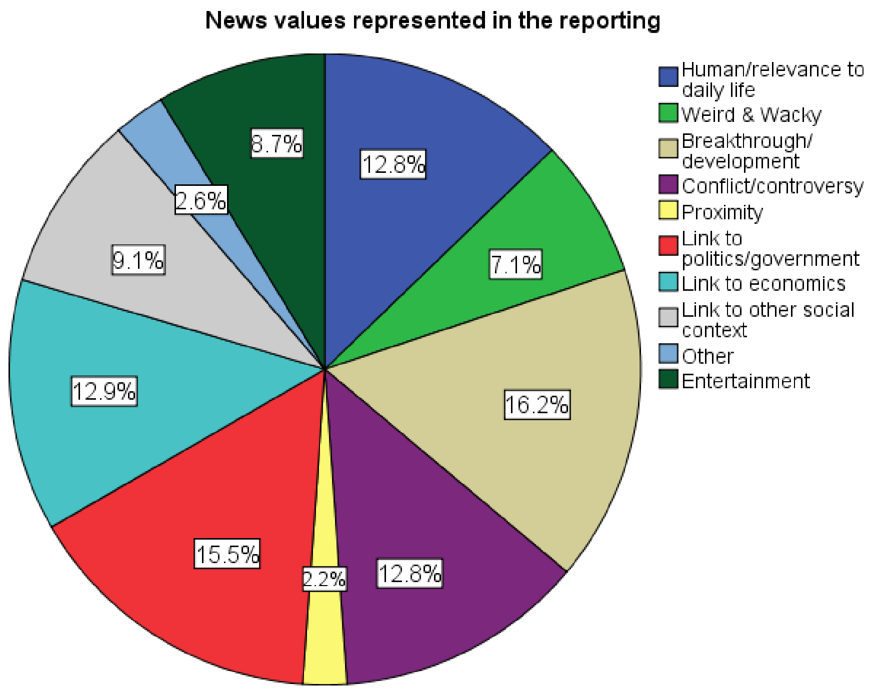

Figure 11: News values represented in the reporting

The chart above illustrates the prominence of breakthrough/development, link to politics and government, link to economics, conflict/controversy and human/relevance to daily life as news values for articles in the study.

Following that, science became newsworthy when it was linked to politics, but like with Hansen’s news values, "politics" was applied broadly. The 15.5 per cent of articles, or 118 cases, of that nature includes stories detailing government funding of science, a government body commissioning research, and interviewing members of the three main political parties in the 2010 UK election regarding their plans for science if elected. Link to economics, including the potential for new jobs or the potential economic benefits of science and technology, was prominent in 12.9 per cent of the reporting, or 98 articles.

However, close behind that were relevance to daily life and a human face on science at 12.8 per cent of the reporting, or 97 articles, and conflict or controversy, also at 12.8 per cent. Stories that were coded as "relevance to daily life" or a human angle on science include a story about the potential benefits of nanotechnology that begins by focusing on how computers will be embedded in our clothes to communicate with our washing machines to ensure they are cleaned properly (*Observer*, 31 Dec. 2000). A more complex example is a *New York Times* story about the use of nanotechnology in the manufacturing of candy bars, which arguably had a link to economics (*New York Times*, 10 October 2006). I chose to code it as relevance to daily life because the story led with the potential changes to favourite candy bars, including new coatings to preserve the candy bars and also ways of shrinking fat particles to cut calories and fat without sacrificing flavour. Additionally, profiles of scientists were coded as a human angle on science.

Conflict and controversy was also a prominent news value, as was noted above. Stories of that nature included a *New York Times* article entitled: “Nanotechnology has arrived, a serious opposition is forming.” The first line of the article also contributes to the labelling of this story as “conflict,” which states: “The great Grey Goo debate is beginning to matter.” Grey goo refers to the risk for robots developed through nanotechnology that would continuously replicate themselves from any and all materials and eventually turn the whole world into “grey goo,” although a number of scientists have dismissed the notion of grey goo as a far off threat or science fiction.

Considering the newspapers individually, it is interesting to see what makes science newsworthy (see Table 1 below) and how the newspapers differ in their choices. *The Guardian* had a higher proportion of conflict and controversy articles with a total of 66 stories, or 15.6 per cent of the reporting, coded as such. That includes a 30 June 2002 *Observer* comment piece that argued warnings about technological advances are more "alarmist" than alarming and asks "Why do we fear the future?" The author, Charles Leadbeater, cited a variety of forms for the warning from fictional representations such as the film Minority Report to published statements from royal astronomer Sir Martin Rees that warned bio-weapons could potentially destroy the planet if left to the wrong hands. More recently, *The Guardian* published a story about the Lords science and technology committee criticising the food industry for not releasing information about their experimentation with nanotechnology (*Guardian*, 8 Jan. 2010).

Top 5 News Values by News Organisation

Guardian	New York Times
1) Conflict/controversy 66 (15.6%)	1) Link to economics 65 (19.4%)
2) Breakthrough/development 64 (15.1%)	2) Breakthrough/development 59 (17.6%)
3) Link to politics 62 (14.6%)	3) Link to politics 56 (16.7%)
4) Human/relevance to daily life 57 (13.4%)	4) Human/relevance to daily life 40 (11.9%)
5) Link to other social context 53 (12.5%)	5) Entertainment 33 (9.9%)

Table 1: Top 5 News Values by News Organisation

The table above lists the five news values most often represented in the study from each news organisation. It shows that primarily the news values are the same across the newspapers, but that in the case of the first and fifth ranked news value the news organisations differ.

Alternatively, the top news value represented in *The New York Times* was "link to economics" with 65 articles or 19.4 per cent of its reporting. That is perhaps not surprising given the number of articles from the business and finance section of the newspaper. Amongst the stories that were coded as link to economics include: a story about a new company that manufactures computer devices using nanotechnology developing an office park in an area of San Jose, Calif. and hopes to attract other companies to occupy the space in order for economic development of the area (*New York Times*, 17 Aug. 2009).

The two newspapers shared the same news values in the case of second, third and fourth positions - breakthrough/development, link to politics, and human/relevance to daily life, respectively. These were discussed above. The two newspapers differed in the fifth position with *The Guardian* publishing 12.5 per cent of its reporting, or 53 articles, which met the news value "link to other social context." Stories of that nature included a number of education stories such as articles about programmes in higher education or efforts to boost science education in schools. *The New York Times* published 33 stories, or 9.9 per cent of its content in this study, that were coded as "entertainment." This news value is also not part of Hansen's news values, as was mentioned above. It was included to differentiate fiction book, video game, and film and television reviews that were published in the newspapers. Other news values might have been appropriate in some cases, but I did not want to obscure the data on news values by coding these articles as something other than entertainment. Amongst the articles coded as entertainment was a column by David Itzkoff about science fiction being "geeky" (*New York Times*, 5 March 2006). Also coded as "entertainment" were book reviews of fiction books, which regularly appear in both publications.

Looking at stories about nanotechnology specifically (see Figure 12 below), both newspapers prioritise breakthroughs and important developments in the field. Breakthroughs represented nearly 30.6 per cent of *Guardian* nanotechnology reporting, or 38 articles, and 40.6 per cent of *New York Times* reporting, or 39 articles. This may not be particularly surprising when it comes to news stories or stories about science because breakthroughs have a “new” character, which is part of what makes them particularly newsworthy.

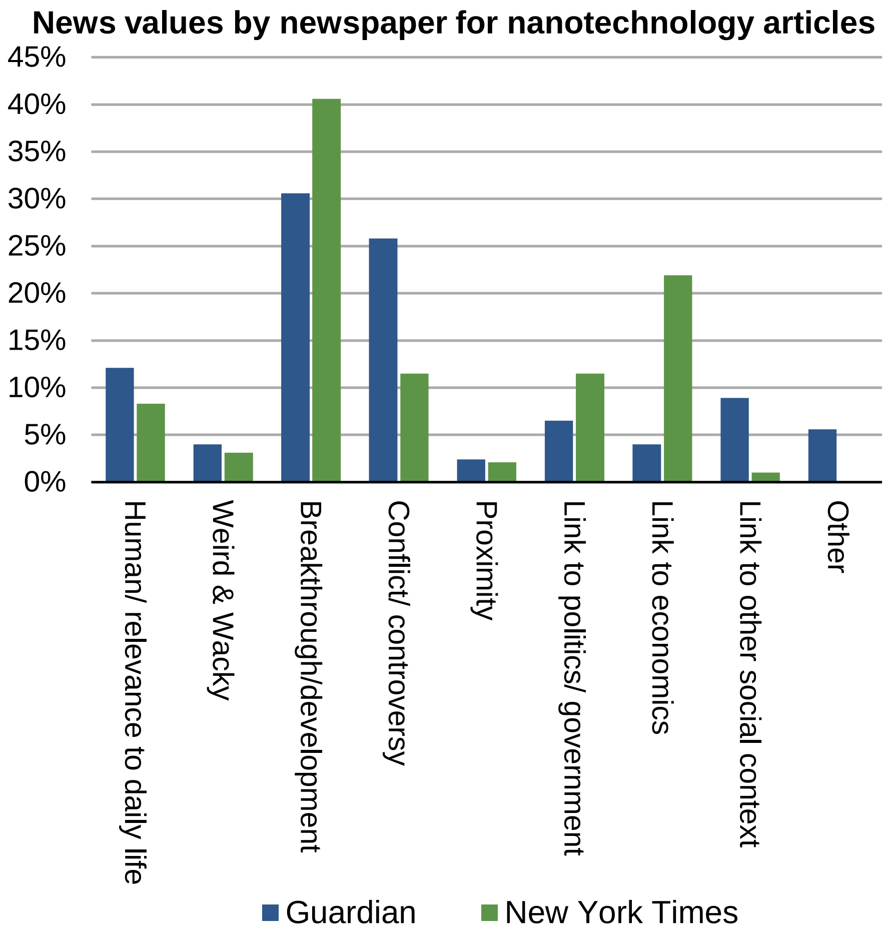

Figure 12: News values by newspaper for nanotechnology articles

The chart above illustrates that nanotechnology is newsworthy when something new happens. For *The Guardian*, conflict/controversy is also an important news value. Alternatively, *The New York Times* appears to prioritise a link with economics.

For *The Guardian*, in 25.8 per cent of nanotechnology reporting, or 32 articles, there tended to be an element of conflict or controversy associated with it, as was discussed above. As with all stories in *The New York Times*, the link to economics was a common news value as approximately 21.9 per cent of the nanotechnology reporting, or 21 articles, were coded as such. A link to politics was slightly less common a news value for nanotechnology stories specifically than overall with 11.5 per cent of *New York Times* reporting, or 11 articles, and 6.5 per cent of *Guardian* reporting, or 8 articles, meeting that definition of news value. Human angles or relevance to daily life was also less prominent with 8.3 per cent of *New York Times* reporting, or 8 articles, and 12.1 per cent of *Guardian* reporting, or 15 articles.

Over time, breakthroughs are consistently newsworthy. As a news value, breakthroughs and developments make news in every year studied and is the only news value represented in the earliest stories. Other news values begin to emerge in the early to mid-1990s, including the weird and wacky news value and link to politics. However, breakthroughs tended to be more common than the other news values throughout the study period. The primary exception to that was the conflict and controversy news value, which was a common news value from the early 2000s. It first appeared in a single story in 2002 and spiked to 17 stories in 2003, which is not surprising given that concerns around nanotechnology were raised by Prince Charles and others. Conflict has continued to be a news value in the years that followed, but in lower numbers where breakthroughs again re-emerge as a more prominent news value in most cases more recently.

When it comes to introducing the word nanotechnology or other such label in the reporting, it tends to appear fairly prominently in the articles in which it is discussed (see Figure 13 below). Almost half of all articles referenced nanotechnology for the first time in the headline, lead or first quarter of the article. In a total of 90 articles, or 11.9 per cent of the reporting, nanotechnology or a reference to it appeared in the headline. The article lead referenced nanotechnology for the first time in 68 cases or 9 per cent of the reporting. The most common place for nanotechnology to appear for the first time was the first quarter of an article with 200 articles or 26.4 per cent of the reporting mentioning nanotechnology for the first time in that location. Where articles had fewer than four paragraphs, it was considered to only have one quarter, so that inflates the first quarter references to an extent. Although that is the case, this particular finding still indicates that when nanotechnology is reported, it tends to be prominent in the articles in which it appears. For the remaining articles, nanotechnology first appeared in the second quarter in 132 cases or 17.4 per cent of the articles, third quarter in 142 cases of 18.7 per cent of the reporting, and the fourth quarter in 127 or 16.7 per cent of the reporting.

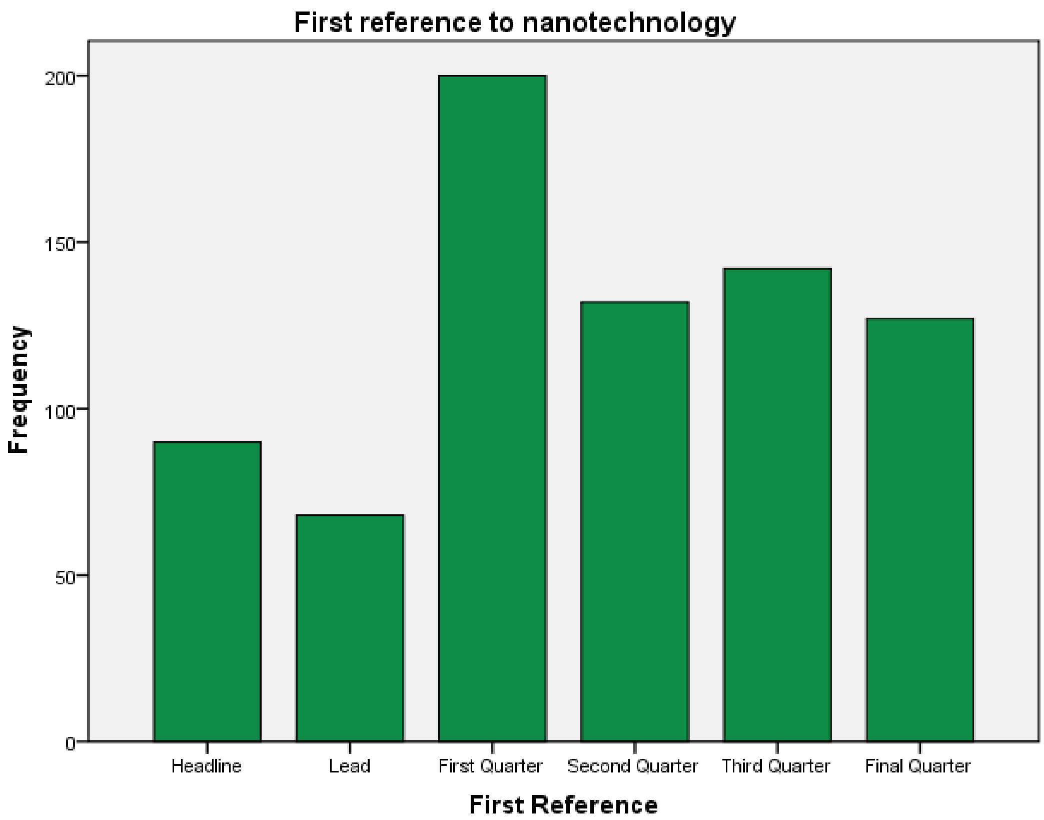

Figure 13: First reference to nanotechnology by quarter

The chart above outlines when nanotechnology was first referenced in an article. Overall, it illustrates that in 358 of the 759 articles, nanotechnology was first referenced in the headline, lead or first quarter.

The discussion above has documented what makes nanotechnology newsworthy, both as a primary subject of news and when it is part of news about something else (a secondary subject). It is often newsworthy because of an event of some kind. Overall, press releases are the most common news hook for all stories that mention nanotechnology, including those where nanotechnology is the subject. However, when nanotechnology is the primary subject of news then journal and magazine articles become the most commonly cited news hook. This also links to the common news values for stories that address nanotechnology. When looking at all articles in the study, nanotechnology becomes news when breakthroughs, link to politics and link to economics. Specifically looking at stories where nanotechnology is the subject, breakthroughs again appear to be why it is a newsworthy subject. There was some variation in the salience of news values for nanotechnology articles for the individual newspapers in that *The Guardian* articles were more often coded as being part of the conflict/controversy news value and *The New York Time* most often appeared to prioritise the link to economics. Now, this chapter turns to how nanotechnology is defined and described in the news reporting, which addresses one of the central research questions.

Newspaper definitions of nanotechnology

As the introduction chapter discussed, there are a variety of definitions for nanotechnology in the science and technology communities and wider society. Although there remains debate as to whether it should be referred to as nanotechnology, nanoscience, nanotechnologies or some other term, this appears to be a debate within more academic circles. *The Guardian* and *The New York Times* appear to have settled on nanotechnology, and sometimes nano-technology, with approximately 84 per cent of the reporting, or 638 of the 759 articles, referring to it as such exclusively (see Figure 14 below). Nanotechnology was also mentioned with nanoscience and other labels, such as "nanobots." In that case, the total number of nanotechnology references was included in 89 per cent of the reporting, or 675 articles.

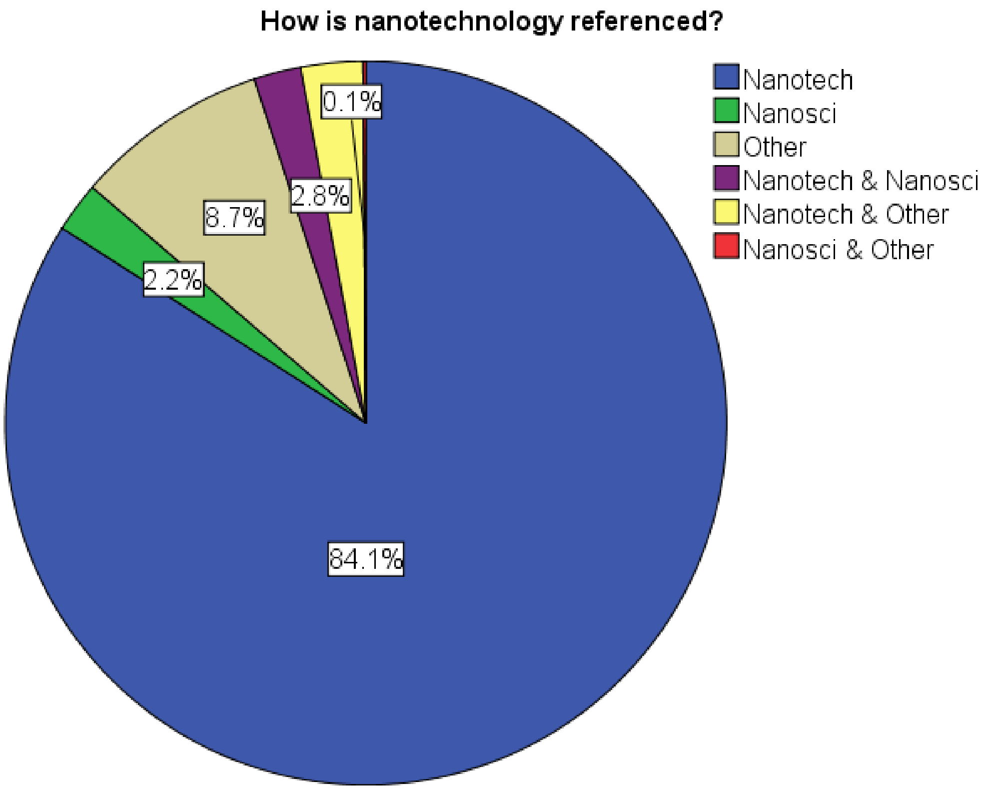

Figure 14: Nanotechnology references

The chart above illustrates that the newspapers primarily refer to this field and the research conducted as nanotechnology almost exclusively. It is occasionally referred to as nanoscience, but less so than references to nanobots or nano-engineering or nano-manufacturing were mentioned (the "other" category).

On the other hand, the term nanoscience very rarely appeared in the reporting, especially on its own with only 2 per cent of the coverage, or 17 articles, making reference to nanoscience instead of nanotechnology or other alternatives. It was also referred to as nano-electronics, nano-engineering, and other similar names in nearly 9 per cent of the reporting, or 66 articles. In addition to those labels, the "other" category also encapsulated references to nanobots. Although the term nanotechnology was the more common term, it was surprising that nanoscience did not appear more often in the reporting either on its own or with other terms. When nanoscience and nanotechnology were both mentioned in just over 2 per cent of articles, the term nanoscience tended to be part of an organisation’s name or an individual’s title, anecdotally speaking. The newspapers frequently described nanotechnology as a science in the definitions they provided for the field, which is why it was surprising that nanoscience was not more commonly referred to in the content.

For the most part, articles did not tend to provide explicit definitions or explanations for nanotechnology or the other terms they used with 462 articles representing nearly 61 per cent of stories having no definition of any kind (see Table 2 below). That leaves 297 articles that include a definition for nanotechnology, or 39 per cent of the reporting. When nanotechnology is the primary subject of the article, explicit definitions for nanotechnology were more common (see Table 3 below). In 69.5 per cent of the reporting that is primarily about nanotechnology, or 153 of 220 articles, the story had an explicit definition for this new field. Articles that mentioned nanotechnology only include definitions in 26.7 per cent of cases, or 144 of 539 articles that are primarily about something else but mention nanotechnology.

Definition

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	297	39.1	39.1	39.1
	No	462	60.9	60.9	100.0
	Total	759	100.0	100.0	

Table 2: Definitions provided for nanotechnology

The table above illustrates the frequency with which the newspapers provided definitions for nanotechnology in the articles they published. Overall, it shows that in most stories, 462 of 759 articles or 60.9 per cent of the reporting, nanotechnology was not defined.

Definitions provided based on the story topic

			Story Topic		
			Nano	Story with nano	Total
Definition	Yes	Count	153	144	297
		% within Definition	51.5%	48.5%	100.0%
		% within Story Topic	69.5%	26.7%	39.1%
	No	Count	67	395	462
		% within Definition	14.5%	85.5%	100.0%
		% within Story Topic	30.5%	73.3%	60.9%
	Total	Count	220	539	759
		% within Definition	29.0%	71.0%	100.0%
		% within Story Topic	100.0%	100.0%	100.0%

Table 3: Definitions provided based on story topic

The table above identifies that when a story is primarily about nanotechnology, it is more common for a definition to be included. In total, 69.7 per cent of articles about nanotechnology included some explicit definition. Alternatively, stories that mention nanotechnology include definitions in only 26.7 per cent of cases.

Additionally, it is useful to explore whether the definitions appeared in the reporting consistently or whether they tended to be provided earlier on in the lifecycle of reporting, especially as it relates to stories where nanotechnology is the primary subject. As the data shows, the newspapers provided definitions more often in the early part of the reporting and throughout the peak in coverage in 2003 and 2004 (see Figure 15 below). More recently, however, nanotechnology has been less likely to be defined for the audience even in stories about nanotechnology. This could indicate that journalists believe that is becoming unnecessary to provide a definition for nanotechnology. However, research into audiences suggests that is not the case as it demonstrates that most citizens know little about nanotechnology (see for example Lee et al., 2005, Lee and Scheufele, 2006, Scheufele and Lewenstein, 2005, Wilsdon, 2004). The findings of this research juxtaposed with the audience research could indicate a disconnect between what the audience knows and the journalists believe the audience knows or needs to know in order to engage with an article. However, it is important to note that this research identifies when the definitions appeared and cannot necessarily predict the reasons why they are less common now. To confirm why definitions are not included in the reporting as often would require a production study that asks journalists when, how and why they choose to define certain terms in stories that discuss science.

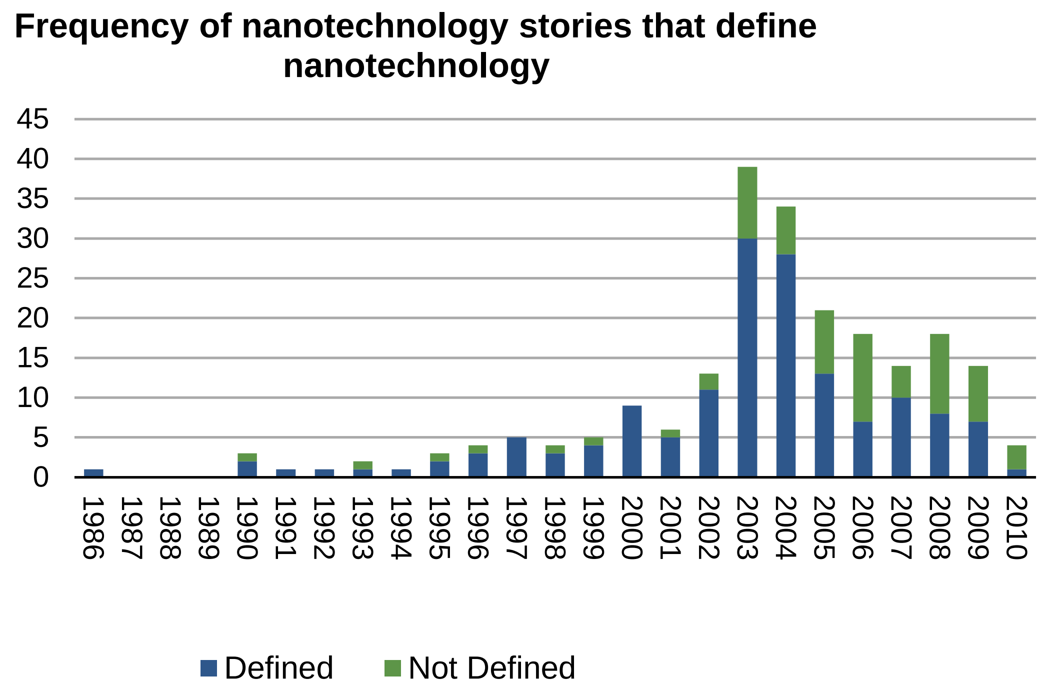

Figure 15: Definitions provided by year for stories about nanotechnology

The chart above illustrates that in the early part of the study period, particularly from 1995 to 2005, that the newspapers were more likely to define nanotechnology for the audience in stories about nanotechnology. More recently, however, it appears that definitions are becoming more rare in this type of story.

Although useful to know how often the terms are defined for the audience, it is also important to understand the definitions themselves, which were analysed qualitatively to get a deeper understanding of the descriptions provided by the newspapers. Arguably defining a topic is a more diffuse concept than framing, which helps set the scene for the framing discussion in Chapter 6. As the methodology chapter discussed, this thesis evaluates the 297 definitions that were provided using Nvivo, qualitative data analysis software. In the course of the analysis, the definitions were coded to identify themes drawing on the lexical choice of the journalists. The software allowed for the qualitative coding of each definition, including to identify key words and themes that appear within the definitions.

Definitions ranged from a few words to whole sentences, which when looking for themes across the reporting provide an interesting picture of what nanotechnology is and what it does. In summary, the newspapers define nanotechnology as a new *science* that is *functional*, rather than theoretical. It works at a *very, very small* scale and involves *building gizmos* that will also be *useful* in society. The benefits of nanotechnology are prioritised in the definitions, although a counter theme of risk is visible to a limited extent. The discussion below outlines the themes summarised here to help provide more texture and depth to the definitions of the term "nanotechnology."

It's a new and functional science…

Statistically speaking, "nanotechnology" was the most common term used to identify this emerging area of science and technology. When it came to definitions of the field, the qualitative analysis revealed that it is identified as a science and the language of science is also an element of the definitions of nanotechnology. References to nanotechnology as a "science" were repeated throughout the definitions. They also invoked a language of science, particularly as seen through repeated references to atoms and molecules. These trends can be seen in the example definitions set out below:

> "Science of the future"
>
> *The Guardian*, 21 May 1996
>
> "The science of manipulating materials at the molecular and atomic level."
>
> *New York Times*, 28 Oct. 2006

> "The high-tech science that makes it possible to breakdown ingredients like seaweed, aloe vera and copper into ultrafine particles that can be imbedded into woven fabrics."
>
> *New York Times,* 29 January 2009

These definitions are amongst those identified in the theme of reporting nanotechnology as a science and using the language of science to make sense of the term for the audience.

It was also defined, although less prominently, as a technology, part of engineering and bioengineering, a commercial entity, part of electronics, and as an interdisciplinary field. Where science and the language of science were so strongly represented in the definitions, it is surprising that "nanoscience" was not the preferred term in the reporting or that it was not cited more frequently, as the quantitative analysis indicated.

Additionally, the qualitative analysis indicated that the newness of nanotechnology was an important factor in the defining of this field of research and development. The newness was communicated in a variety of ways, including to call nanotechnology the science of the future, the science of the 21st Century, and the science of tomorrow. It was also called futuristic, embryonic, emerging, immature, and novel. All of these various descriptors indicate a new character to the field, which also links to its newsworthiness.

The functionality of nanotechnology was also a theme that appeared in the definitions. It is a practical science that involves the construction or building of something – products, devices, and machines. The implications for nanotechnology are wrapped in what it can do and what it can build or construct, according to the definitions. Nanotechnology and the construction of products using nanotechnology are achieved through the “manipulation” of “materials” or “matter” at the nanoscale. “Manipulation” was a common term that is repeated in the reporting. Other terms used to describe the process include: arranging, assembling, changing, transforming, fabricating, modifying, moving, restructuring, controlling, creating, enhancing, intervening, breaking down, chopping up, and disassembling.

Nanotechnology, according to the definitions provided in the reporting, is a beneficial science. It is described using words like advanced, exquisite, innovative, promise, revolutionary, and so on. Risk and the potential for risks of nanotechnology are less prominent in the definitions of nanotechnology. Grey goo – the out of control self-replication of nanobots from atoms that leaves the world devoid of natural life – and the unknown implications of nanotechnology appeared in definitions for nanotechnology, but were eclipsed by claims around the benefits of nanotechnology and references to science that is “exquisite,” “innovative,” and “revolutionary.” It was defined as a “double-edged promise” in one *New York Times* story on 16 June 2002, which describes the potential benefits and risks of nanotechnology at the same time. However, as the quantitative findings around risks and benefits show, risk claims related to nanotechnology rarely appear in the reporting. This will be discussed in more detail in Chapter 6 when discussing the framing of nanotechnology in more detail.

It’s not just small… it’s really small

As with the definitions set out in textbooks and by government and science agencies that were discussed in the introduction chapter, size was an integral element in the definitions of nanotechnology in the newspapers. How the size was communicated varied from the use of more precise language – measured in terms of billionths of a metre or millionths of a millimetre – to generically referring to nanotechnology as science, technology or engineering of the “very small.” Some of the definitions that draw on a more precise language to measure the size of nanotechnology are:

> Such futuristic technology has been dubbed ‘nanotechnology,’ because the machines would have features measured in nanometers, or billionths of meters.
>
> *The New York Times*, 15 March 1988
>
> Nanotechnology foresees a world of machines measured in millionths of a metre. They are already being used to explore surfaces at atomic levels.
>
> *The Guardian*, 23 Sept. 1996
>
> The science of materials measured at billionths of a meter or one-500th of a human hair.
>
> *The New York Times*, 20 Dec. 2007
>
> Materials constructed at the scale of 100 nanometres or smaller.
>
> *The Guardian*, 4 Sept. 2008

By providing measurements in terms of billionths of a metre or millionths of a millimetre, these definitions offer the audience a sense of how small the nanoscale is in a precise way.

An alternative to these more precise definitions are the generic ways in which the smallness of nanotechnology was described. Words and phrases that reflected the very small nature of nanotechnology that appeared in definitions include invisible, minute, infinitesimally small, unfathomably small, microscopic, sub-microscopic, absurdly small, and tiny. Some of the specific definitions include:

> In its purest form, nanotechnology is the attempt to build functional machines on an unimaginably tiny scale – devices many times smaller than the cells that make up a body.
>
> *The Guardian*, 5 Dec. 2002
>
> Which involves engineering substances down to very small sizes.
>
> *The New York Times*, 8 July 2010

As some of the definitions above demonstrate, explaining how small nanotechnology is can involve the use of metaphors to help make sense of the size of nanotechnology. One of the definitions above cites the human hair as a reference point; another draws on the cells in our bodies to help explain the size of nanotechnology.

Gadgets, gizmos and devices

As noted above, the functionality of nanotechnology and the theme around constructing things – gadgets, gizmos and devices – was a prominent theme in the defining of nanotechnology. Definitions referred to microscopic engines, molecular machines, nanobots, tiny robots, and computers developed through nanotechnology. The definitions below illustrate the theme and reiterate some of the themes identified above:

A whole new category of midget gadgetry called 'nanotechnology' has come to the fore.

The New York Times, 29 June 1999

The miniaturisation of computing and robotics could lead to the creation of machines of molecular size, known as nanotechnology.

The Guardian, 20 May 2003

Which describes the manufacture of devices and materials measuring billionths of a metre across.

The Guardian, 30 July 2004

Nanotechnology refers to a rapidly expanding range of devices and industrial processes that manipulate atoms and small clusters of molecules – materials measuring from 1 to 100 nanometers, or billionths of a meter. At such dimensions, traditional materials can develop valuable behaviors, like unusual strength, electrical conductivity or invisibility to the naked eye, and can be recombined with other materials to form novel drugs, foods, and devices

The New York Times, 26 Sept. 2006

These definitions, which were used to highlight a theme around the development of devices, echo the themes discussed above. All together the definitions cited above highlight the practical/applied nature of nanotechnology as a "new science" that constructs devices that are very, very small. Although risk is a theme in the definitions, it is marginal in comparison to the theme of nanotechnology as beneficial. These definitions provide a glimpse into the trends that also appear in the quantitative research around the framing of nanotechnology. However, the notion of a definition for nanotechnology is more diffuse than a frame for nanotechnology, which provides additional meaning and context to the topic. The following section of this chapter also contributes to the defining of nanotechnology in that it discusses some of the uses that were most often cited in the reporting. This furthers the notion of the functionality and practicality of nanotechnology, which was identified in the definitions of the field.

How nanotechnology can be used

In a third of the articles in the study, or 309, no use for nanotechnology was provided (see Table 4 below). For the remainder of the 77 per cent of articles, at least one use was presented for nanotechnology. It was common for a story to present multiple uses for nanotechnology, so it should be noted that these figures will exceed the 759 articles that are included in this study and percentages are based on the 937 total responses for uses of nanotechnology.

Uses for nanotechnology

		Responses		
		N	Percent	Percent of Cases
Uses for nanotechnology	Computers	141	15.0%	18.6%
	Military/security	47	5.0%	6.2%
	Medical	172	18.4%	22.7%
	Manufacturing	171	18.2%	22.5%
	Other	70	7.5%	9.2%
	None specified	309	33.0%	40.7%
	Green technology	27	2.9%	3.6%
	Total	937	100.0%	123.5%

Table 4: Uses for nanotechnology

The table above illustrates the predominant uses identified in the reporting for nanotechnology. In a third of stories, no use was expressly identified. However, where a use was identified, medical and manufacturing uses were amongst the most common, followed by computer uses.

Medical and manufacturing uses for nanotechnology were the most commonly cited uses for nanotechnology with a total of 18.4 per cent (172 references) and 18.2 per cent (171 references) respectively. The use of nanotechnology in computer technology was also frequently cited at a rate of 15 per cent (141 references). These arguably link back to Hansen's (1994) news values for science in that they relate to daily life. Medical, manufacturing and computer uses were often discussed in terms of how nanotechnology will improve our overall health and quality of life with improved technology. These include the pill-sized robots developed using nanotechnology that would repair damaged cells, new computer technologies that enhance the storage and capability of a variety of devices, and new consumer products that make everyday activities more efficient. Other uses, including transportation, virtual reality, electronics, and research, made up 7.5 per cent of uses represented, or 70 references. Military and security uses were referred to in 47 times or 5 per cent of the references to use.

Looking at the uses cited over time, nanotechnology's opportunity to develop computers and computer microchips was a consistent feature throughout the reporting. It was cited in 1986, the first year the reporting was found, and every other year in the study period, apart from 1988. The stories say nanotechnology will allow us to shrink computer technology to unfathomably small sizes and specifically focus on what that will mean for medicine, which will be discussed in the next paragraph. Looking at computer applications more generally, the possibilities of nanotechnology are endless, according to a 16 July 2002 article in *The New York Times*. It states: "On the horizon are faster, smaller computers built from atomic-scaled carbon tubes, ultra strong cables that could be used to build an elevator into space, better drug-delivery systems and much more." *The Guardian* reported other opportunities for nanotechnology that would shrink computers, especially data storage devices. If predictions in the reporting are correct, we are now only a few years away from sugar-cube sized computers with "the power of all today's computers put together," according to the 7 May 1992 *Guardian* story. The online newsletter that this short story cites says these tiny computers will be on the market by 2015.

Similarly, medical uses were cited in every year studied, with the exception of 1986. A number of stories refer to a future where nanotechnology enables us to have tiny computers, often referred to as nanobots or nanocomputers, injected, inserted or introduced into our bodies to fix damaged cells and fight diseases. *The New York Times* talks about it in 1988 in a story about making a computer out of proteins that could repair damaged cells. There, the newspaper refers to nanotechnology as "futuristic." In 1991 it again talks about invisible computers in the human body performing surgery on damaged cells, but also says that these "molecular-level computers and robots are decades away and might never be practical." On 11 June 2000, *The New York Times* reported a number of stories on medical applications of nanotechnology, including one with the headline: "The doctor that floats in your blood stream." The story discusses a variety of applications including opportunities to improve drug delivery to cancer patients, which invokes the language of chemical warfare. It says:

> early models might refine chemotherapy by acting as 'smart bombs' that sense the chemical signature of cancerous cells and dump their toxic payloads on target, or act as a virtual immune system, searching out and destroying viruses and bacteria and even reversing the most common disease of all: aging.

Similar notions of nanobots repairing cells, fighting disease or delivering drugs to individual cells are repeated throughout the reporting, including in 2004 and 2009. Also, *The Guardian* reporting throughout the study period celebrated some of the opportunities to improve health using nanotechnology by improving drug delivery, surgical procedures, and other aspects of health care.

Manufacturing uses were more sporadic in their references in the early part of the study, but from mid-1990s onwards it was consistently mentioned as a use for nanotechnology. The inconsistency in references to manufacturing uses in the early part of the study period could be linked to the limited attention nanotechnology received in the early part of the study period. With that in mind, stories that discuss the potential manufacturing uses of nanotechnology include a 20 May 1999 *Guardian* article entitled "News from the nanoworld" by Michael Gross. As the following excerpt illustrates, nanotechnology is discussed in terms of machinery and the opportunity to construct machinery at the nanoscale to be used in a variety of ways:

> In each cell of your body the machinery that keeps you alive consists of nanometre scale systems. Technology cannot match the

> subtle performance of these systems in the smallest space, but attempts at constructing machinery on this scale have grown into a new research discipline, known as nanotechnology. Some people predict that nanotechnology is going to turn our world upside down.

The story goes on to discuss two different ways in which researchers are attempting to construct machines - making existing machines smaller and smaller and, alternatively, devising ways to assemble machines atom by atom. The excerpt also illustrates one of the less common frames that this research identified - nature/natural nanotechnology. Although framing will be addressed in the following chapter in more detail, briefly some news articles have discussed nanotechnology in terms of the natural instances of nanotechnology and learning from nature.

A more recent example of a manufacturing use of nanotechnology was discussed in a 29 June 2010 article in *The New York Times*, which was titled "Team's Work Uses a Virus to Convert Methane to Ethylene." This story again touches on the notion of learning from nature, but also highlights a potential use for nanotechnology to develop green technology. In this case, the green technology use is tied closely to manufacturing, which is why it is highlighted here. Specifically, the story discusses how the manufacturing of ethylene, which is a gas commonly used in the manufacturing of plastics and solvents, is produced:

> by steam cracking, a high-temperature, energy-intensive and expensive industrial process first developed in the 19th century...

> The search for more efficient, less expensive
> approaches to the production of ethylene
> has gone on for more than three decades,
> and although some progress has been made
> no new techniques have yet proved
> commercially viable.

The article goes on to discuss the development of a “nanoscience-based approach” to produce the gas, which was found by a group of researchers in California at Siluria Technologies. This approach relies on genetically engineering a virus to coat itself with metal that serves as a catalyst for the chemical reaction that produces ethylene, the story says.

In the early part of the study period, military and security applications for nanotechnology were rarely discussed. However, from 2001, it was more often cited, particularly in *The New York Times*. This may relate to the Sept. 11, 2001 attacks on the World Trade Center as *The New York Times* reported on 25 Sept. 2001 in a story titled "Scientists Debate What to Do When Findings Aid an Enemy" that scientists were struggling with the notion that an enemy might use nanotechnology against the United States. It cites examples of weaponised nanotechnology, including supercomputers embedded on the head of a bullet. The story also references a concern that the same medical applications often cited as a way to repair damaged cells could be used to kill instead. It quotes Glenn H. Reynolds, a law professor at the University of Tennessee, as saying “Someday it might even be used to make tiny robots that would lodge in people’s brains and make them truly love Big Brother.” The story highlights some of the “thorny moral issues” associated with scientific discovery and the challenges scientists were facing at the time.

On 11 November 2002, *The New York Times* reported on a research centre at The Massachusetts Institute of Technology, or MIT, that focused on military applications for nanotechnology. The centre is called "The Institute for Soldier Nanotechnologies." The newspaper referred to it as the "super soldier project" and discussed some of the work being carried out there, including the goal to:

> build a sort of exoskeleton that among other things is supposed to give soldiers super human strength, protect them from biological and chemical weapons, and even help heal their injuries.

The most striking promise for how nanotechnology will change the military came on 8 April 2003 in a *New York Times* story that says: "Nanotechnology will eventually alter warfare more than the invention of gunpowder." The statement was attributed to Clifford Lau, a deputy under the Secretary of Defense with the Office of Basic Research at the Department of Defense. He said that nanotechnology will affect every aspect of military operations from weaponry to communications to the welfare of soldiers.

The Guardian too covered military applications for nanotechnology, but it also raised some other concerns for security beyond links to national security. For example, it reported on how technology advances might be used in criminal activity, as well as potential security challenges for governments. On 25 March 2000, the newspaper reported that technological advances would change the nature of crime and make it sometimes more difficult to catch criminals. Nanotechnology “offers the prospect of local drug production where drugs might be produced only at a point of sale and in relatively small quantities, thereby making the detection of the offence very difficult.” On 8 February 2001, *The Guardian* reported on a UK Ministry of Defence report that states new technology can cause problems for security and defence in Britain. The goal of the government report was to foster discussion on the topic. Among the threats cited is micro, unmanned airborne vehicles developed through nanotechnology. Nanotechnology could also turn dust mites into nanospies and “matchbox sized, smart dust” could track the movement of Iraqi Scud missile launchers, according to a 14 September 2002 Guardian article.

Also, green technology - technological advances that have the potential to help preserve the environment - were cited as possible uses for nanotechnology from 1995. These include the development of improved solar panels and water filters developed using nanotechnology. A total of 10 references to it came in 2008, the highest number of references for this particular use. That year *The Guardian* published a series called “CleanTech 100,” which covered green technologies and new developments in solar energy, energy storage such as improved batteries, and other similar technologies. This can account for several of the references to green technology that year. It should be noted that some of the manufacturing references could be considered “green” because references included making manufacturing cleaner and more energy efficient. Additionally, green technology was often linked to manufacturing; however, the green technology category was added to the coding sheet to accommodate specific references to environmentally friendly practices and products. In the course of coding articles, it appeared green technologies were becoming more prominent in the content; however, the quantitative figures do not bear this out.

Overall, the uses of nanotechnology echo some of the key themes identified in the qualitative analysis of the definitions of nanotechnology as provided in the newspaper articles, but further the insight into the functional aspects of those definitions. The medical applications for nanotechnology are a particularly common occurrence in the reporting, as are other uses that would affect individuals' daily lives are frequently referenced in the reporting of how nanotechnology would be used in society. This is perhaps not surprising in light of news values research that points out that importance for journalists to link their stories to the lives of their audience members and make it accessible both in terms of science reporting and reporting more widely (see for example Hansen, 1994, Galtung and Ruge, 1999, Harcup and O'Neill, 2001).

Now, this chapter goes on to discuss the findings of the study of online news. It reviews the reporting gathered from the online archives of the individual websites of the two news organisations and gives a sense of the extent of unique coverage that appears online. The section begins with a discussion of the extent of the analysis and how it was carried out before discussing the findings in more detail.

Nanotechnology news online

At the outset of the project I had intended to examine the online content addressing nanotechnology that appeared on the websites of *The New York Times* and *The Guardian* in as much detail as the print reporting. However, as this section will discuss, little unique online content exists. In total, 845 individual articles were gathered for the online element of the study. That comprised 570 articles from *The Guardian* and 275 from *The New York Times*. As the methodology chapter discussed, these were taken from the online archives of each publication. Admittedly this methodology is problematic as it relies on the individual organisations to provide complete and accurate databases of their reporting. That said an appropriate alternative, independent database is not available, as with the print reporting. Although Factiva, which was the primary database used to gather the print content, provided some online articles, few appeared in searches of the database, which led to relying on the individual newspapers' online archives instead.

With that in mind, the research found 97 articles that appear to be unique to the web for these two publications. That comprised 63 from *The Guardian* and 34 from *The New York Times*. These unique articles were primarily blog entries, many of which promoted content that appeared in the newspapers and elsewhere online or the discussion of nanotechnology was fairly limited. These unique articles were identified by reviewing the articles first electronically, using a computer database to compare the content. The database software, Devonthink, is a programme that allowed me to compare articles from the print and online editions and look for matches that were 95 per cent similar. The limit was set at 95 per cent to allow for some variation, including the presence of links to social networking websites and advertisements that were present in the online edition but not in the print version of articles. This review turned up 752 apparently unique articles for the web editions, which represents 89 per cent of the online content identified. Although this initial result was promising, upon reviewing articles individually 33 articles from *The Guardian* and 57 articles in *The New York Times* did not mention nanotechnology as part of the article. Nanotechnology appeared as a link on the page, which is likely why the search for articles included these results. Additionally, 257 articles in *The Guardian* and 115 in *The New York Times* appeared to be similar to print reporting, but were not initially identified as similar using the electronic comparison. It is difficult to say why the electronic comparison did not correctly identify these as at least 95 per cent similar, but in a side-by-side comparison of the articles there was no clear indication of a difference between the print and online edition.

Meanwhile, alternative packaging of news online contributed to the appearance of unique content online as was the case for 157 *Guardian* and 24 *New York Times* articles. For example, as part of *The Guardian*'s 2010 election coverage, it published question and answer interviews with members of the three leading parties regarding their science policy. The Factiva database used for gathering the print reporting packaged these interviews as a single article. However, on *The Guardian* website, the interviews appeared individually and so were considered three unique articles by the software programme. Additionally, technology briefs in *The New York Times* would appear together in the online reporting, but the newspaper database content presented some as individual stories so those not related to nanotechnology did not appear in the newspaper content collection.

Additionally, the Devonthink programme identified online content as unique if an audio or video element was included with a story that also appeared in the print reporting. Upon review, the online version of the article appeared identical or broadly similar to the print version. An example of this a story *The Guardian* published about Singularity University – a project of Google, NASA and others that aims to bring together leading thinkers in order to address challenges of the future - that briefly mentioned nanotechnology as a subject that would be addressed in this programme. The article's online version was accompanied by an extended interview with Ray Kurzweil, an American inventor involved in the project and whose 2005 book was the inspiration for the university's name. The audio track includes a passing reference to nanotechnology, similar to that of the article itself.

In the end, 97 articles were identified as unique to the web, as was previously discussed. These include podcasts, such as *The Guardian*'s

Science Weekly, which referenced nanotechnology. These represent 11 of the unique online articles. The Science Weekly podcast, which I listened to weekly throughout the study even where nanotechnology was not necessarily covered in the content, often outlined reporting that appeared in the weekly science section on the website and in the newspaper. The podcasts are radio-style interviews with the journalists involved in producing the science sections of each publication and a discussion of some of the articles to be found in the science sections. Nanotechnology did not take centre stage in these podcasts and was discussed in relation to other stories, such as being part of the 2010 Christmas Lectures of the Royal Institution of Great Britain. The 20 Dec. 2010 Science Weekly podcast of *The Guardian* covered the preparation of the television production of the second lecture in the series. Also, *The Guardian* online reporting included the full text of speeches given by government officials and transcripts of interviews with individuals that journalists at *The Guardian* interviewed.

Other unique articles for the web were blog entries on both sites. In total, *The Guardian* website had 45 blog entries that mentioned nanotechnology. Of those 12 mentioned it in passing, 1 was a book review that did not appear in the print edition, and 2 were lists - one of video games that included a game where nanotechnology is part of the plot and another about viral YouTube videos that includes a video about the nanotechnology behind an idea from Nokia for a phone that is wearable and flexible. Another 8 were similar to articles that appeared in the print edition and 15 included information from articles in the print edition, referring to the newspaper for the whole story.

Finally, the remaining blog entries included a technology blog piece on the announcement from IBM that it had produced a self-assembling computer chip, an arts blog on the scientist that created a tiny version of the Thinker sculpture using nanotechnology, and a technology blog that discussed a breakthrough at the University of Florida where scientists there determined how to place nanotubes in a person to attack cancer.

The New York Times published 32 blogs that mentioned nanotechnology. Of those 3 mentioned nanotechnology in passing, 12 appeared to be the same as an article that appeared in the newspaper, and 5 contained content that was similar to the print edition and referred to the newspaper for further information. The remaining blog entries included a "DotEarth" blog that discussed the Department of Energy's plans to fund nanotechnology research that explores non-polluting energy technologies and another annotating a speech by President Obama on a similar topic. Others included a "Bits" blog that discussed the development of a game that aims to teach about nanotechnology and another on art produced using nanotechnology.

Overall, the reporting of nanotechnology online appears to largely replicate the reporting of the print edition, which would suggest that findings regarding the definitions of nanotechnology and framing of nanotechnology in print would be reproduced in nearly identical ways in an online environment. Where apparently unique content exists, it tends to focus on breakthroughs in nanotechnology or human interest articles. Other online content appears to be used to promote the reporting that appears in print or is a web-reproduction of the print reporting. Therefore, the findings of this study appears to suggest that when it comes to the reporting of nanotechnology online we continue to be in a period of “shovelware” (Matheson, 2004) and marketing content in the print edition.

Conclusion

This chapter aimed to provide a sense of the reporting of nanotechnology over the 24 years studied. The findings illustrate the rise and fall of the reporting over time and indicate that nanotechnology reporting most recently is in a period of decline. That could mean that nanotechnology is losing ground as a newsworthy topic, but could also be linked to a lack of newsworthy events more recently. The chapter also discusses the extent to which nanotechnology is a story in its own right and provides an indication of how and why these stories became news. Most often, nanotechnology was reported as a result of press releases, new books and journal publications, which were the most often cited news pegs/hooks in the articles. When stories are about nanotechnology, journal publications are the most commonly cited news hook in stories, followed by press releases or announcements. Furthermore, when it comes to the science in these stories, it is often newsworthy because of a breakthrough or development, which reflects the notion that what’s new is news. The most common news value reflected in *The Guardian* was conflict/controversy; when it comes to articles in *The New York Times* the most common news value was a link to economics. This may reflect the overall focus of the two newspapers studied, especially for *The New York Times* which has a strong business and finance section.

The findings above provide a foundation of what makes nanotechnology newsworthy, how often it is reported, and what news pegs/hooks appear to provide the timely link for a topic to become news now. From this foundation, the chapter also discussed how the two news organisations defined nanotechnology. Overall, the newspapers identified this emerging field of science and technology as "nanotechnology" rather than "nanoscience" or some other term. When it came to defining nanotechnology, the stories most often did not provide an explicit definition with 60 per cent of the reporting lacking a definition. However, when nanotechnology was the subject of the story, the newspapers were more likely to define the field, especially in the first 15 years of the reporting. Looking at those definitions more qualitatively, the newspapers tended to define nanotechnology as a new science at an incredibly small scale that builds gadgets and gizmos that are practical. The definitions of nanotechnology are a more diffuse concept of framing, which is the primary focus of the next chapter. Linked to those definitions, however, are the uses for nanotechnology especially considering the focus on practicality in the definitions themselves.

The uses for nanotechnology were discussed quantitatively, but most commonly the newspapers identified nanotechnology as something key to medicine and computers. These particular uses can be linked back to the news values and the overall topics of science reporting more generally. In terms of news values, medicine and computer applications for nanotechnology are relevant to people's daily life; as such they are newsworthy from a human interest perspective. Looking at the topics covered in science reporting, studies have shown that medicine is the most common topic covered in science news. Therefore, nanotechnology fits with other patterns of science reporting more generally.

With the overview of the content and definitions of nanotechnology in mind, this thesis now turns to the framing of nanotechnology. Before discussing individual frames for nanotechnology, Chapter 6 will review the tone of articles toward nanotechnology. Although not a frame itself, as some scholars have suggested, the tone of articles toward nanotechnology can be useful in terms of understanding the frames. Also useful for understanding the framing of nanotechnology are the claims around the risks and benefits of nanotechnology, which are also discussed in Chapter 6. The findings of the newspaper analysis in these regards help support the identification of a frame and provide a context for the frames.

Chapter 6: Findings & Analysis - Framing nanotechnology

The previous chapter explored how *The Guardian* and *The New York Times* define nanotechnology. It also provided an overview of the thesis's 759 articles representing 24 years of reporting, including what makes the science and technology in those stories newsworthy. Arguably, understanding the definitions of nanotechnology as provided by the newspapers and the news values of science also contributes to the framing of nanotechnology to some extent. It does so by establishing for the journalist what makes nanotechnology a newsworthy item to report, which provides some context for nanotechnology as an issue. Where framing helps to define the parameters of debate (see for example Allan, 2004, Reese et al., 2001, Reese, 2007), the context that it comes from would appear to be relevant. As such, the previous chapter helps provide support and begins to answer the research questions of this study – How do journalists frame nanotechnology for their audiences? How do the characteristic features of the framing processes change over time? And to what extent does the reporting open opportunities for meaningful, democratic discussion around nanotechnology? This chapter discusses the framing of nanotechnology in detail as it relates to the above research questions.

To begin, it discusses the orientation of the news toward nanotechnology. In other words, is nanotechnology discussed in positive, neutral or negative terms? From there, the chapter explores the claims about risks and benefits of nanotechnology, as reported by these news organisations. These two facets of the reporting help support the identification of the tone of articles, but also arguably plays a role in the framing of nanotechnology. Finally, the frames in nanotechnology reporting are explored in detail, including the frames across the study period and how the framing changed over time. As will be discussed in that section, nanotechnology remains a contested topic as a set of a few frames or a single stable frame did not emerge in the study. This helps illustrate the challenging nature of nanotechnology as a newsworthy topic and provides a sense of the contest involved in framing such a complex issue for the audience.

Tone toward nanotechnology

Some scholars have placed a particular emphasis on the tone of articles, calling them framing studies (see for example Faber et al., 2005, Gorss and Lewenstein, 2005). Their work, which was discussed in more detail in the literature review, provides a helpful beginning in understanding the framing of nanotechnology. That said, however, it is only a beginning. To consider the tone of an article alone as a frame, I believe, does not take the notion of framing far enough because it fails to capture the nuances of framing theory and identify the ways in which frames help guide the audience toward a preferred understanding of a topic. Looking at the tone toward a topic helps provide a sense of the reporting in simple terms before exploring framing more deeply, which is how I chose to proceed with the research. In the interest of self-reflexivity, a common sense approach was taken to determine whether an article was positive, neutral/balanced, or negative in its treatment of nanotechnology. While that leaves some opportunity for debate and discussion, other indications of tone were also considered. Specifically, the coding sheet captured where articles identified risks and benefits of nanotechnology and so could also be used to ensure consistency in applying the tonal measure. Where only benefits are highlighted, then that would indicate a story is positive, for example.

Over the study period, nanotechnology has been primarily reported in positive ways with 467 articles, or 61.5 per cent of the reporting, being labelled as such (see Figure 16 below). In 29.6 per cent of the reporting, or 225 articles, nanotechnology is discussed in a more balanced or measured way. In other words, the claims about risks of nanotechnology are identified or doubts are raised about the potential of nanotechnology alongside the benefits. Professional norms of objectivity (see for example Boykoff and Boykoff, 2004, Clarke, 2008, Ward, 2008) would suggest that the balanced or measured approach to nanotechnology would be more common, which is why it was surprising that less than a third of the articles treated nanotechnology in such a way. In 67 articles, or 8.8 per cent of cases, nanotechnology is seen as primarily negative. The overwhelmingly positive reporting echoes the work of Gorss and Lewenstein (2005) who observed a positive orientation toward nanotechnology in their study. As they rightly note, the propensity toward positive reporting of nanotechnology could be especially troubling if a significant risk for nanotechnology comes to light or some crisis arises involving nanotechnology. In that case, the negative reporting could be exacerbated because nanotechnology has thus far been seen in such positive, beneficial ways. The tone of articles and examples of each type of tone will be discussed in more detail as part of the review of frames later in this chapter.

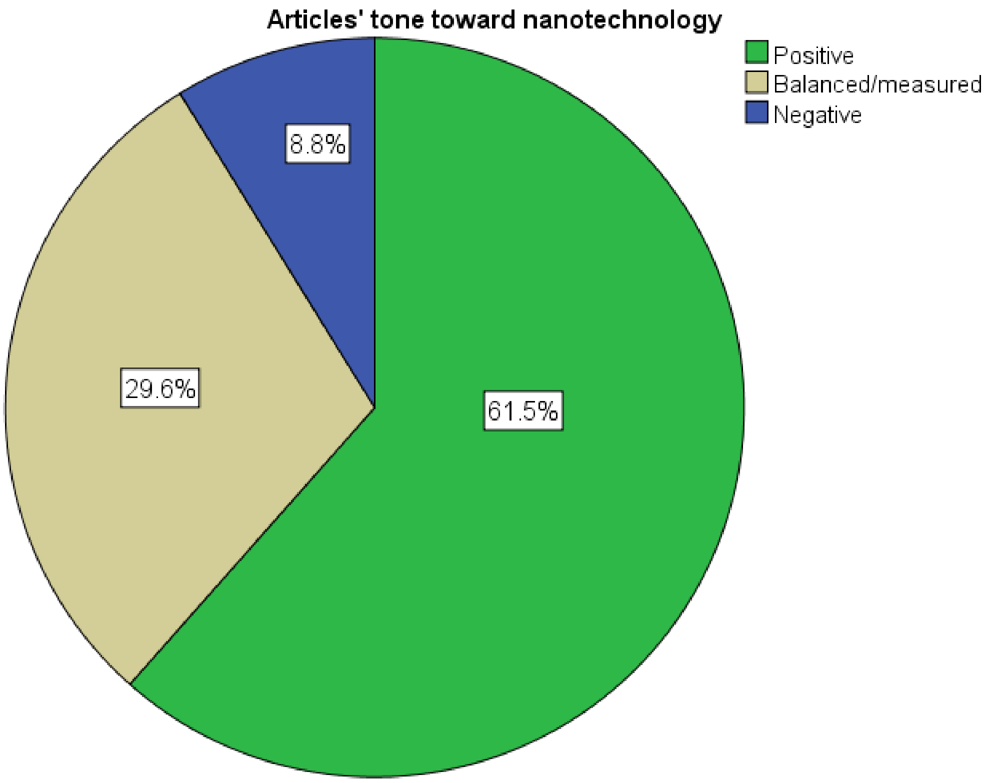

Figure 16: Articles' tone toward nanotechnology

The chart above illustrates that overall, nanotechnology has been reported in primarily positive ways, 467 of 759 articles. Very few articles, only 67 in the study, are primarily negative in their orientation toward nanotechnology.

The trend toward positive reporting remained consistent throughout the study period (see Figure 17 below). In nearly every year across the more than two decades studied, nanotechnology was reported in overwhelmingly positive ways. The only exception to that is 1995 when nine of 13 stories reported that year were coded as being balanced or measured in their tone toward nanotechnology. The remaining four stories reported that year were positive in their orientation toward nanotechnology. At no point in the study was the reporting more negative than positive or balanced. However, from 2002, although nanotechnology continued to be covered in positive ways, it was treated to more scepticism with higher proportions of negative reporting than in the earlier years, which had no negative stories reported in a number of years. For example, from 1986-1995 no negative stories were reported; the same was true in 1997, 1998, and 2007.

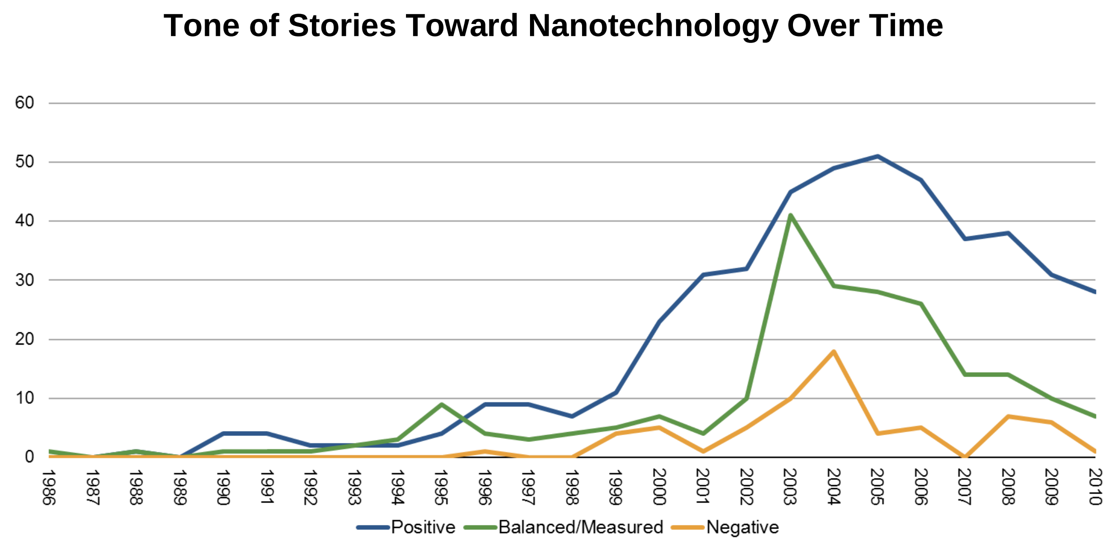

Figure 17: Tone of stories toward nanotechnology over time

The chart above illustrates the relative tone of stories toward nanotechnology over the study period. Specifically, it shows that nanotechnology is seen as primarily positive throughout the study period. When it comes to negative stories, there are none or almost none in the early part of the period. From 2002, more stories are negative in their orientation than before, but still never more than balanced or positive ones.

The same holds true when looking at the reporting based on whether the story is about nanotechnology or if it only mentions nanotechnology (see Figure 18 below). A total of 62.7 per cent of the reporting, or 138 articles, about nanotechnology were primarily positive. That compares with about one-third more balanced stories, or 72 articles. Only 10 articles, or 4.5 per cent, that focused on nanotechnology were primarily negative. When nanotechnology is mentioned as part of an article about something else, there is a small decrease in the proportion of more positive and balanced reporting and an upward shift in negative reporting. Specifically, the positive reporting dips to 61 per cent, or 329 articles that mention nanotechnology. Similarly, the more balanced reporting also declines slightly to a proportion of 28.4 per cent, or 153 stories. Reporting that includes nanotechnology as a secondary subject of the news has a slightly higher chance to be more negative in its orientation as illustrated by the 10.6 per cent of reporting that included nanotechnology, or 57 articles.

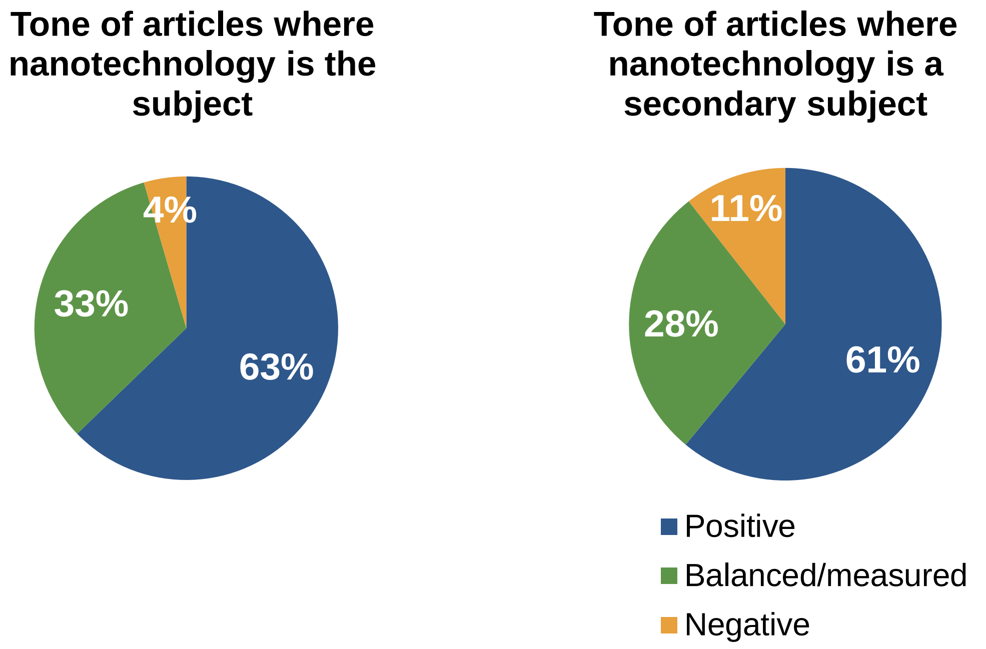

Figure 18: Tone of articles by story topic

The charts above illustrate how reporting on nanotechnology remains positive whether stories are significantly about nanotechnology or only mention it. However, it also shows that there is a slight increase in the proportion of negative reporting of nanotechnology when stories are about something else and only mention nanotechnology.

Looking at the two news organisations individually, the same trend is evident (see Figure 19 below). Both have overwhelmingly positive reporting of nanotechnology across the study period. *The Guardian* reported 241 positive articles, or 56.8 per cent of its reporting. This is less than *The New York Times* proportion of positive reporting, which totalled 67.5 per cent, or 226 articles. Looking at the reporting coded as negative, *The Guardian* was more likely to report more negative stories with 48 articles, or 11.3 per cent of its reporting, that primarily focus on nanotechnology in negative ways. *The New York Times*, on the other hand, had only 19 articles or 5.7 per cent of the reporting, focus on negative aspects of nanotechnology. As the framing section will discuss, *The Guardian* was also more likely to raise questions about risk and frame nanotechnology in terms of the risks of this new science and technology.

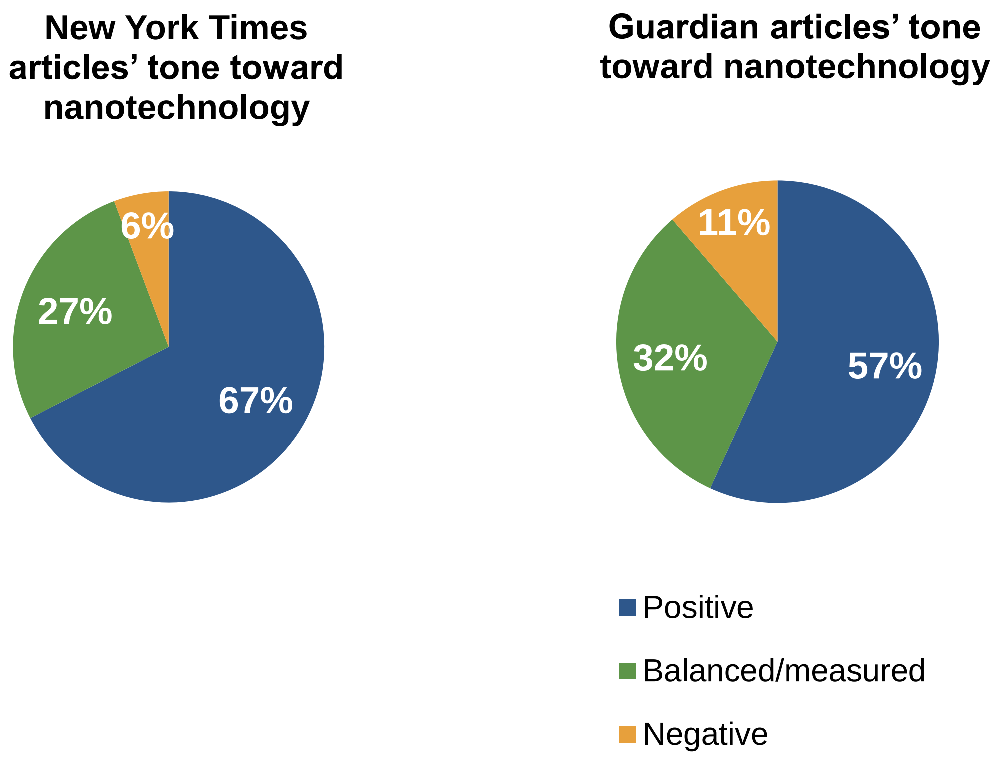

Figure 19: Articles' tone toward nanotechnology by each newspaper

The charts above illustrate that the trend toward positive reporting was similar within the two news organisations. Meanwhile, *The Guardian* was more likely to report nanotechnology in negative ways than *The New York Times*.

When considering the tone of articles in each publication based on the story type, the reporting continues to be more positive in orientation. However, as with the articles overall in the study, there is a slightly higher incidence of negative reporting when nanotechnology is part of a story about something else than when the article is primarily about nanotechnology. That holds true for both newspapers. Specifically, *The Guardian* reported 124 articles primarily about nanotechnology (see Figure 20 below). Of those, 58.1 per cent, or 72, were positive toward nanotechnology; 35.5 per cent, or 44, were more balanced; and 6.5 per cent, or 8, were negative toward nanotechnology. When it comes to the 300 stories that are about something else and include nanotechnology, the reporting remains primarily positive overall, however, the proportion of more negative reporting increases slightly to 13.3 per cent, or 40 stories. The more positive and balanced reporting decreases slightly to 56.3 per cent, or 169 stories, that are positive in nature and 30.3 per cent, or 91 stories, of a more balanced or neutral nature.

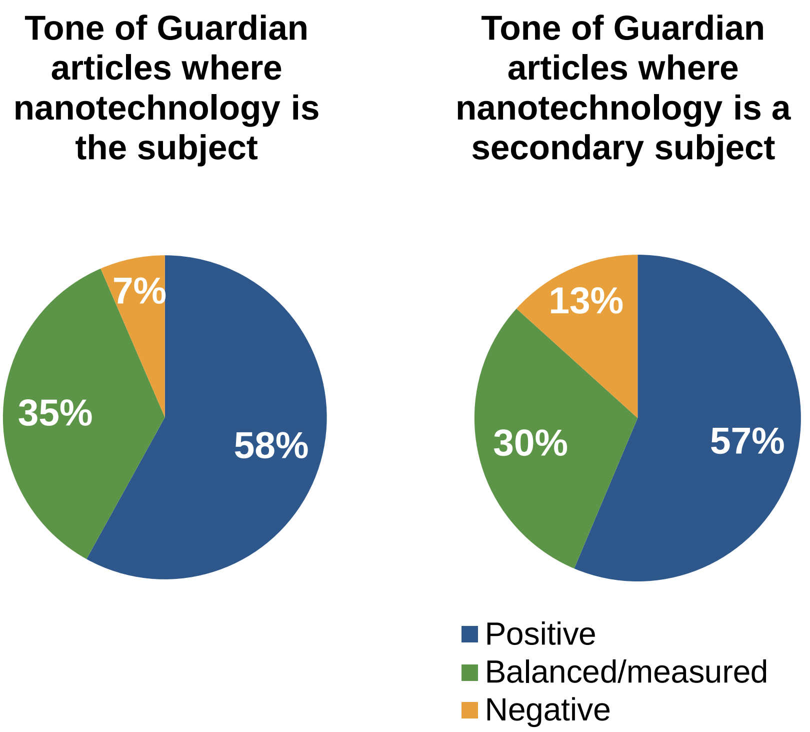

Figure 20: Tone of *Guardian* articles toward nanotechnology based on story type

The charts above illustrate that *Guardian* reporting remains overwhelmingly positive regardless of the story topic. It also has a higher incidence of more balanced reporting than negative in both cases. However, when nanotechnology is part of a story about something else, there is a higher incidence of negative reporting than when it is a story in its own right.

While both publications were overwhelmingly positive in their tone toward nanotechnology, *The New York Times* reporting was more likely to be positive than *The Guardian* reporting. In total, *The New York Times* reported 96 stories that were primarily about nanotechnology and an additional 239 stories that included nanotechnology in the reporting (see Figure 21 below). In both cases, the reporting focused on the ways in which nanotechnology will be beneficial to society and were coded as positive. Sixty-six stories representing more than two-thirds of the reporting primarily about nanotechnology were positive in their orientation toward nanotechnology. Of the stories that mentioned nanotechnology, 160, or 66.9 per cent, were positive. These are similar proportions to that of the stories primarily about nanotechnology, however, where nanotechnology is mentioned, rather than as the focus of the story, the articles were slightly less likely to be positive. Articles were coded as balanced in 28 cases, or more than a quarter of the reporting that is primarily about nanotechnology. When nanotechnology is part of a story about something else, the proportion of more balanced stories drops slightly to just over a quarter (62 articles), or 25.9 per cent of the reporting. Finally, *The New York Times* rarely reported on nanotechnology in more negative ways, especially when stories are primarily about nanotechnology. In that case, only 2 of the 96 stories about nanotechnology were coded as primarily negative. The rate is higher when the story is about something else and mentions nanotechnology. In that case, the proportion of negative stories is 7.1 per cent, or 17 of the 239 articles that mention nanotechnology.

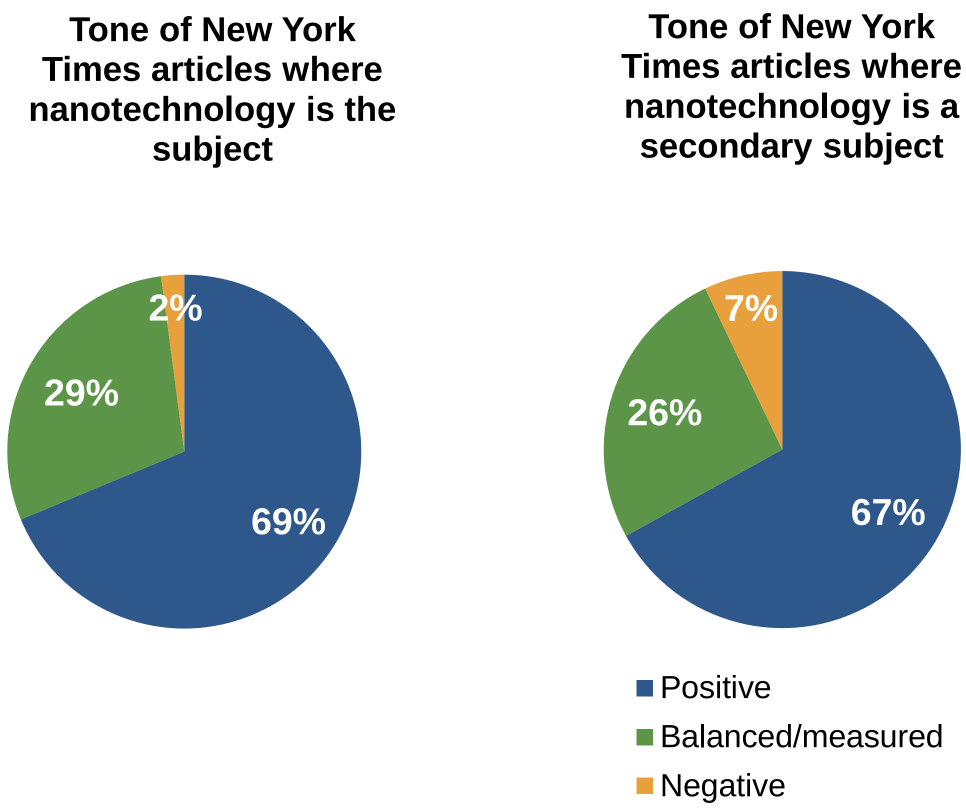

Figure 21: Tone of *New York Times* articles toward nanotechnology based on story type

As with *The Guardian* reporting, nanotechnology is reported in primarily positive ways in *The New York Times* regardless of whether a story is about nanotechnology or if nanotechnology is part of the story. The charts above also illustrate that *The New York Times* rarely reported nanotechnology in negative ways when stories are about nanotechnology and has slightly higher incidence of reporting it in negative ways when nanotechnology is part of a story about something else.

When considering how the tone of stories toward nanotechnology in each newspaper changed over time, some interesting differences in the statistics appear. Here again, both organisations trended toward positive reporting throughout the study period. However, *The Guardian* had higher proportions of more balanced reporting in the latter part of the period (see Figure 22 below). This trend began in 2003 when Prince Charles, among others, raised alarms about nanotechnology risks and a lack of information about the potential risks of this new science and technology. That year, the proportion of *Guardian* articles that were more balanced toward nanotechnology peaked with 27 balanced stories to 25 positive stories. Only four stories that year were primarily negative. From that year onwards, claims about risks began to feature more heavily in the reporting alongside the benefits, giving a more balanced view of nanotechnology.

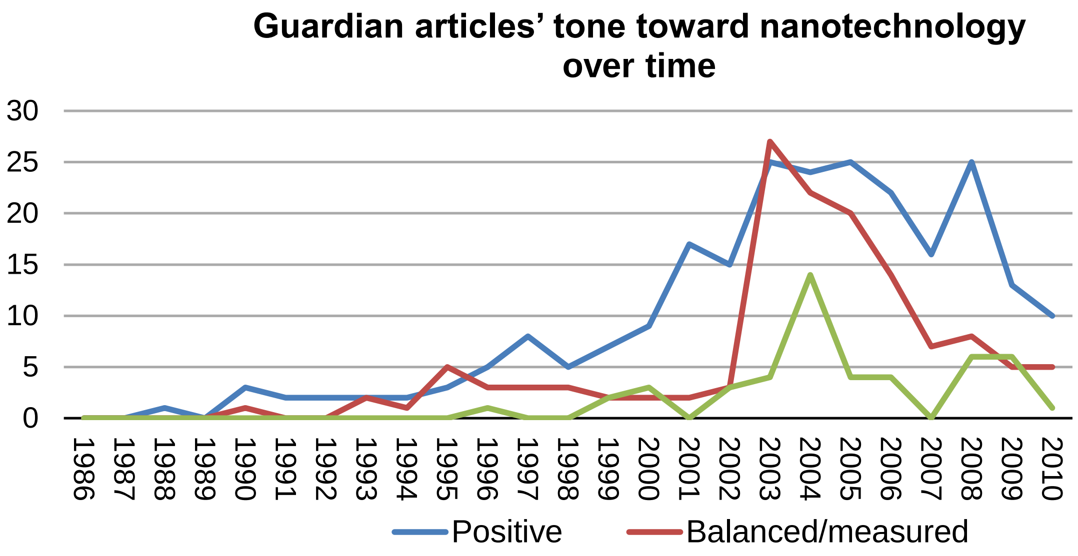

Figure 22: Guardian articles' tone toward nanotechnology over time

Primarily, nanotechnology reporting in *The Guardian* was discussed in positive ways throughout the study period. From 2003, when Prince Charles and others began to raise concerns about nanotechnology, there was a rise in reporting in more balanced ways.

The newspaper's highest proportion of negative reporting came in 2004 with 14 stories representing nearly a quarter of the reporting that year. *The Guardian* reported a number of stories that year on research outlining the risks of nanoparticles seeping into the lungs or across the brain barrier and the unknown consequences of such happenings. Additionally, a number of stories mentioned Prince Charles' warnings about nanotechnology to the Royal Society in 2003. Although the newspaper often linked his cautions on nanotechnology to his suggestions on alternative cancer treatment such as coffee enemas, the proportion of negative reporting on nanotechnology that year was likely higher than other years because news stories about Prince Charles often also discussed his concerns about nanotechnology without discussing more positive aspects or potential benefits of the science and technology. Anderson and her colleagues (2005, 2009b) also found that Prince Charles' concerns would often be treated with derision in the news reporting.

Alternatively, *The New York Times* remained fairly consistent with very high proportions of positive reporting compared to a more balanced or negative orientation to nanotechnology (see Figure 23 below). The trend toward higher levels of negative reporting in *The Guardian* than *The New York Times* supports previous research, which found that North American newspapers and audiences tend to be more positive toward science on the whole, where European publications and audiences have a more sceptical approach (Stephens, 2005). That said, it should be noted this thesis only surveyed the reporting of two leading newspapers, so to compare these and conclude that they are representative of the reporting of their respective countries would be inappropriate. Instead, the trends identified are suggestive only in terms of the international comparison that I can make, but reflect the wider trends identified in earlier studies.

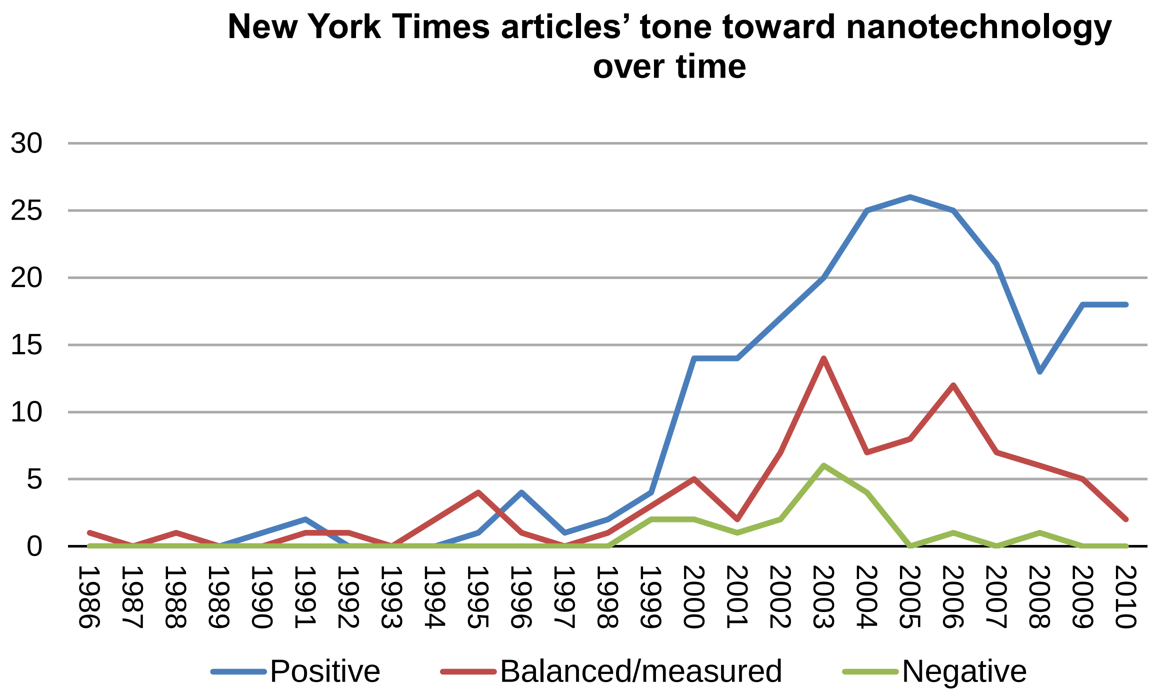

Figure 23: ***New York Times*** **articles' tone toward nanotechnology over time**

The chart above illustrates how *The New York Times'* reporting remained overwhelmingly positive toward nanotechnology throughout the study period.

Overall, the discussion above demonstrates that nanotechnology has been reported in overwhelmingly positive ways. As such, it lacks critique and primarily follows the proponents' views of nanotechnology. This idea will be discussed further in reference to the reporting of claims about benefits and risks of nanotechnology, but demonstrates a lack of accountability and fails to democratise the discussion of nanotechnology.

Benefits of nanotechnology

Linking to the tone of reporting is the identification of benefits and risks in news articles, which this section and the following will address respectively. The reporting in both publications frequently discussed how nanotechnology would be beneficial to society. Based on the review of the literature, it appears that previous research has not specifically documented when and what risk claims about nanotechnology are reported nor have the benefit claims been documented. However, studies have suggested that based on the tonal measure that benefits of nanotechnology outweigh risks (see for example Gaskell et al., 2005, Gorss and Lewenstein, 2005, Faber et al., 2005). Therefore, the coding schedule for this study documented the instances when both benefits and risks are reported so that the thesis could empirically state whether and to what extent the reporting appears to suggest that benefits of nanotechnology outweigh risks.

Meanwhile, there is room for debate about whether and to what extent a development in nanotechnology or potential development in nanotechnology should be seen as a benefit, including in the context of coding it for this research. For example, in some cases the potential medical applications for nanotechnology could be used to lengthen individuals' lives. The news reporting often highlighted such a development as beneficial. Sometimes, the newspapers raised this as a potential ethical, legal or social risk as this could significantly increase the world's population and strain natural resources further than exists today. In the case of the former, it would be coded as a benefit. If ethical implications were raised in relation to this particular example, it would also be coded amongst the risks of nanotechnology.

Another example of a potentially debatable benefit is that of therapies that could restore sight to people who are blind or other similar treatments for disabilities, which is discussed in detail within this section as it relates to the medical benefits of nanotechnology. Below I use an example from *The*

Guardian, which discussed a treatment that could cure blindness in people and discussed it as a benefit. As such, it was coded as a benefit. However, some advocates for people with disabilities might argue that blindness, for example, does not necessarily need to be cured. That view was not represented in the story. Where this study is interested in how nanotechnology is reported by these publications, I took cues from the reporting to indicate whether a benefit should be coded as such and/or whether an idea or development should be coded as a risk.

As discussed in the methodology chapter, a list of benefits for nanotechnology was primarily gathered through the pilot, qualitative readings of the content. In total, the coding sheet captured 11 benefits, however, the “other” category allowed for the addition of new categories not identified in the pilot readings so a total of 13 benefits were identified. Additionally there was an option for "none identified,” which addressed where the benefits of nanotechnology were not discussed. That was the case for 332 articles, or 43.7 per cent of reporting in the study. Where benefits were identified, it was common for more than one benefit to be provided in a story, which is why a total of 1008 benefits are listed in the table below and the per cent of articles with benefits totals 132.8 (see Table 5 below). Although the benefits were primarily taken from the pilot readings, I should also note that drawing on previous nanotechnology risk studies, I included benefit categories that would correspond to risks identified from other research. For example, generic medical and environmental benefits were included because risk research discussed the generic ways in which nanotechnology risk was covered (see for example Friedman and Egolf, 2005, Weaver et al., 2009) . As noted previously, the extent to which nanotechnology coverage includes explicit references to claims about risks and benefits has yet to be documented. Additionally, the notion of risk has been prioritised in previous studies over benefits, which makes sense given the potential for significant health and environmental threats. Nonetheless, I thought it would be useful in getting a sense of the reporting to also see what claims about benefits of nanotechnology was reported, especially where previous research identified the overwhelmingly positive reporting of nanotechnology over the years (Faber et al., 2005, Gorss and Lewenstein, 2005).

Benefits of nanotechnology

		Responses		
		N	Percent	Percent of Cases
Benefits of nanotechnology	Tiny/powerful computers	91	9.0%	12.0%
	Nanobots repairing bodies/cells	58	5.8%	7.6%
	Improved drug delivery/treatment	51	5.1%	6.7%
	Generic environmental	17	1.7%	2.2%
	Generic medical	48	4.8%	6.3%
	Specific environmental	46	4.6%	6.1%
	Specific medical	30	3.0%	4.0%
	Better manufacturing	125	12.4%	16.5%
	Improved military/security	38	3.8%	5.0%
	Cryonics possible	10	1.0%	1.3%
	Other	96	9.5%	12.6%
	None	332	32.9%	43.7%
	Generic benefit	46	4.6%	6.1%
	Surprising properties	20	2.0%	2.6%
	Total	1008	100.0%	132.8%

Table 5: Benefits of nanotechnology

The table above illustrates how nanotechnology is reported as being beneficial to society. Medical benefits, including nanobots repairing our cells and nanotechnology improving drug delivery, are the top benefit cited in the reporting. Manufacturing benefits are the second most often cited benefits of nanotechnology.

Medical benefits were the most commonly cited benefits for nanotechnology. In total, the study documented medical benefits using five categories – nanobots repairing our bodies/cells, improved drug delivery/disease detection, generic medical benefits, specific medical benefits (not otherwise captured by the coding schedule), and making cryonics possible. In total, these benefits appeared in 25.9 per cent of the reporting, or 197 articles. This links to the news values discussion in the previous chapter as these benefits arguably help identify this new area of science as relevant to readers' lives (Hansen, 1994). Additionally, research has demonstrated that news about science and technology tends to centre on medicine and health.

Considering the benefits individually, nanobots repairing damaged cells appeared in 58 articles, or 7.6 per cent of the reporting. This particular benefit was the most prominent medical benefit cited in the articles. References to it appeared in both publications, including a *New York Times* article published on 30 May 2000. The story, "'Camera in a Pill' Views Digestive Tract" by Henry Fountain, discusses research conducted by an Israeli company that made a pill-sized video camera that travels though the digestive tract and transmits pictures along the way. The story does not initially discuss nanotechnology, but the topic is raised in relation to the National Nanotechnology Initiative. Specifically related to nanotechnology, the story discusses how this pill-sized camera is the forerunner to molecular-sized devices, which as nanotechnology develops will enable the pill-size camera to also include technology that would allow for the repair of the damaged cells. Dr. Richard W. Siegel, chairman of materials science and engineering department at Rensselaer Polytechnic Institute, is quoted as saying: "The total package may not want to be small," he said, "but it may be packed with more and more power to do things." This type of quote also links to the tiny/powerful computer category of benefit because it describes the shrinking of devices using nanotechnology. That benefit will be discussed in more detail later in this section.

On 14 March 2006, *The Guardian*'s Ian Sample wrote a story titled "Nanotechnology restores hamsters' sight: Hope raised of stroke and spinal cord treatments: Human trials could start in five years, researchers say." The story focuses on "novel" therapies that may become possible as a result of nanotechnology, and although it doesn't specifically cite "nanobots" repairing damaged cells, it does discuss therapies using nanoparticles that self-assemble to repair damaged brain structures, which is why it was coded as "nanobots repairing damaged cells." Of the research, the story says:

> Rutledge Ellis-Behnke of the Massachusetts Institute of Technology, who led the research, said that the technology could first be used to prevent patients undergoing brain surgery from suffering more damage from the surgeon's scalpel. Injecting nanoparticles into the brain while it was being operated on could, the researchers say, heal nerve damage caused by the removal of a tumour, for example.
> The therapy uses tiny particles which, when injected into a damaged part of the brain, spontaneously assemble themselves into a "scaffold" gel which spreads through the damaged area. Tests show that severed nerves

> later regrow through the scaffold and form new connections.

Similar to the previous category, the reporting also frequently cited an opportunity for nanotechnology to improve drug delivery and disease detection. It appeared in 51 articles, or 6.7 per cent of the reporting. According to the articles, nanotechnology will allow for medicines such as chemotherapy treatment to be targeted directly to the infected areas of the body. It would also allow for disease detection to be more precise and possibly detect disease when minute amounts are present in the body. An example of this benefit from the reporting is a 4 Nov. 2003 *Guardian* article by Tim Radford, science editor at the time, which outlines how nanotechnology can be used to more precisely target cancer cells. Specifically, it says:

> American scientists have found a new way to ‘burn’ cancer tumours but leave healthy tissue unhurt. The technique harnesses nanotechnology - science at the scale of a millionth of a millimetre - to reach cancers beyond the surgeon's knife.

A more recent example is a 22 Nov. 2009 *New York Times* article in the business section by Anne Eisenberg, which discussed how nanotechnology researchers have developed artificial “good” cholesterol particles. The story says:

> Now scientists have created tiny particles in the laboratory that mimic those good carriers, scooping up the cholesterol before it can grow into dangerous deposits of plaque. The surfaces of these new particles are coated with fats and proteins so they can bind

> tightly with the sticky cholesterol to transport it through
> the bloodstream.

This is the kind of precise treatment that the code was used to capture. In documenting it in this way, the thesis is able to explore the extent to which this type of medical treatment is reported in the news and the longevity of it in the coverage.

The medical benefits of nanotechnology were also cited in generic ways. In 48 articles, or 6.3 per cent of the reporting, nanotechnology was said to improve medical technology without further description. Additionally, 30 articles, or 4 per cent of the reporting studied, included references to nanotechnology improving medicine in specific ways, although not covered by the other categories identified in the coding. Amongst these specific ways that nanotechnology would improve medicine is a 21 Oct. 1997 *Guardian* article that discusses how nanotechnology could be used to treat paralysis. This was not coded as “drug delivery/diagnosis” because it did not appear to involve medications.

Finally for medical benefits, in 10 stories, or 1.3 per cent of the articles, nanotechnology reportedly will allow for cryonics in the future. As *The New York Times* reported on 22 April 2001:

> Today about 90 people are "suspended" nationwide. Not strung up with wires or making do without driver's licenses, but frozen in the hope that molecular nanotechnology will soon allow bodies suspended cryonically post mortem to be reanimated.

The excerpt was part of a story titled “Freezing Time” by Abby Ellin. The article features companies involved in cryonics services. Cryonics is the low-temperature preservation of dead humans and animals. It is sometimes mistakenly referred to as cryogenics, which is the study of very low temperatures and how material behaves at these low-temperatures. Cryonics draws on cryogenics and other sciences, which one day may include nanotechnology specifically for the reanimation and repair of dead tissue.

This idea was not exclusive to the early days of the reporting, as on 14 Feb. 2008 *The Guardian* reported on advances in cryonics research as part of a piece on an Arizona, US-based cryonics organisation. Toward the end of the story, it references how research into nanotechnology could make cryonics successful. As the examples illustrate, these articles often reported on cryonics conferences or were feature stories about cryonics companies and technology.

Following the medical benefits of nanotechnology, the second most common benefit cited for nanotechnology was improved manufacturing with 125 references to it. In terms of the proportion of articles, manufacturing improvements were cited in 16.5 per cent of the articles in the collection. This is not surprising given the propensity for citing nanotechnology as being useful for manufacturing, which was addressed in the previous chapter. Such benefits of nanotechnology included more efficient manufacturing of a variety of products and the opportunity to develop products at a smaller scale. Such benefits were highlighted in a story about companies investing in nanotechnology for the potential manufacturing benefits, which appeared in a *New York Times* article published on 15 March 2004. Additionally, *The Guardian*'s Sunday paper, *The Observer*, published a "backgrounder" on nanotechnology, paying particular attention to food production opportunities. A quote from one source in the article reflects part of the reason the story was coded as including improved manufacturing as a benefit:

> "There are many ways in which nanoparticles could be used to boost food production," said Professor Terry Wilkins, of Leeds University's Nanomanufacturing Institute. "They could be used to encapsulate flavouring into foods; create packages that will change colour if their food contents go off or be used as coatings that will be bacteria-proof. However, we cannot expect the public to accept this technology without evidence that it has been rigorously tested to show it is completely safe. That must be the first task of any initiative in this field."

This excerpt illustrates the focus on the potential for manufacturing of new products and improved products as a result of nanotechnology.

Benefits labelled as "other" were the third most commonly found benefit claims in the reporting, when taken all together. These benefits are those that do not fit with others identified in the list. In total, these benefits account for 96 references and appear in 12.6 per cent of the reporting.

Computer applications for nanotechnology and the opportunity to shrink microchips and other computer technology also featured heavily in the reporting. In total, 91 references appeared throughout the study in 12 per cent of the reporting overall. As noted in Chapter 5, computers were prominent in the uses of nanotechnology, appearing in 18.6 per cent of the reporting. As such, it is not surprising that the benefits of nanotechnology would also include a higher number of references to shrinking computer technology as a benefit. Stories that included such a benefit included an 18 May 1990 *Guardian* article entitled "Computers shrunk a thousand-fold and molecules designed to order sound the stuff of sci-fi" by Nina Morgan. In addition to the headline, the following sentence taken from the story provides a glimpse into the type of discussion in the news reporting about how nanotechnology will benefit computer technology:

> The potential is enormous and the main hope is to develop materials that will sidestep and ultimately supersede silicon by shrinking the scale of computing over a thousand fold.

Another example of this benefit appears in a 31 August 2010 *New York Times* article by John Markoff. The headline, "Advances Offer Path to Shrink Computer Chip", provides a sense of the discussion around shrinking computer technology. The story itself offers limited references to nanotechnology except to say research carried out by Hewlett Packard and Rice University was conducted by nanotechnology researchers. It focuses on the limitations of shrinking computer technology by more traditional means, as the following excerpt illustrates:

> In recent years the limits of physics and finance faced by chip makers had loomed so large that experts feared a slowdown in the pace of miniaturization that would act like a brake on the ability to pack ever more power into ever smaller devices like laptops, smartphones and digital cameras.

The story goes on to discuss how the new research discovered a way to build “reliable small digital switches — an essential part of computer memory — that could shrink to a significantly smaller scale than is possible using conventional methods.”

In terms of salience in the reporting, the potential benefits for the environment follows shrinking computer technology. The environmental benefits of nanotechnology were captured in two ways - generic references to benefits for the environment and specific references to benefits for the environment. In total, the reporting includes 93 references to benefits for the environment. It appears in 8.3 per cent of the study’s articles. More generic references to environmental benefits account of 17 of those references. These generic references to the environment include a reference to “huge environmental and energy returns” that nanotechnology can bring in an 11 Feb. 2003 *New York Times* article. This particular story also links to the improved manufacturing benefit as the story discusses new manufacturing processes to improve batteries and LED television displays.

Another example of generic environmental benefits comes from a 5 July 2007 *Guardian* article by Kim Thomas. The headline for the story provides the initial sense of this benefit: “Tiny particles that are used to tackle the biggest issues: Nanotechnology applications are being developed to improve energy efficiency and combat global warming.” The story goes on to discuss some of these environmental benefits in both generic and specific ways, as the following excerpt illustrates:

> If the term nanotechnology conjures up futuristic visions of grey goo and self-replicating nano-robots, think again. Nanotechnology - at the scale of about a millionth of a millimetre - is already being used in everyday objects, from trousers that have been coated with nanoparticles to make them stain-resistant to sun creams that use nanoparticles to increase their absorbency. In fact, the most widespread use of nanotechnology is in cosmetics - particularly foundation powders, since the particles can fill in tiny blemishes.
> But it can also be used to tackle big issues - and they don't come any bigger than global warming. Nanoparticles can be used to improve the energy efficiency of traditional materials. Examples range from lightbulbs that will last 60 years, now being developed at Cambridge University, to Envirox, a nanoparticle-based fuel additive used by Stagecoach to improve the efficiency of its buses.

The discussion around nanotechnology being used to "tackle big issues" like global warming is amongst the ways in which the generic benefit to the environment was mobilised. However, the above example also offered the research at Cambridge University to develop light bulbs that last 60 years as a more specific benefit to the environment. In total, the coverage included 46 references to specific benefits of nanotechnology for the environment.

Finally, nanotechnology was also cited as being beneficial for military and security. This benefit links to the uses discussion in Chapter 5, which found that military applications for nanotechnology were cited in 47 instances and appeared in 6.2 per cent of the reporting. In the context of benefits, I coded articles that discussed ways in which nanotechnology would not only be used for military or security purposes, but would also improve some aspect or element of military/security technology. The articles include 28 references to benefits for the military or security and appear in 5 per cent of the reporting.

These benefits were highlighted in a *New York Times* story on 30 Sept. 2001 by Mary Williams Walsh. The story discusses the economic impacts of the Sept. 11 World Trade Centre attack. Where the story is so intensely focused on the attacks, it is not surprising that the military and security are featured in the article. Overall, nanotechnology is a small part of the story, and is primarily featured in a discussion around how such research will benefit the military, as the excerpt highlights:

> Now, America's heightened sense of insecurity may give rise to even more commercial applications. Mr. [Webb] Johnson spoke of Sandia's work in nanotechnology — the science of engineering complex machines the size of a pinprick — and the promise it holds for developing microscopic nerve-gas detection robots or spy satellites the size of grains of pollen.

Additionally, this example also addresses how nanotechnology is discussed as an economic benefit, which perhaps should have been a category within the benefits of nanotechnology. That said the economic and business aspects of nanotechnology are addressed in the framing of nanotechnology, which is discussed later in this chapter.

Before moving on to how benefits were reported based on whether nanotechnology was the subject, I'd like to return to the idea that the benefits of nanotechnology were discussed in generic ways, which was mentioned regarding medical and environmental benefits. In addition to those medical and environmental benefits, nanotechnology was also discussed in generic ways that had little or nothing to do with medicine or the environment. In total, the study captured three different ways in which nanotechnology was discussed as improving society in some way without a specific benefit being identified, encapsulating 14.6 per cent of the stories in the study. A total of 111 references to generic benefits were identified in the reporting. These generic benefits included where nanotechnology would reportedly improve medicine and the environment without a more specific benefit being cited, as previous paragraphs in this section discussed. Other generic references to nanotechnology benefits were raised 46 times in a total of 6.1 per cent of the reporting studied. A brief article, 102 words, in *The New York Times* on 26 Sept. 2001, announced the development of nanotechnology research centres at several universities in New York. It provides an example of the more generic ways that nanotechnology benefits have been discussed. The story says the research centres aim to "foster research in extremely small technologies that it hopes will transform electronics, medicine and other fields."

In summary, claims about the potential for medical and manufacturing benefits were amongst the most salient in the reporting of *The Guardian* and *The New York Times.* This finding addresses a gap in the previous research, which had not documented the specific benefit claims nor did it document risk claims, which are addressed later in this chapter. Overall, where medicine and health are such popular topics in the reporting of science and technology, it is perhaps not surprising that it is the most prominent of the benefit claims cited in the coverage of nanotechnology. What was surprising were some of the benefits themselves, which appeared frequently in the reporting. For example, the opportunity for nanobots exploring our bodies and conducting surgery on damaged tissue, was the top medical benefit cited. Although articles, including those cited in the narrative above, offered some potential near future application, many of the discussions were more fantastical and futuristic in nature. This raises a question about the potential for meaningful discussion by the audience where nanotechnology may be seen as a field with great promise, but little potential for application now. Therefore, to what extent will the audience potentially engage beyond a “gee whiz” level of engagement (see for example Lewenstein, 2005a, Allan, 2008, Weigold, 2001, Priest, 2001, Carvalho, 2007).

Now, the thesis turns to how nanotechnology’s potential benefits were reported based on whether it was the primary topic of a story or if it was discussed as part of a story on something else (a secondary subject of news), beginning with stories primarily about nanotechnology. When nanotechnology is the focus of an article, it most often identified some benefit to this new technology. A total of 22 articles, or 10 per cent of the reporting, mentioned no explicit benefit to nanotechnology, leaving 90 per cent of the reporting primarily about nanotechnology as having discussed some benefit, even in generic ways.

The most prominent benefit identified in the reporting of nanotechnology was for medical technology (see Table 6 below). Such benefits appeared in 97 articles, or 44.1 per cent of the reporting. The most often referenced of which was the opportunity to improve drug delivery or disease detection, which appeared in 34 articles (see Table 7below). Also prominent within this category was the potential for nanobots repairing damaged cells, which was referenced in 28 articles. More generic medical benefits appeared in 19 articles and specific benefits not otherwise categorised appeared in 14 articles. Finally, the opportunity for cryonics appeared in two articles about nanotechnology.

Top 5 Benefits of Nanotechnology by story type

Stories about Nanotechnology	Stories that mention nanotechnology
1) Medical 97 articles (44.1%)	1) Medical 100 articles (18.7%)
2) Manufacturing 70 articles (31.8%)	2) Manufacturing 55 articles (10.2%)
3) Shrinking computer technology 59 articles (26.8%)	3) Other 38 articles (7.1%)
4) Other 58 articles (26.4%)	4) Shrinking computer technology 32 articles (5.9%)
5) Environmental benefits - generic & specific 37 articles (16.8%)	5) Environmental benefits - generic & specific 22 articles (4.1%)

Table 6: Top 5 Benefits of Nanotechnology by story type

The table above outlines the top five benefits of nanotechnology as reported based on story topic. Overall, the same five benefits are most prominent in the reporting whether stories are primarily about nanotechnology or if stories are about something else and mention nanotechnology. The medical benefits, including the potential for nanobots to be inserted in our bodies to repair damaged cells and generic medical benefits, are the most often cited benefits of nanotechnology for both types of stories. However, as the statistics suggest, stories that only mention nanotechnology are far more likely to have no benefits cited. The detail of these benefits is displayed in the table below.

Benefits of nanotechnology by story topic

			Story Topic		
			Nano	Story with nano	Total
Benefits	Tiny/powerful computers	Count	59	32	91
		% within Story Topic	26.8%	5.9%	
	Nanobots repairing bodies/cells	Count	28	30	58
		% within Story Topic	12.7%	5.6%	
	Improved drug delivery/treatment	Count	34	17	51
		% within Story Topic	15.5%	3.2%	
	Generic environmental	Count	11	6	17
		% within Story Topic	5.0%	1.1%	
	Generic medical	Count	19	29	48
		% within Story Topic	8.6%	5.4%	
	Specific environmental	Count	26	20	46
		% within Story Topic	11.8%	3.7%	
	Specific medical	Count	14	16	30
		% within Story Topic	6.4%	3.0%	
	Better manufacturing	Count	70	55	125
		% within Story Topic	31.8%	10.2%	
	Improved military/security	Count	17	21	38
		% within Story Topic	7.7%	3.9%	
	Cryonics possible	Count	2	8	10
		% within Story Topic	.9%	1.5%	
	Other	Count	58	38	96
		% within Story Topic	26.4%	7.1%	
	None	Count	22	310	332
		% within Story Topic	10.0%	57.5%	
	Generic benefit	Count	17	29	46
		% within Story Topic	7.7%	5.4%	
	Surprising properties	Count	17	3	20
		% within Story Topic	7.7%	.6%	
	Total	Count	220	539	759

Percentages and totals are based on respondents.

Table 7: Benefits of nanotechnology based on story type

The table above illustrates the benefits most often cited in the reporting by these two newspapers based on whether nanotechnology is the subject of the story or whether it is part of a story about something else.

The second most prominent benefit cited in nanotechnology stories was the opportunity to improve manufacturing, which appeared in 70 articles or 31.8 per cent of the reporting about nanotechnology. The proportion of stories focusing on nanotechnology as useful for manufacturing was high, as was the proportion of stories citing benefits for manufacturing in the entire collection of stories examined.

Nanotechnology was also cited as beneficial for shrinking computer technology in 59 articles about nanotechnology or 26.8 per cent of the reporting on the topic. That is followed closely by the “other” benefits for nanotechnology, which appeared in 58 articles or 26.4 per cent of the reporting on nanotechnology. Finally, the benefits for the environment – generic and specific references – appeared in 37 articles or 16.8 per cent of the reporting on nanotechnology. Specific references to environmental benefits made up the majority of those references with 26 articles citing such benefits.

Looking at the stories primarily about something else, the benefits of nanotechnology are discussed far less often than in stories where nanotechnology is the main subject of the story. In total, 310 of the 539 articles about something else that mention nanotechnology have no benefit cited in the reporting. That represents 57.9 per cent of the reporting. Where benefits are cited, the medical benefits and the manufacturing benefits of nanotechnology appear to be the most prominently discussed benefits. The medical benefits, taken together appear in 100 articles or 18.7 per cent of the reporting. Specifically within the medical benefits overall, the potential for nanobots being injected into a person’s body to repair damaged cells is the most often cited benefit. It appears in 30 articles, or 5.6 per cent of the reporting. Second to that are more generic medical benefits, which appear in 29 articles or 5.4 per cent of the reporting. Manufacturing benefits on the whole appear in 55 articles, or 10.2 per cent of the reporting that mentions nanotechnology.

The above discussion offered examples of these benefits from each publication, which helps to provide a sense of the reporting beyond the statistics. That said, however, the statistics are useful in understanding the salience of each benefit in the overall reporting. The following discussion will identify the prominence of the benefits for each publication.

As with the overall reporting, the news organisations did not discuss the benefits of nanotechnology explicitly in a number of cases. *The Guardian* did not provide benefits in 187 articles, representing 44.1 per cent of the reporting (see Table 8 below for a summary of the results and Table 9 below for details). *The New York Times* had a similar proportion of articles without benefits with a total of 145 articles representing 43.3 per cent of the reporting that did not include an explicitly stated benefit. However, that leaves more than half of the stories in both publications discussing benefits either generically or specifically.

Top 5 benefits as reported by each news organisation

Guardian	***New York Times***
1) Medical 112 (26.5%)	**1)** Medical 85 (25.5%)
2) Manufacturing 63 (14.9%)	**2)** Manufacturing 62 (18.5%)
3) Other 57 (13.4%)	**3)** Tiny/powerful computers 52 (6.9%)
4) Tiny/powerful computers 39 (5.1%)	**4)** Other 39 (11.6%)
5) Environment 37 (8.8%)	**5)** Environment 26 (7.8%)

Table 8: Top 5 benefits of nanotechnology as reported by each newspaper

The table above outlines the benefits most commonly referred to in each of the two publications. *The Guardian* and *The New York Times* broadly report the same five benefits most often. The categories in the table above aggregate some of the information provided in Figure 32 below.

Benefits by News Organisation

			News Organisation		
			Guardian	New York Times	Total
Benefits[a]	Tiny/powerful computers	Count	39	52	91
		% within NO	9.2%	15.5%	
	Nanobots repairing bodies/cells	Count	42	16	58
		% within NO	9.9%	4.8%	
	Improved drug delivery/treatment	Count	22	29	51
		% within NO	5.2%	8.7%	
	Generic environmental	Count	7	10	17
		% within NO	1.7%	3.0%	
	Generic medical	Count	22	26	48
		% within NO	5.2%	7.8%	
	Specific environmental	Count	30	16	46
		% within NO	7.1%	4.8%	
	Specific medical	Count	21	9	30
		% within NO	5.0%	2.7%	
	Better manufacturing	Count	63	62	125
		% within NO	14.9%	18.5%	
	Improved military/security	Count	21	17	38
		% within NO	5.0%	5.1%	
	Cryonics possible	Count	5	5	10
		% within NO	1.2%	1.5%	
	Other	Count	57	39	96
		% within NO	13.4%	11.6%	
	None	Count	187	145	332
		% within NO	44.1%	43.3%	
	Generic benefit	Count	29	17	46
		% within NO	6.8%	5.1%	
	Surprising properties	Count	5	15	20
		% within NO	1.2%	4.5%	
Total		Count	424	335	759

Percentages and totals are based on respondents.

a. Group

Table 9: Benefits of nanotechnology as reported by each news organisation

The table above outlines the benefits of nanotechnology as reported by the two news organisations. Specifically, it demonstrates the salience of medical benefits - when taken together - and manufacturing benefits in the reporting.

As the tables above illustrates, medical benefits of nanotechnology are the most prominent benefits cited by both publications. *The Guardian* includes 112 references to medical benefits in all categories used from this research. It appears in 26.5 per cent of the reporting. Within those medical benefits, the opportunity for nanobots repairing damaged cells is the most often referenced with 42 mentions in the newspaper's reporting (see Table 9 above). It appears in 9.9 per cent of the articles published. Second to that are generic references to nanotechnology and the opportunity for improved drug delivery or disease detection, which each have 22 references in the coverage and appear in 5.2 per cent of the reporting. More specific references to medical benefits arise in 21 instances and 5 per cent of the reporting; while the opportunity for cryonics is discussed in only 5 cases and appears in 1.2 per cent of the reporting.

The New York Times reporting provides a similar proportion of reporting medical benefits at a rate of 85 references in 25.5 per cent of the reporting. However, the similarities end there. The most common medical benefit reported by the newspaper was the opportunity for improved drug delivery with 29 references to it in the reporting. It appears in 8.7 per cent of the newspapers' articles. Secondly, *The New York Times* reported the medical benefits of nanotechnology in more generic ways in 7.8 per cent of articles in the study with a total of 26 references to generic medical benefits. Nanobots repairing cells appeared in 16 articles or 4.8 per cent of the newspaper's reporting. The newspaper included 9 references to specific medical benefits not otherwise identified by the coding sheet, which represented 2.7 per cent of the reporting. Finally, the opportunity for cryonics was mentioned only 5 times, representing 1.5 per cent of *The New York Times* reporting in the study.

The two newspapers also reported manufacturing benefits of nanotechnology as the second most prominent benefit of nanotechnology. *The Guardian* reporting included 63 references to it in 14.9 per cent of the articles. Similarly, *The New York Times* had 62 references to improved manufacturing in 18.5 per cent of the reporting.

However, when it comes to the third and fourth most prominent benefits in each publication, the two newspapers differ in their reporting. For *The Guardian* the "other" benefits of nanotechnology received 57 references in 13.4 per cent of the reporting. As noted above, these "other" benefits represent a variety of benefits that were not otherwise categorised. *The New York Times* on the other hand discussed the opportunity to shrink computer technology as the third most often cited benefit with a total of 52 references in 6.9 per cent of the reporting. The fourth most prominent benefit in *The Guardian* is the shrinking of computer technology with a total of 39 references in 5.1 per cent of the reporting. *The New York Times*' fourth most prominent benefit is the "other" benefits of nanotechnology with 39 references in 11.6 per cent of the reporting.

The two newspapers again report the environmental benefits of nanotechnology as the fifth most common benefit. *The Guardian* reporting refers to environmental benefits in 37 instances across 8.8 per cent of the reporting. This includes 7 generic references to nanotechnology's potential environmental benefits and 30 specific references to environmental benefits. *The New York Times* coverage includes 26 references to environmental benefits across 7.8 per cent of the reporting. This includes 10 references to generic benefits and 16 references to specific benefits.

Risks of nanotechnology

Conversely, the risks of nanotechnology also featured in the reporting, although not as frequently as the benefits. The table below (see Table 10 below) outlines the risks of nanotechnology that were identified in the reporting. In many cases they mirror the benefits of nanotechnology, although more generic risks were identified. As with the benefits, the list of risks was gathered during the pilot readings of the content. Previous research was also a guide for establishing what risks to include in the coding schedule (Weaver et al., 2009, Anderson et al., 2009b, Friedman and Egolf, 2005), which provided the wait and see, runaway technology, grey goo and some of the generic risk categories.

Risks of nanotechnology

		Responses		
		N	Percent	Percent of Cases
Risks of nanotechnology	Generic medical	38	4.3%	5.0%
	Generic environmental	23	2.6%	3.0%
	Generic ELSIs	26	3.0%	3.4%
	Specific medical	20	2.3%	2.6%
	Specific environmental	3	.3%	.4%
	Specific ELSIs	10	1.1%	1.3%
	Wait & see	32	3.6%	4.2%
	Misuse/abuse	20	2.3%	2.6%
	Runaway technology	19	2.2%	2.5%
	Grey goo/self-replication	62	7.1%	8.2%
	Other	8	.9%	1.1%
	None	559	63.7%	73.6%
	Generic risk	57	6.5%	7.5%
	Total	877	100.0%	115.5%

Table 10: Risks of nanotechnology as reported by the new newspapers combined

The table above outlines the risks identified in the reporting. These risks were less frequently mentioned in the reporting than the benefits of nanotechnology. In total 73.6 per cent of the reporting made no reference to risk. Other references to risk were primarily generic in nature.

The risks of nanotechnology were far less commonly reported in the articles than the benefits had been which is evidenced by the volume of stories that identify no risks. In total, 559 of the 759 articles in the study had no risks identified in the reporting. That represents 73.6 per cent of the overall reporting in the study. As noted above, more than half of the articles in the study offered some benefit of nanotechnology. As previous studies have suggested based on the tone of reporting, the benefits therefore outweigh the risks of nanotechnology in the reporting. This thesis, however, empirically documents the extent of this idea and illustrates what benefits and risks are particularly highlighted in the reporting. Where benefits are so prominent and risks are virtually absent in the reporting, it raises a question about the professional norm of objectivity and contrasts with the reporting of such topics as climate change (see for example Boykoff and Boykoff, 2004, Boykoff and Boykoff, 2007, Carvalho, 2007). Additionally, as was discussed with regard to the tone of nanotechnology reporting, the lack of risk coverage contributes to the overwhelmingly positive reporting of the topic throughout the study period. Again, this can mean that if/when a significant threat is posed by nanotechnology that coverage becomes more so negative and we see a backlash to the issue and perhaps the research and those researchers involved in the study (Gorss and Lewenstein, 2005).

Before looking at what risk claims were reported, I should note that in some cases more than one risk was identified in the story, which is why per cent of cases in the table below and in the narrative here will total 115.5 per cent, which includes the per cent of cases where no risk was identified in the reporting. Now to look at what has been covered, the most prominent risk in the reporting of nanotechnology was technology advancing too quickly and getting out of control, which was represented by two categories - runaway technology and grey goo/self-replication. Combined, they represented 81 references and appeared in 9.3 per cent of the reporting. Examples of this reporting include a 9 Dec. 2003 Science Times story in *The New York Times* that discusses a "Point/Counterpoint" article that had been published in the Chemical & Engineering News magazine outlining the positions on nanotechnology and the potential of nanobots in particular. The two sides of the argument were presented by Dr. K. Eric Drexler, who wrote *Engines of Creation* and is credited with coining the term "nanotechnology", and Nobel Prize winning Rice University professor Dr. Richard E. Smalley. The article says:

> In "Engines of Creation" (1986), Dr. Drexler proposed his idea of "molecular assemblers," nanobots that would be able to build almost anything, including copies of themselves. Swarms of nanobots may one day be able to perform tasks like breaking down pollutants into harmless molecules or repairing damage in individual cells, perhaps even reversing the effects of aging.
>
> If swarms of nanobots were capable of such miraculous feats, they could also conceivably multiply out of control: a microscopic mechanical cancer that pushed biological life to extinction. Drawing on Dr. Drexler's work, Bill Joy, chief scientist of Sun Microsystems, argued in April 2000 in *Wired* magazine that humanity was on the technological road to ruin and that scientists should voluntarily give up research that could lead to nanobots.

The idea of nanobots reproducing out of control has been called "grey goo" because if nanobots continue to self-replicate by continuing to draw on all biological life, then all that will be left in the world will be “grey goo.” Later in the article, Dr. Smalley goes on to dismiss the idea that nanobots can even be created because the manufacturing that is required is so precise that it is unlikely that scientists and engineers would be able to conduct such work. As such, this example highlights some of the nuances of the risk reporting, which other researchers have highlighted by pointing out that despite the potentially negative connotations of risk that reporting tends to balance the risks (Friedman and Egolf, 2005). The news organisations have balanced the risk of nanotechnology with alternative views on the potential for such risks to come true, as in this case where grey goo was identified and dismissed in the reporting.

Looking at risk claims about “runaway technology” provides a similar story. This category sometimes overlaps with the notion of “grey goo”, but what makes it different is that it does not specifically deal with self-replication. A 4 May 1995 *Guardian* article that features Ed Regis, a former philosophy professor at Howard University in Washington, D.C. and author of the book “Nano!” that outlines the early history of nanotechnology. The story outlines some of the benefits of nanotechnology and in the course of discussing risks, it says:

> Even though he has heard the dire prophesies about nanotechnology running out of control, like some virus eating up everything in its path, Regis is not worried by the possibility. 'I am much more afraid of nanotechnology working correctly. The human race has always had to contend with things 'going wrong' - that's something we've learned how to do. But if nanotechnology really works, if it works right, then people will no longer have to work for a

> living. There will be nothing that they have to do. This is an unprecedented prospect, and I'm wondering if most people will be able to stand it....'

In this example, the article not only discusses runaway technology, but Regis' quote raises an ethical, legal or social implication. Although the story does not provide a specific reason why nanotechnology may eliminate people's need to work, Regis' quote within the excerpt offers it as a potential risk.

The second most common risk identified in the reporting was medical risks, which were captured by the categories of generic and specific medical risks. Overall, the medical risks of nanotechnology were referenced in 58 instances and appeared in 7.6 per cent of the reporting. More generic references to risks make up most of those references, or 38 instances. Such generic references to medical risks include a 19 May 2005 *Guardian* article about a citizens' jury set up by Greenpeace and scientists at the Cambridge University. The jury aimed to prompt a public debate about nanotechnology and the potential risks of it. The story discusses the potential benefits and risks posed by nanotechnology. In particular, the potential environmental and medical risks of nanotechnology are highlighted, as the following excerpt illustrates:

> In 2003 concerns raised by the Prince of Wales prompted an inquiry into nanotechnology by the Royal Society and the Royal Academy of Engineering. Last year the bodies called for rules to protect human health and the environment from any threats posed by nanotechnology, in particular nanoparticles.

> Nanoparticles, which can be up to 800 times finer than a human hair, posed legitimate concerns, Royal Society scientists said. The particles can be far more toxic than larger particles of the same material yet they are already used in sunscreens and cosmetics.

More specific, although still a generic risk of nanotechnology appeared in a 14 Jan. 2007 *New York Times* article about Berkeley, Calif.'s decision to regulate businesses that are engaged in nanotechnology research and the work done by the city's hazardous waste manager Nabil Al-Hadithy to research and create a regulation for work being done on the nanoscale. The story begins by pointing out the challenge of regulating nanotechnology in part because it is difficult to define nanotechnology and understand exactly what it is, how it works and what it does. When it comes to the medical risks associated with nanotechnology research, the story says:

> But he [Mr. Al-Hadithy] said he hoped that Berkeley's move would draw attention to animal studies suggesting ways that at least some nanoparticles might harm the lungs or brain and would influence regulators elsewhere to seek more information. Federal and state regulators, like their counterparts overseas, have so far been happy to sponsor meetings and studies that call for regulation but notably reluctant to engage in any. A very small fraction of the billions of dollars being invested in nanotechnology research is being used to ferret out potential risks.

The excerpt above talks about the potential for causing damage to animals' lungs and brain is still quite a generic way of describing the potential risk of nanotechnology. The same issue is highlighted in a more specific way in the following excerpt, which comes from one of 20 articles that were coded as specific medical risks of nanotechnology. The 17 May 2006 *New York Times* article that discusses the risks of new technology, including nanotechnology talks about the toxicity of nanoparticles and the potential hazards it can cause, as the following illustrates:

> It is already documented in animal research that some man-made nanoparticles can move easily into the brain and deep into the lungs. "But we don't know how to find these things in the body or how to measure them in the air," said John M. Balbus, a nanotechnology expert at Environmental Defense, an advocacy group that has argued that investment in safety research should be more than doubled and restrictions be imposed on the use of some nanoproducts. "There's a lot of basic gaps in information."

Generic risks, not including those generic risks that link to medical, environmental, and ethical, legal and social implications of nanotechnology, are the fourth most salient risk in the reporting with 57 references that appear in 7.5 per cent of the reporting. Examples of such generic risk reporting includes a *New York Times* articles published on 12 March 2006, which talks about the consumer products that are developed using nanotechnology. The risks are only mentioned in passing in the following sentence, which leads the article:

> One way to grasp all the fuss about nanotechnology — the billions of dollars invested; the talk of potential breakthrough products in energy, computing and health care; the fears of novel hazards unleashed on an unsuspecting populace — is to plunge into the underlying science

If the 57 references where risks are simply discussed as they were in the example above together with the generic ways that medical, environmental and ethical, legal and social implications of nanotechnology were addressed, that would mean in total these more generic ways of talking about nanotechnology were referenced in 176 articles across 23.1 per cent of the reporting. That's nearly every article in the study that mentions risk.

The ethical, legal and social implications of nanotechnology appear in 4.7 per cent of the reporting with a total of 36 references. These implications were articulated in primarily generic ways with 26 such references appearing in 3.4 per cent. Examples of such generic references include a *Guardian* Comment and Debate article published on 30 June 2006. The story links nanotechnology to the idea of transhumanism where biology and technology will be merged to the point that "humanity is on the brink of being liberated from its biology". One example of this idea is that a human consciousness might one day be "uploaded" to a computer and live on in that state beyond the death of their human body. The article outlines the debates around this idea of transhumanism, including the criticism of these ideas:

> This is the prospect that horrifies the so-called "bio-conservatives" such as Francis Fukuyama, who argues that transhumanism is the most dangerous ideology of our time. There are plenty who share his concerns, pointing out that the implications for human rights, indeed for our understanding of what it is to be human, are huge.

In addition to such complex ideas around the nature of humanity as a potential social implication of nanotechnology, this category captured circumstances where the reporting highlighted ethical debates around nanotechnology, including a 12 Aug. 2008 article in *The New York Times* that discussed new technology and the need for discussion around the ethics of certain research, including nanotechnology. In the story, scientists and engineers debated who is best placed to participate in these discussions.

Additionally, specific references to ethical, legal and social implications of nanotechnology accounted for 10 references, which appeared in 1.3 per cent of the reporting. Examples of these specific references include a *New York Times* article published on 19 May 2003 that discussed concerns raised about nanotechnology by the Prince of Wales and the ETC Group, a non-profit organisation based in Canada. In particular, the story discussed an essay the ETC Group published in an ecology magazine that was later re-printed by *The Times of London*. According to the *New York Times* article, "the essay began with the suggestion that although the gray goo nightmare might be 'far- fetched,' nanotechnology could 'create a divided and inequitable world where the rich live forever.'" The potential for a more significant gap between the rich and poor was amongst the moral implications of nanotechnology, which was raised in the reporting and documented using this particular category.

Following that, a wait and see attitude to the risks of nanotechnology appeared in 4.2 per cent of the reporting. A total of 32 references to potential risks that cannot currently be identified were found in the reporting. While this could arguably be part of the generic risks category, it stood on its own in this study because it had in previous research. Examples from this study include a *Guardian* article published on 19 Jan. 2006 under the headline "Does Scarlett need regulatory oversight?" The headline refers to actress Scarlett Johansson, who had signed a celebrity endorsement deal with L'Oreal at the time the story was published. The cosmetics company had 192 patents involving nanotechnology and its products. As part of the story, which focused primarily on the regulation of nanotechnology in cosmetics products, the risks of nanotechnology and nanoparticles in cosmetics was also discussed, as the example below illustrates.

> But is it safe for Johansson to put this stuff on her skin? L'Oreal insists there is no evidence that the nanoparticles used in its cosmetics can penetrate to the living cells, rather than the dead dermis. But there's no definitive answer, mostly because commerce is moving a lot faster than regulatory bodies.
> There has been no movement, for example, on the Royal Society's call last November, saying that further research into the health and safety aspects of nanotechnology was "urgently needed". With the jury out, Johansson is essentially a guinea pig - albeit a very well-paid one.

The excerpt above illustrates the “wait and see” category of risk by the question it opens with and especially the last sentence, which refers to Johansson as a well-paid guinea pig for nanotechnology in cosmetics.

Following wait and see in terms of salience in the reporting was environmental risks of nanotechnology, which were less prominent in the reporting than the benefits to the environment had been. In the case of risks, only 26 references to environmental risks were identified and appeared in 3.4 per cent of the reporting. As with the benefits, the environmental risks had been discussed in generic and specific ways. The risks were primarily referenced in generic ways with a total of 23 such references that appeared in 3 per cent of the reporting. Such references included a 30 Sept. 2009 *New York Times* article about the U.S. Environmental Protection Agency’s plans for research around the health and environmental risks of nanotechnology, particularly nanomaterials that are found in consumer products like sunscreen and adhesives. The story provides little discussion of specific environmental or health risks, instead talking about potential “hazards” that could be posed, as the following example illustrates:

> Little is known about whether substances engineered at the nano scale persist and accumulate in the environment in unusual and potentially harmful ways. In August, a coalition of groups including Friends of the Earth and Consumers Union issued a report urging people to avoid sunscreens containing nano-forms of zinc oxide, saying their risks were unknown.

This example can also be used to illustrate the “wait and see” idea of nanotechnology risk because it discusses how “little is known” about the risks of nanotechnology and what can happen as a result of nanoparticles in the environment.

In a *Guardian* Comment and Debate article published on12 June 2003, Caroline Lucas, a Green party MEP for the south-east of England, says:

No regulatory body has taken the lead to ensure that nanotech applications are safe and many of the hard questions have not yet been asked: who will control nanotechnology? What mischief can synthetic nanoparticles create floating around in our ecosystem, food supply and bodies?

The article raises a number of questions about the risks of nanotechnology, but the last question posed illustrates the more generic way in which the risk to the environment appeared in the publication.

Additionally, the reporting included three specific references to environmental risks. These references included a business brief in the 1 Oct. 2007 *New York Times* about the Environmental Protection Agency's decision to classify the Samsung washing machine that uses nano-silver to kill bacteria during the washing. In discussing the regulation and the implications of it, the story says:

> The case had been viewed by some as another crucial test of how the government will treat consumer products that exploit nanotechnology, the rapidly developing use of particles consisting of small numbers of atoms or molecules — a scale normally measured in nanometers, or billionths of a meter. More than 100 other products, like clothing, countertops and bandages, are impregnated with silver nanoparticles to kill bacteria. The presumption is that since these products are intended to hold onto the particles rather than release them, they will have less environmental impact. But some experts fear that a proliferation of such products will eventually spur the evolution of silver-resistant microbes.

The potential for developing silver-resistant microbes is a specific environmental risk raised by the reporting.

When looking at the risks associated with nanotechnology based on the story's topic, the newspapers represent the risk of nanotechnology differently (see Table 11 below). When nanotechnology is the subject of the story, it is more likely that risks will be discussed. In total, 91 articles about nanotechnology included references to risk, which represents 41.4 per cent of the reporting about nanotechnology. That still leaves 129 stories primarily about nanotechnology, or 58.6 per cent of the reporting, that did not mention any risks associated with the technology. Although more promising than the 73.6 per cent of all of the reporting in the study that lacked a discussion or risk, it remains a large proportion of reporting primarily about nanotechnology that lacks any mention of the potential risk.

Risks by Story topic

			Story Topic		
			Nano	Story with nano	Total
Risks[a]	Generic medical	Count	32	6	38
		% within StoryTopic	14.5%	1.1%	
	Generic environmental	Count	22	1	23
		% within StoryTopic	10.0%	.2%	
	Generic ELSIs	Count	11	15	26
		% within StoryTopic	5.0%	2.8%	
	Specific medical	Count	15	5	20
		% within StoryTopic	6.8%	.9%	
	Specific environmental	Count	1	2	3
		% within StoryTopic	.5%	.4%	
	Specific ELSIs	Count	7	3	10
		% within StoryTopic	3.2%	.6%	
	Wait & see	Count	25	7	32
		% within StoryTopic	11.4%	1.3%	
	Misuse/abuse	Count	6	14	20
		% within StoryTopic	2.7%	2.6%	
	Runaway technology	Count	5	14	19
		% within StoryTopic	2.3%	2.6%	
	Grey goo/self-replication	Count	32	30	62
		% within StoryTopic	14.5%	5.6%	
	Other	Count	7	1	8
		% within StoryTopic	3.2%	.2%	
	None	Count	129	430	559
		% within StoryTopic	58.6%	79.8%	
	Generic risk	Count	27	30	57
		% within StoryTopic	12.3%	5.6%	
Total		Count	220	539	759

Percentages and totals are based on respondents.

a. Group

Table 11: Risks reported by story topic

The table above outlines the risks reported in stories about nanotechnology and those that mention nanotechnology. Where nanotechnology was the subject of a story, it was more likely to discuss the potential risks involved. In total, 91 articles about nanotech included references to risk (129 did not), which represents 41.4 per cent (58.6 per cent of the reporting mentioned no risk). When stories were about something else but discussed nanotechnology, far fewer addressed risk (109 stories mentioned risk, representing 20 per cent of the reporting). Medical risks – generic and specific – were the most prominent risk identified in stories about nanotechnology with a total of 47 references across 21.3 per cent of the reporting. For stories that mention nanotechnology, the potential for it to run out of control – either with self-replicating nanobots or other runaway technology – was the most prominent risk identified with 44 references that appeared in 8.2 per cent of the reporting.

Where risk is reported, medical risks – both generic and specific references – are the most salient in the reporting with references in 47 articles or 21.3 per cent of stories about nanotechnology. The generic references to nanotechnology are more often cited with a total of 32 references. Specific risks appear in 15 articles.

The opportunity for technology to expand out of control was the second most common risk found in the reporting about nanotechnology, which totalled 37 references in 16.8 per cent of the reporting. That includes 30 references to grey goo and 7 references to other runaway technology.

Thirdly, generic risks were discussed in 27 articles about nanotechnology, which represents 12.3 per cent of the reporting. These references do not include the generic ways in which medical, environmental, or social implications are discussed, which are addressed elsewhere in this section.

Environmental risks of nanotechnology were discussed in 23 stories or 10.5 per cent of articles about nanotechnology. That includes 22 articles that discuss the environmental risks more generically and 1 article that discusses a specific risk of nanotechnology to the environment.

The fifth most common risk found in reporting about nanotechnology were the ethical, legal and social implications of nanotechnology, which appeared in 18 articles or 8.2 per cent of the reporting about nanotechnology. That includes 15 generic references to such risks and 3 more specific references to the ethical, legal and social implications that nanotechnology potentially poses.

Where stories are about something else and mention nanotechnology, the risk of nanotechnology appears in only 20 per cent of the reporting, or 109 articles. That means 430 articles that discuss nanotechnology, or 79.8 per cent, fail to mention any risk associated with nanotechnology. In cases where risk is identified in stories that include nanotechnology, the most common risks identified are the opportunity for technology to expand out of control, which was mentioned in 44 articles or 8.2 per cent of the reporting. That combines the reporting of nanobots self-replicating to the point that the world turns to grey goo, which was discussed in 30 articles. It also includes other references to runaway technology that does not link to nanobots, which appeared in 14 articles.

Generic risks are the second most salient risks cited in stories that mention nanotechnology. In total, it appears in 30 articles or 5.6 per cent of reporting that is about something else but mentions nanotechnology. Thirdly, the ethical, legal and social implications of nanotechnology are mentioned in 18 articles or 3.4 per cent of the reporting. That includes 15 generic references and 3 specific references to ethical, legal and social implications of this new technology.

The potential for nanotechnology to be misused or abused was the fourth most common risk identified in reporting that is about something else, but mentions nanotechnology. In total, it appeared in 14 articles or 2.6 per cent of the stories. Although interesting in that it is fourth most common, it remains a small number of references, especially when thinking about the overall proportion of the reporting that was examined.

The medical risks of nanotechnology appeared in only 11 articles or 2 per cent of this type of story. That includes 6 generic references and 5 specific references to medical risks. As noted previously, it was the most prominent risk of nanotechnology as identified in stories primarily about nanotechnology, so it is interesting that it was so rarely mentioned in stories that discussed nanotechnology as part of an article about something else.

Looking at the two news organisations' reporting of risks, both had a high proportion of stories that did not discuss risks (see Table 12 below for a summary of the data and Table 13 for a detailed review). However, *The Guardian* reported risks slightly more often than *The New York Times*. Risks were absent in 303 articles by *The Guardian* representing 71.5 per cent of its newspaper reporting. Similarly, *The New York Times* reporting did not discuss any risks of nanotechnology in 256 cases or 76.4 per cent of the reporting. This high rate of not reporting risks is amongst the concerns of previous studies into nanotechnology risk, which had been addressed above.

Top 5 Risks as reported by each newspaper

Guardian	***New York Times***
1) Runaway technology & grey goo 49 (11.6%)	1) Runaway technology & grey goo 32 (8.7%)
2) Generic risk 39 (9.2%)	2) Medical risk 20 (6%)
3) Medical risk 38 (9%)	3) Generic risk 18 (5.4%)
4) Ethical, legal & social implications 28 (6.6%)	4) Wait & see 14 (4.2%)
5) Wait & see 18 (4.2%)	5) Ethical, legal & social implications 8 (2.4%)

Table 12: Top 5 risks of nanotechnology as reported by each newspaper

The table above outlines the most prominent risks identified in the reporting. It should be noted that in the case of both publications, the risks of nanotechnology was reported in only 28.5 per cent of *Guardian* articles and 23.6 per cent of *New York Times* articles. However, where nanotechnology risk was identified, these are the most prominent risks in the reporting and the table above aggregates some of the information from the figure that follows. For a more detailed look at the risks of nanotechnology as reported by each publication, please see Figure 36 below.

Risks by news organisation

			News Organisation		Total
			Guardian	New York Times	
Risks[a]	Generic medical	Count	24	14	38
		% within NO	5.7%	4.2%	
	Generic environmental	Count	14	9	23
		% within NO	3.3%	2.7%	
	Generic ELSIs	Count	20	6	26
		% within NO	4.7%	1.8%	
	Specific medical	Count	14	6	20
		% within NO	3.3%	1.8%	
	Specific environmental	Count	2	1	3
		% within NO	.5%	.3%	
	Specific ELSIs	Count	8	2	10
		% within NO	1.9%	.6%	
	Wait & see	Count	18	14	32
		% within NO	4.2%	4.2%	
	Misuse/abuse	Count	9	11	20
		% within NO	2.1%	3.3%	
	Runaway technology	Count	8	11	19
		% within NO	1.9%	3.3%	
	Grey goo/self-replication	Count	41	21	62
		% within NO	9.7%	6.3%	
	Other	Count	5	3	8
		% within NO	1.2%	.9%	
	None	Count	303	256	559
		% within NO	71.5%	76.4%	
	Generic risk	Count	39	18	57
		% within NO	9.2%	5.4%	
Total		Count	424	335	759

Percentages and totals are based on respondents.

a. Group

Table 13: Risks of nanotechnology as reported by each newspaper

The table above illustrates the risks identified in each newspaper and the extent to which each is reported across the coverage. Overall, both newspapers rarely reported the risks of nanotechnology with more than 70 per cent of the coverage having no references to risk of nanotechnology. The single most prominent risk reported in each of the publications is grey goo, which as discussed above was also often dismissed as an unlikely scenario.

As with the reporting overall, the most common risk that was reported in both publications was the risk that nanotechnology would advance too quickly and become out of control (Table 12 above). *The Guardian* reporting included 49 references to grey goo and runaway technology, the two categories that encapsulate the out of control advancement of nanotechnology. Of the two, grey goo was the primary risk identified in the reporting with 41 references to the self-replication of nanobots that continues until all that's left of the world is "grey goo". It appeared in 9.7 per cent of the reporting. Other forms of runaway technology appeared 8 times in the newspaper for a total of 1.9 per cent of the coverage. In the case of *The New York Times*, grey goo was again the most prominent with 21 references across 6.3 per cent of the reporting. Other references to runaway technology totalled 11 across 1.4 per cent of the reporting.

From there, the newspapers' reporting of risks diverges in terms of the salience of each risk. Taking *The Guardian* first, the second most prominent risk reported was generic risks with a total of 39 references across 9.2 per cent of the reporting. The medical risks of nanotechnology - both generic and specific references - appear as the third most commonly reported risk with a total of 38 references across 9 per cent of the reporting. The ethical, legal and social implications of nanotechnology were referenced in 28 articles across 6.6 per cent of the reporting. Finally, the fifth most salient risk in the reporting was the notion of "wait and see" what risks develop with a total of 18 references across 4.2 per cent of the reporting.

By contrast, *The New York Times* reported the medical risks of nanotechnology as the second most prominent risk with a total of 20 references that appeared in 6 per cent of the reporting. The generic risks of nanotechnology were referenced in 18 articles across 5.4 per cent of the reporting. The fourth most common risk in the reporting was the notion of "wait and see" what risks develop, which appeared in 14 articles across 4.2 per cent of the reporting. The ethical, legal and social implications of nanotechnology had only 8 references in 2.4 per cent of the reporting.

Overall, this section has demonstrated the overall lack of reporting that identifies risk claims. When risks are reported, as with the discussion of claims about benefits, the most commonly cited risks of nanotechnology tended to be fantastical in nature, specifically grey goo. These issues raise significant questions about the potential for democratising the news about nanotechnology and allowing for meaningful debate because the risks are far-reaching in nature and appear largely fictional and more along the lines of popular culture.

Framing of nanotechnology

Moving on to framing, the methodology chapter discussed the theory of framing in some detail, including some of the metaphors used to help understand the theory. One such metaphor is that of the picture frame, which although helpful for understanding the theory, can also limit the ways in which we understand the process of framing. Specifically, the picture frame metaphor implies the frame is somehow nailed down, concrete, and stable. Arguably, it is best suited once a dominant frame has developed, perhaps as a result of a major incident that serves as a defining moment. Here I will discuss how nanotechnology provides interesting insights into the complexity of framing and the subtle ways a complex issue can be framed because a dominant frame has yet to be identified in the reporting.

To understand that complexity, this study considered a wide variety of potential frames adopting a list of frames gathered from a number of previous studies that considered nanotechnology reporting (Anderson et al., 2005, Stephens, 2005, Weaver et al., 2009). Additionally, pilot readings of the content highlighted instances of nanotechnology being framed as a natural entity; as such a “nature” frame was added to the list. Finally, an “other” category was also included to capture frames not identified from previous studies and the pilot readings. Although some might argue that such an approach lacks stability and therefore reliability, I believe the frames would lose shape and become overly broad if a conception of nanotechnology were included in a frame category that did not adequately address the ideas encapsulated by the frame title and descriptor. If frames become overly broad, then they lose their meaning and therefore power to help understand the reporting on an issue such as nanotechnology. As such, a total of 15 frames were identified through the various means just described. Each was defined in the methodology chapter, but will be discussed in detail over the course of this chapter to further clarify what the each frame means and how the discussions of nanotechnology in the reporting were applied to the frames.

Some framing studies may see each story as framing an issue in one particular way and often look to the headline and opening and closing paragraphs of a story. However, this study considers where framing can happen in a phrase or sentence and so the body of a story can play an important role in the framing of an issue. Additionally, the approach adopted for framing can also mean that a single story may contain multiple frames for nanotechnology.

However, the headline and opening and closing paragraphs are a useful indicator of a primary frame for a story. These elements of a story are important because the headline and lead help set up an article, in particular, which is why other framing research has looked there for frames. This study used those indicators to identify a primary frame for stories. Another indicator for a primary frame was the repetition of a frame in an article. Where nanotechnology could be part of a story on another topic, it may only be discussed in a phrase or sentence so that framing would be the primary frame for the story. Where it wasn't clear if a story had a primary frame, no such primary frame was identified. Additionally, stories might include other frames, which I also coded as part of the study. Where stories might have multiple frames, the totals for frames and the percentages exceed the 759 articles in the study and percentages total more than 100.

In nearly 94 per cent of cases, or 711 stories, nanotechnology had a primary frame (see Figure 25 below). In other words, most stories offered a preferred interpretation of nanotechnology. However, across all of the newspaper articles there was not a single preferred interpretation. Four frames - visionary, discovery, funding or investment, and risk or social implications -

encompass approximately half of the stories in the study, with at least 10 per cent of articles in each of the frames. The remaining 11 frames varied in their salience from less than 1 per cent to 9.6 per cent. The following paragraphs outline the frames in descending order of salience.

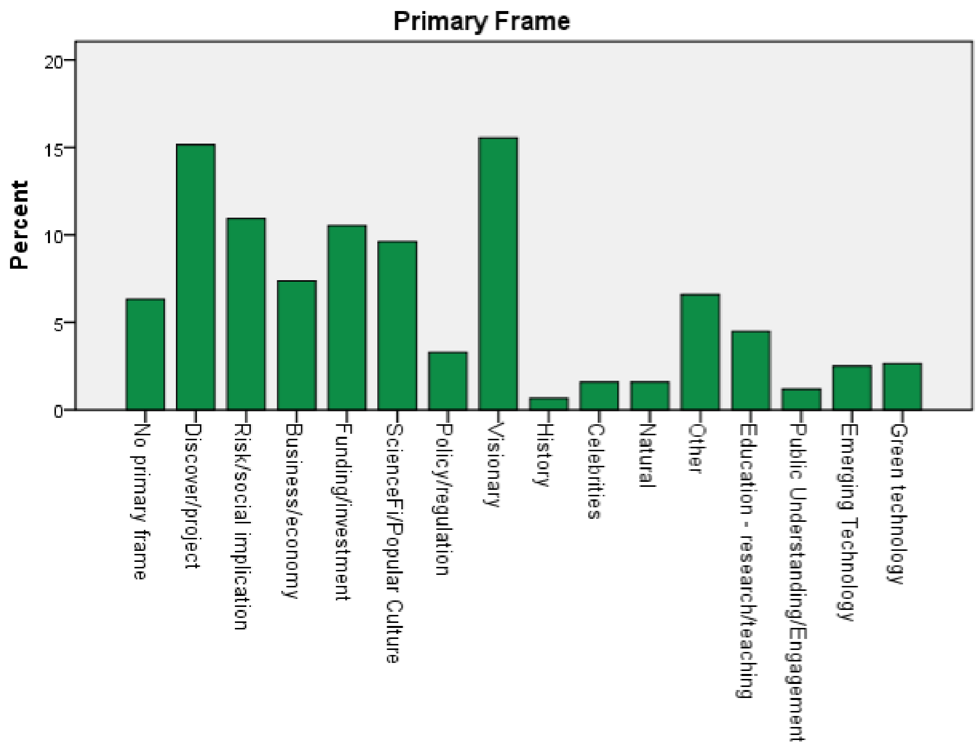

Figure 24: Primary frame for nanotechnology

Over the study period, nanotechnology has primarily been framed as a visionary science and the process of scientific discover, both the pursuit of science and, more commonly, individual projects in pursuit of specific answers.

Nanotechnology was framed as a visionary science in 118 articles, or 15.5 per cent of the cases. The visionary frame describes when nanotechnology is framed in terms of far reaching benefits. For example, a story published on 15 March 1988 in *The New York Times* was identified as part of the visionary frame because of its use of language to discuss the researchers, the research, and nanotechnology itself, as the following excerpt illustrates:

> Some visionary scientists even dream of making computers out of proteins that could be manufactured by living cells. A protein that can alternate between two different shapes, for instance, could theoretically be used to store a unit, or bit, of information, allowing computers to be so small that they could travel down a human blood vessel to repair injuries. Such futuristic technology has been dubbed "nanotechnology," because the machines would have features measured in nanometers, or billionths of meters. But many scientists doubt this technology will ever be possible.

It is perhaps not surprising that nanotechnology would be framed as visionary in the early reporting, but such framing continues in more recent reporting despite nanotechnology and materials produced using nanotechnology becoming more commonly used in consumer products and other applications. For example, on 5 March 2009 *The Guardian* reported on developments in nanotechnology being used by the US military. The headline for the story is part of why it is arguably part of a visionary frame:

> Nanotechnology goes to war: The Pentagon is pioneering micro technology for just about every device, from 10g video cameras to tiny atomic clocks on a chip

The article goes on to discuss a variety ways in which the Pentagon's "extreme science wing", The Defence Advanced Research Projects Agency, is developing smaller and smaller technologies from the "lab-on-a-chip" that allows analysis of DNA using a very small device to "microsensors for imaging [that would] deliver an infrared video camera on a chip weighing just 10g" that could be used for unstaffed aircraft or night-vision goggles. What I found surprising was that apart from the headline, the article does not again mention or define nanotechnology.

After the visionary frame, nanotechnology was most commonly framed as being part of the process of scientific discovery in 115 articles, or 15.2 per cent of cases. For example, on 16 Feb. 1993, *The Guardian* reported on a meeting of the American Association for the Advancement of Science where scientists discussed research into nanotechnology and some of the then recent advances:

> Engineers who have learned to think small since the transistor revolution may have reached "the holy grail of nanotechnology": a box containing one "artificial" atom... Nanotechnology is the engineering of tomorrow, on the smallest scale.

In the story above, the language of a “holy grail” and defining nanotechnology as “the engineering of tomorrow” also made it part of a visionary frame, however, much of the story cantered on the work of scientists in the field and how their research is leading toward future benefits, which is why its primary frame was identified as “discovery”.

A more recent and perhaps straightforward example of discovery is *The New York Times* reporting on 8 Sept. 2009 about a development by scientists at the Israeli Institute of Technology to develop a portable sensor that could be used in screening for lung cancer. The technology works because, as the story says, the breath of people with lung cancer contains more alkenes and other similar volatile compounds. In that story, the work of the scientists was discussed in some detail, as the following excerpt illustrates:

> The sensor, described in Nature Nanotechnology, uses tiny particles of gold, five-billionths of a meter in diameter, that are capped with organic compounds chosen for their ability to react

> with four of the volatile compounds found in higher concentrations in the breath of lung cancer patients. When the particles are deposited in a thin film between two electrodes, they act as an electrical resistor.

Risk and social implications of nanotechnology, although rarely highlighted in the reporting, are a significant part of framing nanotechnology with 10.9 per cent of the reporting, or 83 articles, framing nanotechnology around issues of risk. Amongst the articles that are framed around risk is a 29 March 2004 article by *The New York Times* that begins with:

> Buckyballs, a spherical form of carbon discovered in 1985 and an important material in the new field of nanotechnology, can cause extensive brain damage in fish, according to research presented yesterday at a national meeting of the American Chemical Society in Anaheim, Calif.

The story cited above was coded as a primary frame of risk in part because the lead sentence raises the potential for brain damage in fish. Additionally, the story goes on to talk about additional research that discusses potential environmental and health risks that are raised by other studies involving synthetic nanoparticles.

On 12 Nov. 2008, *The Guardian* published an article under the headline “National: Attack of the tiny particles: Report calls for more tests on 'wonder ingredient': Proliferation of nano materials could pose risk”. The story’s headline and the first two sentences support the identification of the primary frame as risk:

> The government must begin a "major and urgent" effort to assess the safety of nanomaterials, the tiny particles commonly used in products as varied as sun creams, sports clothing and medicine, leading experts warn today. Hundreds of consumer products made with nanoparticles, which can be 100 times smaller than a virus, are already on the market, despite an almost complete lack of knowledge of the dangers they may pose to human health and the

> environment, according to a report by the royal commission on environmental pollution.

The excerpt above highlights how prominent risk is in the reporting, which continued throughout the story.

Following risk is the funding/investment frame for nanotechnology, which appeared as the primary frame in 10.5 per cent of the reporting, or 80 articles. This includes both government and private investment of nanotechnology. Amongst such articles was a 7 Nov. 1996 *Guardian* article about Britain's investment in nanotechnology research as it compares with the US, Japan and Europe. The story begins with the following:

> The Labour Party this week called for a radical overhaul of the government's scientific research policy, after the Parliamentary Office of Science and Technology (Post) warned that Britain could be sidelined in the fledgling but strategic area of nanotechnology: the science of the infinitesimally small.

The idea that Britain is falling behind other countries in a race to advance nanotechnology research was repeated in a number of articles. This idea was linked to the funding of nanotechnology, as the following excerpt from the same article illustrates:

> But despite a healthy start for Britain's nanotechnologists, under two government initiatives that have now run their course, some advanced projects are the funding of a final round of projects. But now there is nowhere for nanotechnologists to turn for new funding and Post fears that 'the earlier momentum generated is in danger of being lost'.

The funding frame extended beyond federal funding of nanotechnology projects as this *The New York Times* article published on 19 July 2005 illustrates:

> New York State officials are continuing to think small when it comes to trying to reinvigorate the flagging upstate economy.
> They plan to announce a $600 million partnership with the computer industry on Thursday to develop technology at the State University at Albany to make transistors even more unimaginably tiny, so they can cram even more of them onto computer chips.

The funding and investment frame also incorporated funding from private industry, which a 1 Oct. 22 article in *The Guardian* illustrates. It discusses the decision by Unilever to invest £113 million in a venture capital fund that is investing in nanotechnology, among other investments.

The science fiction/popular culture frame, which previous research had highlighted as a significant frame for nanotechnology (Anderson et al., 2005, Anderson et al., 2009b), appears as a primary frame in 9.6 per cent of the reporting, or 73 articles. Amongst those stories is an Observer article published on 6 June 1999 about a number of technological advances. The story's headline is "Playing God". In reference to nanotechnology, Dr Hugo de Garis, head of the Brain Builder Group at the ATR laboratories just outside Kyoto in Japan, talks about how nanotechnology will allow for the production of food using trillions of wheat atoms. He likens it to using a replicator from Star Trek and says that a lot of "plausible future science" can be found in Star Trek. Research by Anderson and her colleagues (2005, 2009b) suggested that the popularity of the science fiction frame was problematic in that it suggests that nanotechnology may not be considered a serious science. However, this research, which considers a wider time period than the Anderson study, finds science fiction to continue as a prominent way for framing nanotechnology, but perhaps not as popular as it had been previously. As such, that could indicate that nanotechnology is gaining some purchase as a serious science. That said this research considered two publications in two countries, where the Anderson study considered the framing in the British press more widely.

As this chapter discussed earlier, the reporting on nanotechnology tended to be overwhelmingly positive. That is especially so where stories are framed in particular ways, as this section of the chapter will discuss. Additionally, some frames were more likely to be discussed in balanced or measured ways. No frames received more negative coverage than positive or balanced reporting.

Within the visionary frame, nanotechnology was reported in very positive ways (see Figure 26 below). A total of 104 of the 118 articles, or 88.1 per cent of the articles in the visionary frame, demonstrate a more positive tone, as the examples cited above suggest. The remaining 14 articles, or 11.9 per cent, in this primary frame were more balanced or measured in the approach to nanotechnology, meaning some risks or potential drawbacks were also highlighted in the reporting. The same is true for the discovery frame. Of the 115 articles in the discovery frame, 101 or 87.8 per cent were primarily positive toward nanotechnology. That leaves 13 as more balanced and 1 as more negative toward nanotechnology. The funding/investment frame, business/economy frame, and education frame are other frames that saw high portions of positive reporting of nanotechnology. Nanotechnology was framed in terms of funding/investment in 80 articles of which 64, or more than three-quarters, were positive in nature. The remaining 16 articles were more balanced in the treatment of nanotechnology. A total of 56 articles were coded as framing nanotechnology in terms of business or the economy of which 47 were positive and 9 were more balanced. Finally, the education frame included 34 articles of which 28 were positive and 6 were balanced.

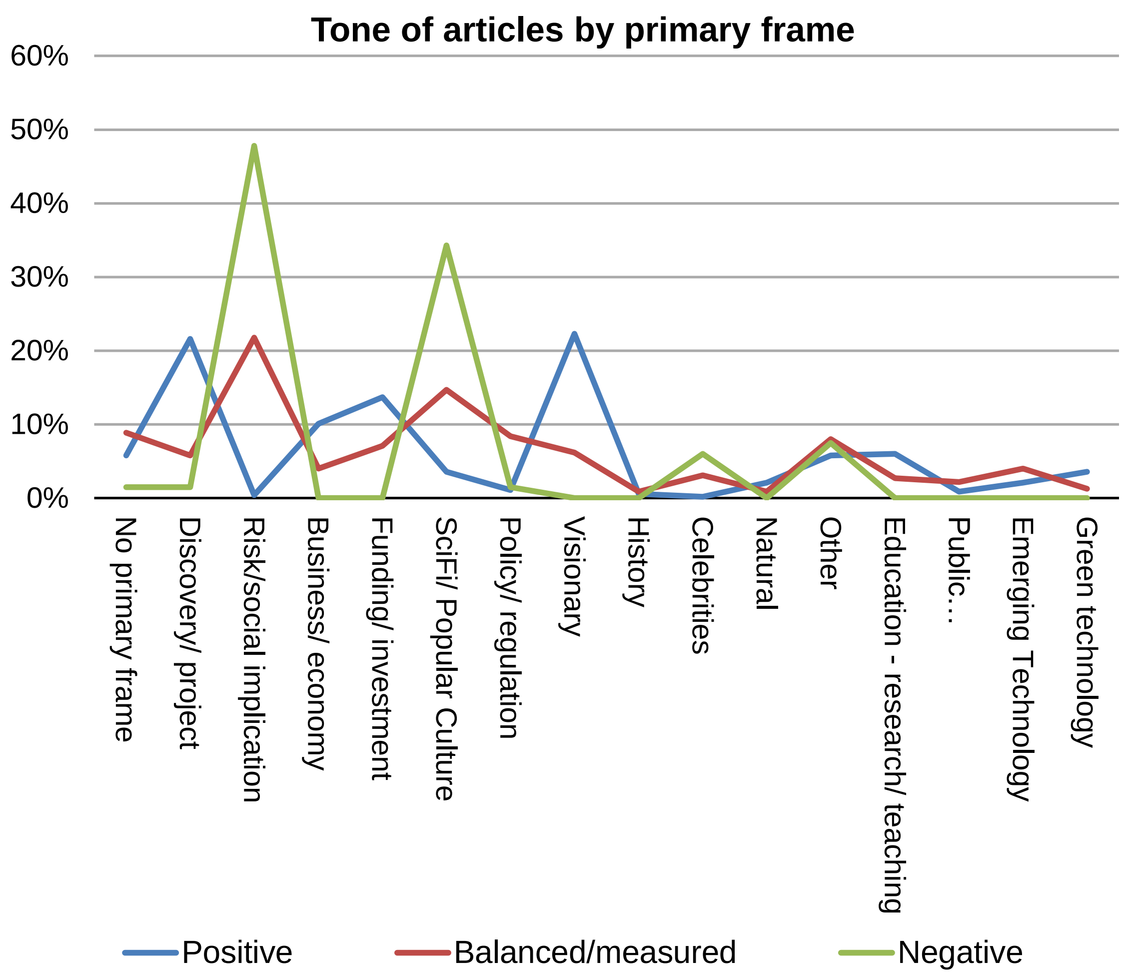

Figure 25: Tone of articles by primary frame

The bar chart above illustrates the tone of article based on the primary frame associated with nanotechnology. Overall, it continues to point to the primarily positive tone toward nanotechnology. However, it also illustrates that for some frames, such as the visionary and discovery frame, the tone is overwhelmingly positive. It also shows that when nanotechnology is framed around issues of risk or subject to a science fiction frame, the tone tends to be more balanced in nature and is much more likely to be negative than if framed in other ways.

For three frames, nanotechnology was reported in more balanced ways. The first is when nanotechnology is primarily framed in terms of risk or social implications. A total of 83 articles were included in that frame of which 49 were more balanced and 32 were negative toward nanotechnology. The higher number of balanced stories fits with the professional norm of objectivity. Additionally, risk carries a negative connotation, so a negative tone toward nanotechnology also makes sense. The remaining two articles in the risk frame were primarily positive toward nanotechnology. The science fiction/popular culture frame included 73 articles of which 33 were more balanced and 23 were more negative in their treatment of nanotechnology. The remaining 17 articles were primarily positive toward nanotechnology. The other frame that tended to include articles that were more balanced toward nanotechnology was the celebrity frame. This frame was not very salient in the reporting with only 12 articles being primarily framed around people or personalities. In this case, 7 were more balanced toward nanotechnology, four were more negative and one was positive in its treatment of nanotechnology.

Earlier in the chapter, I discussed the framing of nanotechnology across the whole study period, which illustrates how a single frame for nanotechnology has not yet emerged. However, looking at the reporting in five-year increments within the study period illustrates that a few frames have been stable in the earlier years of the reporting, but in the last several years there has been a confluence of frames and none are clearly a dominant frame. This section of the chapter will discuss that in more detail.

In the earliest years of the reporting, there were few stories that discussed nanotechnology or were about nanotechnology. As such, there were few frames for nanotechnology in the period 1986-1990. In total, 8 primary frames were identified in the period and the visionary frame was the most common with 5 articles displaying such a frame (see Table 14 below). For this early period, it could be argued that the visionary frame was the dominant frame of the time; however, there were so few articles in the period so its dominance as a frame should be noted with some hesitation.

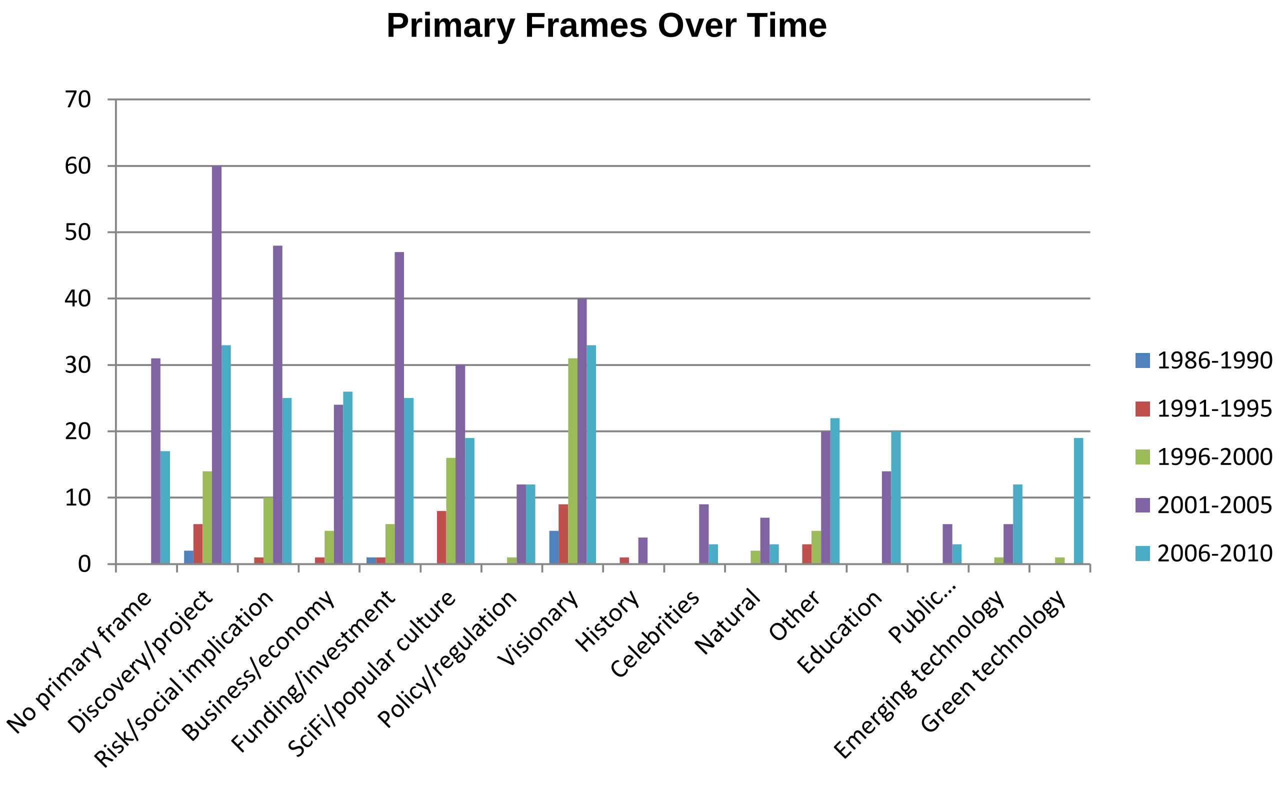

Figure 26: Primary Frames Over Time

The chart above shows the popularity of each frame by time period. It also further demonstrates the volume of reporting since 2001 as being the highest. Specifically it shows that although some frames are popular, there are many representations for nanotechnology and that a dominant way of thinking has not yet emerged. For additional detail on the frequency of frames, please see Table 14 below.

Primary frames over time

1986-1990	1991-1995	1996-2000	2001-2005	2006-2010
1) Visionary (5)	**1)** Visionary (9)	**1)** Visionary (30)	**1)** Discovery (60)	**1)** Discovery (33) Visionary (33)
2) Discovery (2)	**2)** Science Fiction (8)	**2)** Science Fiction (16)	**2)** Funding (47)	**2)** Business (26)
3) Funding (1)	**3)** Discovery (6)	**3)** Discovery (14)	**3)** Risk (43)	**3)** Funding (25)
	4) Other (3)	**4)** Risk (10)	**4)** Visionary (40)	**4)** Risk (24)
	5) Risk (1) Business (1) Funding (1) History (1)	**5)** Business (7)	**5)** Science fiction (30)	**5)** Other (22)
		6) Funding (6)	**6)** Business(29)	**6)** Education(20)
		7) Other (3)	**7)** Other (20)	**7)** Green tech(19) Science Fiction (19)
		8) Natural (2)	**8)** Education (14)	**8)** Emerging tech (12) Policy (12)
		9) Green tech(1) Emerging tech(1) Policy (1)	**9)** Policy (12)	**9)** Celebrity (3) Natural (3) Public Understanding of Science (3)
			10) Celebrity (9)	
			11) Natural (7)	
			12) Public Understanding of Science (6) Emerging tech(6)	

Table 14: Primary frames over time

The table above outlines the primary frames over time in five year increments. The numbers in brackets indicate the number of stories identified as having been framed in that particular way. It demonstrates that the visionary and discovery frames were the most salient frames in each of the periods, but that other frames were also common in nearly equal numbers of articles in other periods.

In the period that follows, 1991-1995, the visionary frame is again the most common with 9 articles displaying that primary frame, but the science fiction frame is the primary frame for 8 articles and the discovery frame for 6 articles, which is nearly as many as the visionary frame. As a result, it is difficult to say that there was a single stable frame in the period. The prevalence of the science fiction frame in this time period fits with previous research, however, it considered a later time period (Anderson et al., 2005, Anderson et al., 2009b) .That research pointed out that although no frame appeared to be dominant across their studies, science fiction appeared to be amongst the common ways for framing nanotechnology. This research, at least for this time period, would concur with that finding. However, it should also be noted that Anderson and her colleagues considered a wider variety of newspapers, including tabloid publications that would not surprisingly use such popular culture references in the reporting. Although this study did not consider tabloid newspapers, it too found a prevalence of news reporting that drew on science fiction language and imagery.

As in the period 1991-1995, the visionary, science fiction and discovery frames were the most common frames identified from 1996 to 2000. That period had 92 articles with a primary frame. Of those, the visionary frame was more dominant with 30 articles displaying it as a primary frame. That represents a third of the articles with a primary frame in the period. The science fiction frame is the primary frame in 16 articles and the discovery frame is the primary frame in 14 articles. Although not as prominent as the visionary frame, those two frames remain an important way of making sense of nanotechnology in these newspapers during the period. Other frames that emerge at this time are the risk, business and funding frames, but again not as prominent as the other three that have been discussed.

In the period 2001 to 2005, the visionary frame again is the primary frame in 40 articles, or 12.2 per cent of the reporting in the period, but it is no longer the most commonly found primary frame in the period. Instead, the discovery, funding and risk frames become more salient in the reporting. A total of 327 articles during those early years of the 2000s displayed a primary frame for nanotechnology. Of those, the process of scientific discovery becomes the more dominant way of talking about nanotechnology with 60 articles or 18.3 per cent of that period's reporting with a primary frame. Although it was more prominent than others, it is difficult to say it was the dominant frame for nanotechnology because funding appeared as the primary frame in 14.4 per cent of the reporting with a primary frame, or 47 articles. Risk was also the primary frame in 43 articles, or 13.1 per cent of the reporting. Finally, science fiction was the primary frame in 30 articles and business was the primary frame in 29 articles, or 9.2 and 8.9 per cent of the reporting. As with the Anderson studies, science fiction is a common framing for nanotechnology, but perhaps less so than their research found which again can be attributed to their consideration of tabloid publications that would be more inclined to take a popular culture tone to the articles than perhaps broadsheet newspapers would.

In the most recent reporting from 2006 to 2010, 254 articles were coded as having a primary frame. As the figure below illustrates, the frames reported in the period are contested. The discovery and visionary frames appear as primary frames in 33 articles each, which represents 13 per cent of the reporting. The business, funding and risk frames were the primary frames in

26, 25, and 24 articles, respectively. That represents 9.4 to 10.2 per cent of the reporting with primary frames during that period. As none had a clear preponderance within the period, the most recent reporting illustrates the contest over meaning making.

The discussion above outlines how the framing of nanotechnology changed over the 24 years studied in this research. In the early period of the study, nanotechnology was framed as visionary, which the section on tone in the articles points out was primarily the opportunity for significant benefits of nanotechnology sometime far into the future. Together with the visionary frame and the discovery frame also appeared as a salient primary frame in the study. This frame highlighted the science of nanotechnology and the process of scientific discovery. The science fiction frame was also an important way of making sense of nanotechnology for the audience. It appeared amongst the most common frames for nanotechnology throughout the study, but particularly in the middle period of the research. Framing nanotechnology in terms of risk became more salient in the reporting from the mid 1990s, which is surprising given that this research and previous research found that risk was rarely discussed in the reporting. Particularly in the last 10 years, funding emerged as a more common frame for nanotechnology. Although Weaver and his colleagues (2009) found the regulation frame to be emerging more recently, this research does not find the same trend in these two newspapers.

Overall, this discussion illustrates that in the early part of the reporting when nanotechnology was covered less frequently, one frame or a few frames were more dominant in the reporting. However, as nanotechnology began to be reported more often in these newspapers, the dominance of a frame or a few frames attenuates. As such, it illustrates the complexity of the framing process and the on-going contest in setting a preferred way of thinking about nanotechnology.

When looking at the primary frame based on where in the newspaper the stories were published, some of the frames appear to be more common in certain sections. This can go some way to explaining why nanotechnology is framed in particular ways. For example, it would seem logical that the business and finance sections would frame nanotechnology around business and the economy, as well as funding and investment.

Few of the articles in the study appeared on the front page and those primary frames that appeared on the front page varied. A total of 26 articles appeared on the front page. Frames that appeared on the front page were business and the economy, funding and investment, emerging technology, visionary or far future implications, risk, discovery, education, green technology, and celebrities. Each was represented on the front page one to four times. As a result, the framing of nanotechnology on the newspapers' most prominent page was mixed.

The news section included more frames for nanotechnology, but four of the frames appear to be the most salient way of making sense of nanotechnology. In total, 62.5 per cent of the 112 articles the news section were framed in one of four ways. The most common primary frame identified in the news section was funding and investment in nanotechnology, which appeared in 22 articles or 19.6 per cent of the articles that appeared in the news sections of the newspaper. The second most salient primary frame in the section was discovery, which appeared in 21 articles or 18.8 per cent of the reporting in the news section. Thirdly, the business and economy frame appeared as the primary frame in 15 articles or 13.4 per cent of the reporting in the section. The fourth primary frame that appeared more commonly in the news section than others was that of risk. A total of 12 articles or 10.7 per cent of the reporting displayed a primary frame of risk. Although these four frames appeared most often and make-up more than 60 per cent of the reporting in the section, each takes up a smaller proportion and therefore cannot be seen as a dominant or stable frame for nanotechnology, further illustrating the contested nature of framing nanotechnology at this time.

Of the 87 articles that appeared in the science section of the paper, 34 were primarily framed around scientific discovery. For the discovery frame, the science section was the most likely place for it to appear as a primary frame with the news section being the second most common section for the frame to appear. Within the science section, it was the primary frame for more than a third of all articles that appeared in that section. It is perhaps the most fitting section for a discovery frame. The second most common primary frame for the science section was the visionary frame with its focus on the implications of nanotechnology on the future. A total of 16 articles in the science section were coded as primarily framing nanotechnology around its possibilities for the future, which were most often positive as the discussion around tone indicated. Risk was also a more common frame for nanotechnology than others in terms of primary frames in the science section; however, only 7 articles within the section were coded as such. The technology section had only 36 articles that discussed nanotechnology published during the study period. The more common primary frames identified in this section were discovery and green technology, although in the case of 8 articles (nearly a quarter of those in the section) it was difficult to discern a primary frame. That was likely because a number of competing frames existed within the story, which made it difficult to select a primary frame.

The business section reported on nanotechnology - both in terms of stories about nanotechnology and stories that include nanotechnology - in 117 articles. Not surprisingly, the business and economy frame was the most common primary frame found in this section with 24 articles or 20.5 per cent of the reporting identified as such. The second most prominent primary frame in the business sections with a total of 18 articles or 15.4 per cent of the reporting was the funding and investment frame. A total of 17 articles in the reporting did not clearly display a primary frame, which represents 14.5 per cent of the reporting in the business sections of these newspapers. Other frames with at least 10 per cent of the reporting in business are the visionary frame with 15 articles or 12.8 per cent of the reporting and the risk frame with 12 articles or 10.3 per cent of the reporting. If these sections were to have a preferred meaning for nanotechnology, it would be to describe it in terms of its use for business and the economy, which is appropriate for this section of the newspapers.

The opinion section of the two newspapers included 50 articles. Of those 10 were primarily framed around risk, 8 around the visionary and future implications of nanotechnology, 5 around business and economy, and 4 each around funding/investment and policy/regulation of nanotechnology. Little variation exists in the number of articles for each frame within this section of the newspaper, which suggests the preferred meaning for nanotechnology is still contested in the opinion section.

When looking at the primary frames reported in each newspaper, they had a similar way of looking at nanotechnology overall (see Figure 27 below). The discovery frame and visionary frames were amongst the most common frames in the two newspapers for reporting nanotechnology. *The Guardian* was slightly more likely to report nanotechnology as visionary, according to the statistics. A total of 70 *Guardian* articles, or 16.5 per cent of the reporting, framed nanotechnology as visionary and having the potential for far reaching implications. Comparatively, *The New York Times* reported 48 stories in that frame, or 14.3 per cent of its reporting. A more common frame for *The New York Times* was that of discovery, which focused on individual projects and the unfolding of science and technology. In that case, *The New York Times* reported 56 articles, or 16.7 per cent of its reporting, within that frame. Alternatively, *The Guardian* reported 59 articles or 13.9 per cent of its reporting.

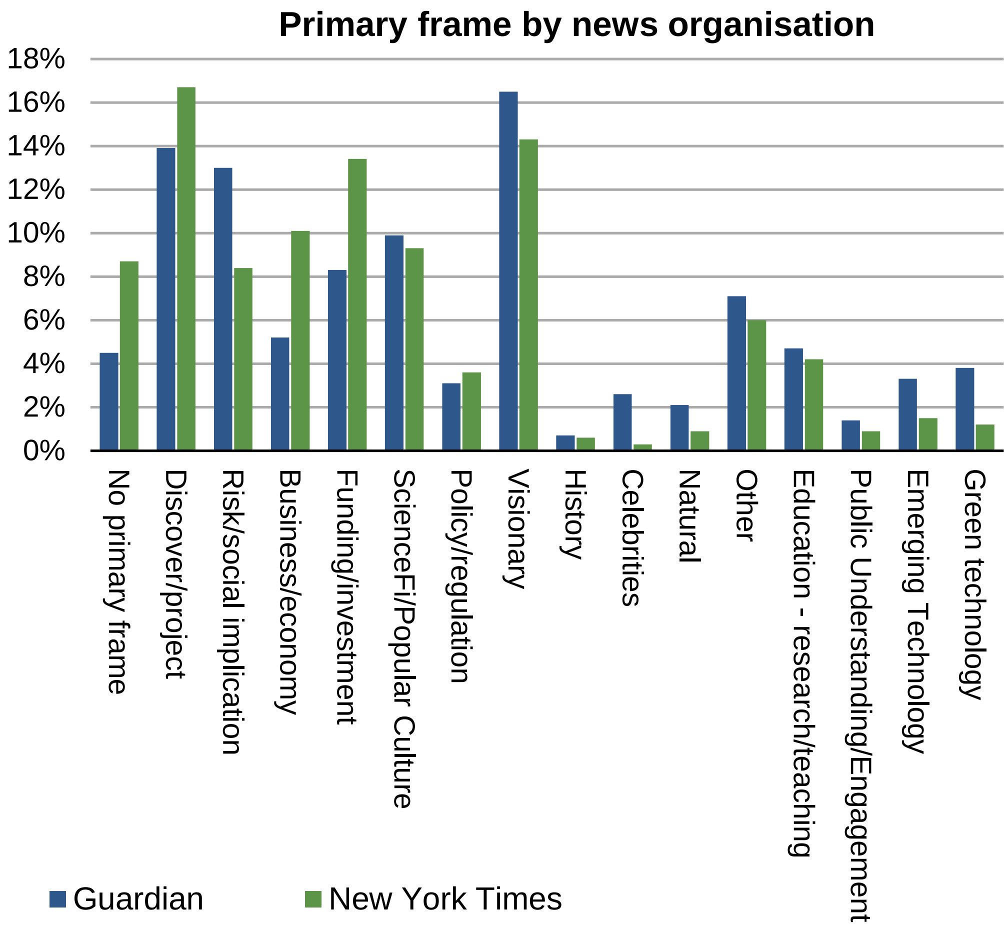

Figure 27: Primary frame as reported by each news organisation

The chart above illustrates the prominence of primary frames by newspaper. Visionary and discovery frames for nanotechnology were prominent in both publications, but *The Guardian* was more likely to frame nanotechnology in terms of risk and social implications than The *New York Times*. Instead, *The New York Times* favoured the business/economy and funding/investment frames for nanotechnology.

The Guardian framed nanotechnology in terms of its potential risks and social implications at a much higher proportion than *The New York Times*. A total of 55 articles or 13 per cent of *The Guardian*'s reporting discussed nanotechnology in terms of the risks it posed. *The New York Times* framed nanotechnology in terms of risk in only 28 articles or 8.4 per cent of the reporting. Instead, when it came to primary frames for nanotechnology, *The New York Times* was more inclined to frame nanotechnology in terms of investment and funding opportunities with 45 articles or 13.4 per cent of the reporting reflecting such a frame. *The Guardian* framed nanotechnology around funding and investment in 35 articles or 8.3 per cent of its reporting.

Both newspapers framed nanotechnology around science fiction and popular culture at similar rates. *The Guardian* reported 42 articles or 9.9 per cent of its reporting around science fiction, and *The New York Times* reported 31 articles or 9.2 per cent of its reporting within that frame. However, more common for *The New York Times* was the frame around business and the economy, which included 34 articles or 10.1 per cent of the reporting. *The Guardian* framed nanotechnology in such a way in only 22 articles, or 5.2 per cent of the reporting in such a way.

When nanotechnology is the subject of news articles, it is most often framed around discovery and breakthroughs with 65 articles or 29.5 per cent of the reporting that focused on nanotechnology (see Figure 28 below). The second most common frame was risk and social implications of nanotechnology, which was the primary frame for 33 articles or 15 per cent of the reporting on nanotechnology. The visionary frame was the third most common frame with a total of 30 articles or 13.6 per cent of the reporting about nanotechnology. When stories mention nanotechnology, but are about something else, the framing is different. The top frame in that case was to discuss nanotechnology as visionary with 88 articles reflecting such a primary frame, or 16.3 per cent of the reporting that mentions nanotechnology. The second most common frame was science fiction with 71 articles or 13.2 per cent of the reporting that mentions nanotechnology. The funding and investment frame was the third most salient frame with 12.8 per cent of the reporting.

The risk frame was identified as the primary frame in 50 articles, or 9.3 per cent of the reporting.

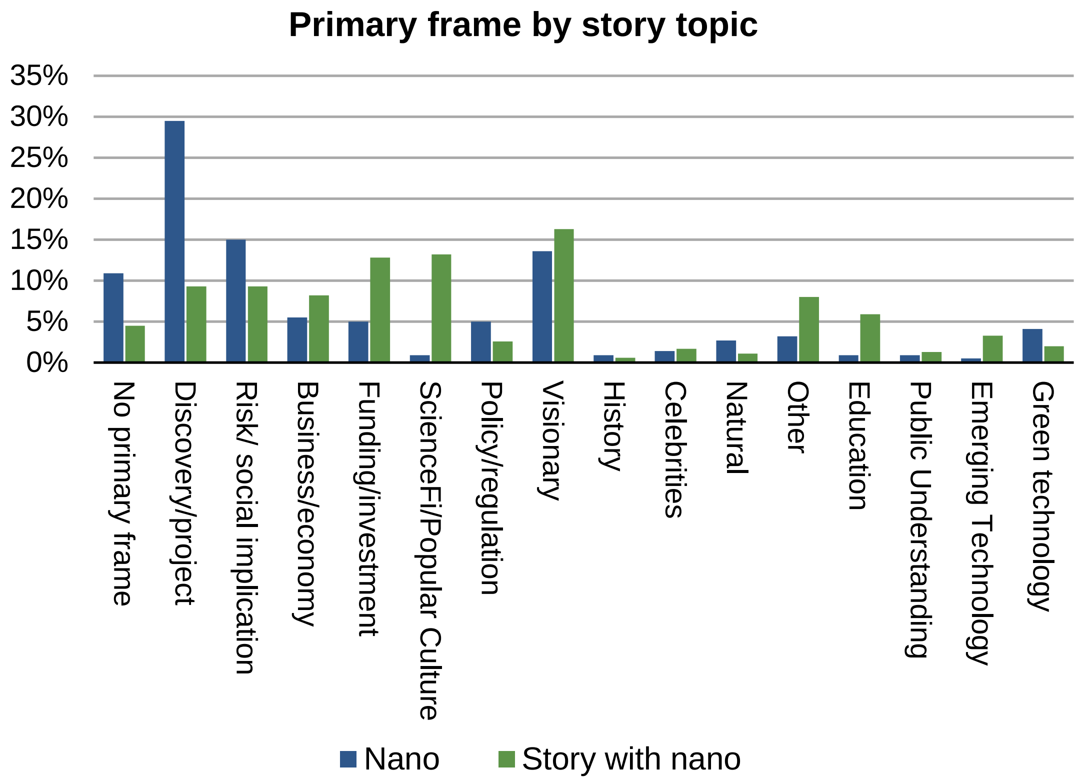

Figure 28: Primary frames by story topic

The chart above illustrates the primary frame for nanotechnology depending on whether it is the subject of the story or only mentioned in the article. Overall, when nanotechnology is the subject of an article, it is most often framed around scientific discovery and breakthroughs and secondly as risk. Stories that mention nanotechnology most often framed nanotechnology as visionary or science fiction.

The discussion above reviewed where primary frames were identified for each story. Meanwhile, some articles were labelled as not having a primary frame because one was not readily discernible. Additionally, a number of articles appeared to frame nanotechnology in different, more subtle ways throughout the story, so were coded as having more than one frame. This section of the chapter focuses on all the ways in which nanotechnology was framed in a given article across the study period in both publications. In addition to discussing the frequency of frames across the collection of content, it also breaks down the framing based on when stories were primarily about nanotechnology or discussed nanotechnology as part of a story about something else and the ways in which the two newspapers framed nanotechnology.

The frames highlighted as primary frames for nanotechnology are here again the most salient ways of framing nanotechnology (see Table 15 below). The newspapers framed nanotechnology around the far reaching implications and visionary possibilities – good and bad – in 167 articles or 22 per cent of stories (or cases as the table indicates). In these cases, nanotechnology was talked about as science and technology with implications far into the future. A total of 138 articles or 18.2 per cent of the reporting framed nanotechnology around the process of scientific discovery and the projects that resulted in breakthroughs in the fields of science and technology.

Frequency of frame

		Responses		
		N	Percent	Percent of Cases
Frames	Discovery/project	138	13.0%	18.2%
	Risk/social implication	129	12.1%	17.0%
	Business/economy	96	9.0%	12.6%
	Funding/investment	130	12.2%	17.1%
	SciFi/Popular Culture	84	7.9%	11.1%
	Policy/Regulation	55	5.2%	7.2%
	Visionary	167	15.7%	22.0%
	History	7	.7%	.9%
	Celebrity	24	2.3%	3.2%
	Natural	19	1.8%	2.5%
	Education - teaching/research	45	4.2%	5.9%
	PUS	12	1.1%	1.6%
	Emerging Technology	67	6.3%	8.8%
	Green Technology	26	2.4%	3.4%
	Other	65	6.1%	8.6%
	Total	1064	100.0%	140.2%

Table 15: Frequency of frames in the news reporting

The table above outlines the frequency of frames for nanotechnology when multiple frames are identified in each article. The most common frames, as the table shows, are the visionary and discovery frames followed by funding, risk, business and science fiction.

Where the risk frame was third most prominent in the primary frames, it was less so when considering multiple frames in each story. In that case the third most prominent frame for nanotechnology was the funding and investment frame, which appeared in 130 articles or 17.1 per cent of the reporting. In that case, nanotechnology was discussed as an area of investment for businesses and the government. That included articles such as a 2002 story stating that the UK government would be investing in nanotechnology research because Tony Blair, prime minister at the time, warned that Britain needed to increase its investment in nanotechnology or risk falling behind others. *The New York Times* also framed nanotechnology around funding and investment, including several stories that identified new centres for research being opened up with funding from government, business and universities.

Risk then followed as the fourth most prominent frame for nanotechnology with 129 articles or 17 per cent of the reporting discussing the potentially harmful effects of nanotechnology. As the section on risk discussed in more detail, the risks cited were most often the fear of self-replicating nanobots taking over all natural life in the world, however, the risks were often balanced or dismissed in the reporting. For example, on 9 June 2004, *The Guardian* reports that fears of grey goo that are the result of self-replicating nanobots would not happen, according to K. Eric Drexler of the Foresight Institute and Chris Phoenix of the Center for Responsible Nanotechnology. *The Guardian* reported that grey goo is “unlikely” and that “all risk of accidental runaway replication can be avoided”. In that case, the reporting was framed around risk, but that does not mean that the discussion was negative in nature.

Following risk was the frame around business and the economy, which appeared in 96 articles or 12.6 per cent of the reporting. These stories, as the discussion of primary frames noted, included a 1995 *New York Times* article that framed nanotechnology around the potential for job creation. The article predicted that by 2005, nanotechnology would be a leading field for employment opportunities.

Science fiction was also less salient as a frame for nanotechnology when considering multiple frames in a story. It was the fifth most common primary frame, but was sixth most common way of framing nanotechnology when considering all the frames for nanotechnology in each story. In total it appeared in 84 articles or 11.1 per cent of the reporting. This is surprising given previous research which have identified nanotechnology as being framed around science fiction in much more prominent ways (Anderson et al., 2005). Where I included fictional book reviews in the content collection, I would have expected even more framing around science fiction and coded for what section in the newspaper these articles appeared to be able to speak to that in particular. In this study, however, it appears nanotechnology is framed around science fiction much less often than in previous research, which can partly be attributed to the newspapers examined and that no tabloid newspapers were studied. That could be as a result of the wider study period being considered, as science fiction appeared to be a more common frame in some time periods than others. It could also indicate that overall, nanotechnology is beginning to be seen as more science and technology and less science fiction.

When exploring the framing by each newspaper when multiple frames are considered per article, *The New York Times* frames are different than when looking at the primary frames alone. In nearly a quarter of the articles reported (see Table 16 below) by the newspaper, nanotechnology was framed around funding and investment. A total of 79 articles or 23.6 per cent of the newspaper's reporting included the funding and investment frame. When it came to primary frames for nanotechnology in articles in *The New York Times,* the discovery and visionary frames were more prominent than funding and investment, so it was surprising to see that the funding and investment frame was so prominent when considering more than one frame per article. However, the visionary frame was the second most common frame in the news reporting when considering multiple frames in the article. A total of 76 articles, or 22.7 per cent of the reporting, included the frame. The discovery frame appeared in 61 articles or 18.2 per cent of the reporting. Fifty-eight articles or 17.3 per cent of the reporting included a frame of business and economy. Finally, the fifth most common frame in *The New York Times* was risk and social implications, which was included in 43 articles or 12.8 per cent of the reporting.

Frames by newspaper

			News Organisation		
			Guardian	New York Times	Total
Frames	Discovery/project	Count	77	61	138
		% within NO	18.2%	18.2%	
		% of Total	10.1%	8.0%	18.2%
	Risk/social implication	Count	86	43	129
		% within NO	20.3%	12.8%	
		% of Total	11.3%	5.7%	17.0%
	Business/economy	Count	38	58	96
		% within NO	9.0%	17.3%	
		% of Total	5.0%	7.6%	12.6%
	Funding/investment	Count	51	79	130
		% within NO	12.0%	23.6%	
		% of Total	6.7%	10.4%	17.1%
	SciFi/Popular Culture	Count	51	33	84
		% within NO	12.0%	9.9%	
		% of Total	6.7%	4.3%	11.1%
	Policy/Regulation	Count	30	25	55
		% within NO	7.1%	7.5%	
		% of Total	4.0%	3.3%	7.2%
	Visionary	Count	91	76	167
		% within NO	21.5%	22.7%	
		% of Total	12.0%	10.0%	22.0%
	History	Count	5	2	7
		% within NO	1.2%	.6%	
		% of Total	.7%	.3%	.9%
	Celebrity	Count	19	5	24
		% within NO	4.5%	1.5%	
		% of Total	2.5%	.7%	3.2%
	Natural	Count	11	8	19
		% within NO	2.6%	2.4%	
		% of Total	1.4%	1.1%	2.5%
	Education - teaching/research	Count	27	18	45
		% within NO	6.4%	5.4%	
		% of Total	3.6%	2.4%	5.9%
	PUS	Count	9	3	12
		% within NO	2.1%	.9%	
		% of Total	1.2%	.4%	1.6%
	Emerging Technology	Count	37	30	67
		% within NO	8.7%	9.0%	
		% of Total	4.9%	4.0%	8.8%
	Green Technology	Count	19	7	26
		% within NO	4.5%	2.1%	
		% of Total	2.5%	.9%	3.4%
	Other	Count	40	25	65
		% within NO	9.4%	7.5%	
		% of Total	5.3%	3.3%	8.6%
	Total	Count	424	335	759
		% of Total	55.9%	44.1%	100.0%

Percentages and totals are based on respondents.

Table 16: Frames by newspaper

The table above outlines the framing of nanotechnology by each newspaper. When considering that stories can include more than one frame for nanotechnology, the funding and investment frame emerges as the most prominent frame in *The New York Times*. Alternatively, *The Guardian* was most likely to draw on the visionary frame, quickly followed by the risk and social implications frame.

The Guardian also demonstrated differences in the framing when looking at the primary frame for a story and when stories had multiple frames. The most prominent frame in both cases was the visionary frame. When multiple frames were identified in stories, it appeared in 91 articles or 21.5 per cent of the reporting. The second most prominent frame was that of risk and social implications where 86 articles or 20.3 per cent of the reporting included a frame of risk or social implications. When looking at primary frames, the risk frame was the third most salient frame behind the discovery frame. In the case of more subtle framing, the trend was reversed. The discovery frame appeared in 77 articles or 18.2 per cent of the reporting, when considering the more subtle framing. Following the discovery frame, the frames of science fiction and popular culture, as well a funding and investment, each appeared in 51 articles or 12 per cent of the reporting.

The framing of nanotechnology changes too when looking at whether the story is primarily about nanotechnology or when nanotechnology is part of an article about something else. First, considering when nanotechnology is the subject of the news, the most prominent frame identified in the reporting is the discovery frame and the focus on individual projects, which appeared in 81 articles or 36.8 per cent of the reporting (see Table 17 below). Risk is the second most common frame in articles about nanotechnology, which is evidenced by its appearance in 58 articles or 26.4 per cent of the articles. The visionary frame follows with 52 articles including such a frame or 23.6 per cent of the reporting. A total of 41 articles included a frame around funding and investment or 18.6 per cent of the reporting. The fifth most common frame for nanotechnology in stories primarily about nanotechnology was shared by the business and economy frame and the policy and regulation frame, which each had 30 articles that included such a frame for nanotechnology or 13.6 per cent of the reporting about nanotechnology.

Frames by story topic

			Story Topic		
			Nano	Story with nano	Total
Frames	Discovery/project	Count	81	57	138
		% within Story Topic	36.8%	10.6%	
		% of Total	10.7%	7.5%	18.2%
	Risk/social implication	Count	58	71	129
		% within Story Topic	26.4%	13.2%	
		% of Total	7.6%	9.4%	17.0%
	Business/economy	Count	30	66	96
		% within Story Topic	13.6%	12.2%	
		% of Total	4.0%	8.7%	12.6%
	Funding/investment	Count	41	89	130
		% within Story Topic	18.6%	16.5%	
		% of Total	5.4%	11.7%	17.1%
	SciFi/Popular Culture	Count	6	78	84
		% within Story Topic	2.7%	14.5%	
		% of Total	.8%	10.3%	11.1%
	Policy/Regulation	Count	30	25	55
		% within Story Topic	13.6%	4.6%	
		% of Total	4.0%	3.3%	7.2%
	Visionary	Count	52	115	167
		% within Story Topic	23.6%	21.3%	
		% of Total	6.9%	15.2%	22.0%
	History	Count	3	4	7
		% within Story Topic	1.4%	.7%	
		% of Total	.4%	.5%	.9%
	Celebrity	Count	10	14	24
		% within Story Topic	4.5%	2.6%	
		% of Total	1.3%	1.8%	3.2%
	Natural	Count	9	10	19
		% within Story Topic	4.1%	1.9%	
		% of Total	1.2%	1.3%	2.5%
	Education - teaching/research	Count	2	43	45
		% within Story Topic	.9%	8.0%	
		% of Total	.3%	5.7%	5.9%
	PUS	Count	2	10	12
		% within Story Topic	.9%	1.9%	
		% of Total	.3%	1.3%	1.6%
	Emerging Technology	Count	12	55	67
		% within Story Topic	5.5%	10.2%	
		% of Total	1.6%	7.2%	8.8%
	Green Technology	Count	12	14	26
		% within Story Topic	5.5%	2.6%	
		% of Total	1.6%	1.8%	3.4%
	Other	Count	17	48	65
		% within Story Topic	7.7%	8.9%	
		% of Total	2.2%	6.3%	8.6%
	Total	Count	220	539	759
		% of Total	29.0%	71.0%	100.0%

Percentages and totals are based on respondents.

Table 17: Framing of nanotechnology by story topic

The table above illustrates the framing of nanotechnology based on whether it was the primary subject of a story or only mentioned as part of a story about something else. Specifically, the table shows that nanotechnology was framed mostly as a process of scientific discovery or through the reporting of individual research projects and secondly around issues of risk and the social implications of this science and technology. When stories mentioned nanotechnology, but were about something else, nanotechnology was framed around its far reaching potential - the visionary frame - or funding and investment.

Alternatively, when nanotechnology was included in stories about something else, the framing of this emerging science and technology was different. The visionary frame was most common in the reporting with 115 articles or 21.3 per cent of the reporting including the frame. The funding and investment frame was the second most salient frame in this type of story with a total of 89 articles or 16.5 per cent of the reporting framing nanotechnology around its far reaching implications. Science fiction and popular culture framing was also very prominent in the reporting of nanotechnology when it was included in articles about something else. In total, 78 stories or 14.5 per cent of the reporting framed nanotechnology around science fiction and popular culture. Although the risk and social implication frame of nanotechnology appeared in more articles that mentioned nanotechnology than articles that were primarily about nanotechnology, 71 to 58 articles respectively, proportionally the risk frame was much less prominent in articles that mention nanotechnology. In total, the frame appeared in 13.2 per cent of the reporting, rather than the more than a quarter of the reporting primarily about nanotechnology. The fifth most prominent frame for nanotechnology in stories that mention the field was that of business and the economy. It appeared in 66 articles or 12.2 per cent of the reporting about something else, but mentioning nanotechnology.

Looking at how the framing of nanotechnology changed over time when all frames in a story are considered, the framing of nanotechnology is somewhat different than when looking at the primary frame. Some frames that were identified as the primary frame for an article were more common in certain time periods, but when all frames are considered they are less salient.

In the period 1986-1990, five articles framed nanotechnology as visionary and its far-reaching benefits (see Table 18 below). Three articles framed nanotechnology around scientific discovery, and one framed nanotechnology around funding and investment. This is a similar framing for nanotechnology as with the primary frames, and as with the primary frame, where few articles were reported during the period it would be inappropriate to take these findings too far. However, the visionary frame for nanotechnology appears to be the most salient frame for the time period, but that is stated with some hesitation given the low levels of reporting at the time.

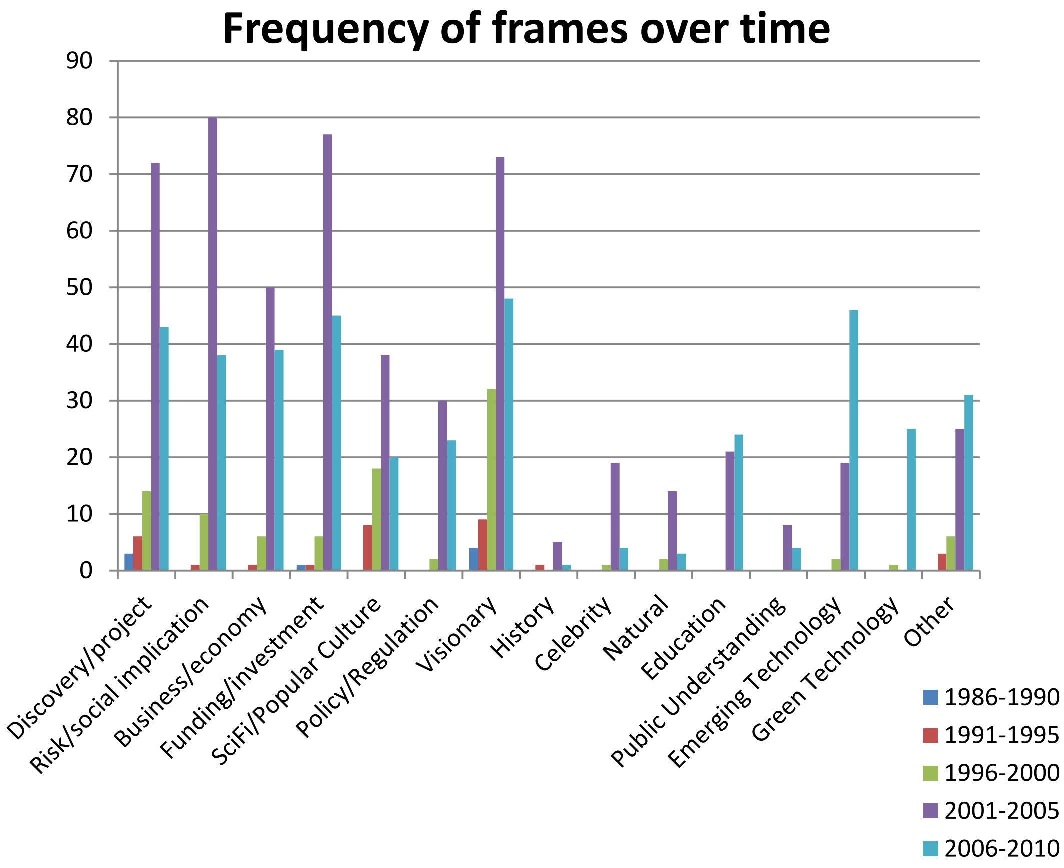

Figure 29: Frequency of frames over time

The figure above illustrates how popular individual frames were in the reporting over the study period. The table below provides additional detail on how many articles the individual frames appeared in throughout the study period.

Frequency of frames over time

	1986-1990	1991-1995	1996-2000	2001-2005	2006-2010
1)	Visionary (4)	Visionary (9)	Visionary (32)	Risk (80)	Visionary (48)
2)	Discovery (3)	SciFi (8)	SciFi (18)	Funding (77)	Emerging Tech (46)
3)	Funding (1)	Discovery (6)	Discovery (14)	Visionary (73)	Funding (45)
4)		Other (3)	Risk (10)	Discovery (72)	Discovery (43)
5)		Business (1); Funding (1); History (1); Risk (1)	Business (6); Funding (6); Other (6)	Business (50)	Business (39)
6)			Emerging Tech (2); Natural (2); Policy (2)	SciFi (38)	Risk (38)
7)			Celebrity (1); Green Tech (1)	Policy (30)	Other (31)
8)				Other (25)	Green Tech (25)
9)				Education (21)	Education (24)
10)				Celebrity (19); Emerging Tech (19)	Policy (23)
11)				Natural (14)	SciFi (20)
12)				Public Understanding (8)	Celebrity (4); Public Understanding (4)
13)				History (5)	Natural (3)
14)					History (1)

Table 18: Most common frames identified in the reporting over time

The table above highlights the most prominent frames identified in the reporting in each five-year period. The numbers in brackets represent the number of stories that included such frames for nanotechnology.

The most common frame in the reporting during 1991-1995 was the visionary frame with 9 articles. The science fiction frame appeared as the second most common frame for nanotechnology with 8 articles, followed by the discovery frame with 6 articles. Again during this period, the reporting was sporadic, so the identification of a dominant frame for the time period is therefore more tentative. With that in mind, the visionary frame and the science fiction frame appear to be more dominant for the time period than others. This is similar to the findings for the primary frame for nanotechnology during the same time frame.

As with the previous period, reporting from 1996 to 2000, nanotechnology was framed most commonly as visionary in 32 articles. The second most common frame was science fiction with 18 articles, and the third most common frame was discovery with 14 articles including such a frame. This time period had much more reporting than the two previous periods, and the visionary frame again appears to be the most dominant way of framing nanotechnology. Where more articles are reported at this time, I can be more confident in calling the visionary frame the dominant frame for the time period. The same was true for the primary frame during this time period.

In the period 2001-2005, the framing of nanotechnology was different than in previous periods. The most common frame in the period was risk and social implications with 80 articles including such a frame for nanotechnology. The funding frame was the second most common frame with 77 articles during that time, followed by visionary with 73 articles, discovery with 72 articles, and business with 50 articles. The reporting of nanotechnology rose during this period to a peak, according to the statistics discussed in Chapter 5. During this time, a number of organisations and individuals raised concerns about nanotechnology's risks, including Sun Microsystems founder Bill Joy, Prince Charles, the ETC Group and Greenpeace. Also, Michael Crichton's thriller *Prey*, which centres on the threat of nanobots swarming together and taking over organic life in order to replicate, was published. This could be why risk emerged as the more common framing for nanotechnology at the time. This is different than when looking at the primary frame for a similar time period. In that case, the discovery, funding and risk frames were most salient in that order.

From 2006-2010, the visionary frame again emerged as the most common frame for nanotechnology with 48 articles during that time frame. The second most common frame, which had not been as prominent in the reporting previously, was emerging technology with 46 articles. That means nanotechnology was made sense of by likening it to other emerging technologies, including biotechnology, stem cell research, genetically modified organisms, and other similar new technologies. The third most common frame for nanotechnology was funding and investment with 45 articles, followed by discovery with 43 articles, and business with 39 articles. This period saw a decline in articles that reported on nanotechnology, and the framing of nanotechnology appears to be more contested during the period because nearly equal numbers of articles are framing nanotechnology as visionary, emerging technology, funding, and discovery. As with the previous period, this timeframe displayed a different framing when all frames identified in a story are considered in the reporting. In the case of primary frames, the discovery and visionary frames were most common, followed by business and funding.

Overall, when looking at the development of frames over time it demonstrates how at times a frame can appear stable, but does not necessarily remain as the preferred way of looking at nanotechnology. Also, when considering the multiple frames in a story against the primary frames, it shows that the framing of nanotechnology is contested even within an article.

Conclusion

This chapter reviewed the framing of nanotechnology beginning with the tone of articles toward nanotechnology. As the findings demonstrated, nanotechnology is seen as primarily positive for society and benefits are seen to outweigh risks. Claims about the benefits of nanotechnology, which appear in a majority of the articles reported, are most often linked to medicine and manufacturing, but generic benefits of nanotechnology are also salient in the reporting. Risk claims about nanotechnology are much less salient in the reporting with only 26.4 per cent of the reporting identifying a risk. When risks are cited, grey goo and runaway technology are most common. The risks of nanotechnology are also commonly discussed in generic ways. These more positive ways of reporting nanotechnology and the lack of substantive discussion around the potential risks of nanotechnology arguably fail to democratise news by providing an array of views on the subject. Additionally, the focus on more far-reaching benefits and risks further limit the opportunity for meaningful debate because the most commonly cited of them tend to be from popular culture and appear fictional in nature.

When it comes to the framing of nanotechnology there has yet to be a dominant frame, although it appears that some frames prevail at times demonstrating that all frames are not equal. The visionary, discovery, investment, and risk frames are amongst the most salient frames in the reporting, but none has become dominant the reporting as they tend to be reported at similar rates. That is true when looking at these frames as the primary frame in a story or when framing is considered in more subtle ways - when news articles can have more than one frame for a topic.

Overall, the findings of this research suggest that the framing of nanotechnology continues to be contested. There has yet to be a preferred way of thinking about nanotechnology in terms of the reporting of it. To an extent, that may be because there has yet to be a defining moment for nanotechnology to help journalists make sense of nanotechnology for the audience. No real controversy has erupted around nanotechnology, although there have been moments in the cycle of reporting that could have easily turned into a defining moment. Key figures and organisations - Prince Charles, Bill Joy a founder of Sun Microsystems, Greenpeace, Which? and the ETC Group - have raised concerns about nanotechnology, which could have sparked significant debate and helped solidify a frame. However, when questions about nanotechnology were asked by those individuals and organisations, the newspapers did not establish a stable frame as has happened with other issues in science be it climate change or genetically modified food or stem cell research. Instead, the incident was covered and no further debate was taken up.

Some researchers might argue that in that case framing is not a useful theory to draw on to help make sense of nanotechnology and more specifically the reporting of nanotechnology. I, however, would argue that framing is precisely the theory needed to help understand how that meaning is developed over the life of the issue and the complexities of developing meaning. Framing theory is, as many suggest, about the contest over meaning making and understanding how journalists make sense of issues for their audiences. In that case, the reporting of nanotechnology and this study in particular helps highlight the early stages of making sense of the complexities of this issue and the way in which the meaning is developed in and through the news. Understanding the framing of nanotechnology before a defining moment in the news discourse helps understand nanotechnology in a way that we will be unable to understand it once that defining moment happens. If there comes a time when nanotechnology is faced with a controversy or some miraculous breakthrough is uncovered and reported, then researchers will have that frame of reference as part of the discussion. Although if the former happens, news reporting about nanotechnology to date can be criticised as cheerleading for the proponents of nanotechnology rather than providing an engaged and informed debate that considers not only the potential for nanotechnology in positive ways, but also some of the risks and hazards that could arise. Whatever the event, it will serve as a frame for nanotechnology in the same way that significant terrorist events such as Sept. 11, 2001 has influenced the framing of terrorism in the news more recently and has also fostered research around how terrorism is reported.

While meaning making also takes place outside of the mainstream media, other studies have pointed out that for most people the opportunity to engage with science after traditional education comes from the mainstream media. In that case, the media plays an important role in creating meaningful narratives about science and areas within science, like nanotechnology, for the public.

Chapter 7: Discussion and Conclusion

Broadly speaking, this thesis has explored the contours of framing nanotechnology in the news over an extended period of time, demonstrating that individual frames for nanotechnology are not represented equally in the news. The findings have shown that certain frames appear to prevail over others at different times during the 24 years of reporting by *The Guardian* and *The New York Times*. Additionally, nanotechnology appears to elude critique in that reporting is overwhelmingly positive and fails to address risk claims associated with this emerging field in any substantive way. The positive tone, coupled with the preponderance of government and corporate news pegs and related news values demonstrates that the reporting primarily projects a government and corporate interpretation of nanotechnology. In other words, it reflects the proponents' view that nanotechnology will primarily benefit society.

Chapter review

This thesis began with a discussion of nanotechnology more generally and provided a brief history of this emerging field, including its introduction into news discourse. As the introduction set out, nanotechnology is interdisciplinary in nature and draws on chemistry, biology, physics, engineering, and computer science (Chakrabarty, 2008, Turner, 2008). What started as an idea from Prof. Richard P. Feynman in 1959 is now being researched by governments, universities and companies across the world and products are available for purchase today in a number of countries (see for example Project on Emerging Nanotechnologies, 2010, Sargent, 2008, Rensselaer Lally School of Management and Technology, 2004). Governments and businesses worldwide expect nanotechnology to be highly beneficial to society for the potential advances in medicine, manufacturing, and computing, as well as economic benefits such as job creation. However, the uncertainties of nanotechnology are worrying in that some research has indicated that nanoparticles can be toxic. Additionally, a variety of individuals and groups from Prince Charles to Bill Joy to Greenpeace to Which? have sounded alarms over the years suggesting that what the world does not know about nanotechnology could be very dangerous. These claims - both positive and negative - have been reported by the mainstream media and journalists strive to make sense of these complex issues for their audiences.

How these issues are reported in the mainstream media is an important issue for social scientists to research because, as has been discussed throughout the thesis, news is the primary place for citizens to learn about science and technology (see for example Friedman and Egolf, 2005, Gorss and Lewenstein, 2005, Boykoff and Boykoff, 2004). As such, news coverage plays a vital role in drawing the public's attention to a topic in science and technology, which research says audiences know little about especially as it relates to individual fields (see for example Lewenstein, 2005). That is especially true for emerging science and technology, such as nanotechnology, because the news media is an essential source for people's ideas and attitudes toward new science and technology. Exploring the reporting as it unfolds helps researchers understand the climate around an issue as it develops (Gorss and Lewenstein, 2005). That is why this thesis adopted a longitudinal approach to researching nanotechnology news and considered how nanotechnology was framed absent a significant event that helped crystallise the preferred definition for the emerging field.

The second chapter of the thesis discussed how news about science and technology is often reported beyond the specialty pages of the newspaper, which is why it was important for this thesis to also consider news beyond the science and technology sections of each of the newspapers analysed. Previous studies have also documented what makes science newsworthy, which was discussed in reference to news values and the news peg/news hook. Overall, science and technology become news most often when it has a relevance to the readers, which is based around the journalists' conception of their audience (see for example Lewenstein, 2005a, Allan, 2008, Weigold, 2001, Priest, 2001, Carvalho, 2007). To help explore news values as it relates to the reporting of nanotechnology, the thesis adopted Hansen's (1994) news values for science as developed through interviews with science journalists. These news values broadly reflect journalists' ideas of what they believe the audience finds interesting and important, as well as can signal framing in that it suggests a context for science and technology. This idea is revisited later in this chapter with specific attention to how the findings of this thesis relate to the journalists view of the audience. Also contributing to the newsworthiness of science and technology is the notion of the news peg or news hook, which provides journalists a timely link that demonstrates why a particular topic is important at the time of publication. These often include press releases and events. For science news, journal publications are also an important place for journalists to find stories, which will be discussed again in reference to the findings of this thesis.

The second chapter summarised and evaluated a variety of literature that provided a conceptual background for this thesis overall. It serves as a useful introduction to the literature around nanotechnology in the news, but also was key in helping to identify elements for research and provide a theoretical underpinning for the data collection. In particular, it was useful to understand previous research on conceptions of the audience for science and technology, science news values and news hooks/pegs, and risks/uncertainty. Some of these elements, particularly risk, was revisited in the review around literature on nanotechnology in the news, but were also addressed in the methodology chapter as it specifically related to data collection procedures.

Turning to Chapter Three, which looked at the literature around the reporting of nanotechnology, it noted that research has been limited to date, but what has been conducted has primarily focused on the audience. When it comes to the coverage itself, content studies have indicated that nanotechnology is reported in primarily positive ways, which scholars have suggested indicates that benefits outweigh risks (see for example Gorss and Lewenstein, 2005, Faber et al., 2005). However, no studies so far had documented the risks and benefits explicitly in order to make that conclusion. When it comes to framing research, no dominant frame has yet emerged in the research, but the scientific discovery frame and the science fiction frame have been amongst the most salient (see for example Anderson et al., 2005, Anderson et al., 2009b, Weaver et al., 2009). Regarding the discovery frame, scholars have suggested it is popular because it identifies breakthroughs in nanotechnology research and reflects news values around new information. The salience of the science fiction frame has been seen as both potentially beneficial and problematic (Lopez, 2004, Anderson et al., 2005, Anderson et al., 2009b). It is beneficial in that it could be a way for journalists to make the risks of nanotechnology more accessible to the audience. It is also potentially problematic in that it can raise questions about whether nanotechnology is "science" at all or whether it is fiction, which is perhaps more troubling than the potential benefits of the frame.

To date, researchers have conducted few production studies, but what has been done indicates that scientists and journalists believe the risks of nanotechnology have received limited attention in coverage. Scientists reportedly find the news around nanotechnology to be sensational in nature, and journalists struggle with the complexities of the reporting (Ebeling, 2008, Petersen et al., 2009). Although this thesis was not a production study, it sought out textual evidence of the decisions journalists make. Therefore understanding what some journalists and sources have said about the reporting has been useful for understanding the scholarship on the whole and helps contextualise the findings of this thesis.

Finally, the most well developed area of the nanotechnology news literature has been around the audience. Several studies appear to have been the result of a single survey, which suggests the findings of all of those studies are potentially limited because they stem from the same sample of individuals. However, what the audience research has indicated is that although people know little about nanotechnology, it appears they are influenced by the news media in that they take cues about nanotechnology from the news and as a result primarily hold positive attitudes toward the emerging science and technology (see for example Besley et al., 2008, Gaskell et al., 2005, Dudo et al., 2011, Wilsdon, 2004, Lee et al., 2005, Sheetz et al., 2005). Here again, this thesis was not an audience study, but understanding scholarship around the coverage of nanotechnology from a variety of angles is useful for placing this research into the wider landscape. Also, understanding how audiences potentially interpret the news is useful when studying the content itself.

The literature review outlined the limited research into how nanotechnology has been reported, paying particular attention to audiences and content. When it comes to the content of news, previous research has demonstrated that a preferred way of thinking about nanotechnology has yet to be established in the reporting. Most of the studies to date have centred on a small number of years in the early 2000s, which was when nanotechnology had been debated and discussed most often in the press. While a longitudinal approach has also not found a dominant frame, this thesis has demonstrated the unequal nature of the representation of individual frames across 24 years. This will be discussed in more detail when reviewing the findings of the thesis.

The methodology chapter began by exploring the concept of framing, which has many definitions and approaches (see for example Scheufele, 1999, Entman, 2003). Broadly speaking a frame helps set the parameters of debate and identifies the salient issues for journalists to help make sense of complex topics for the audience. These frames, therefore, are important for the democratic process in that they help determine the relevance and importance of debates around a topic like nanotechnology. Although the myriad of definitions and approaches to framing provide challenges to social science research (Scheufele, 1999, Entman, 1993), this thesis aligns with Hertog and McLeod's (2001) views that it is a “blessing” to have a variety of approaches because it offers the opportunity for creative analysis so long as researchers clearly outline their approach in detail. Tankard (2001) describes a number of empirical approaches to framing research, but the list approach best describes how this study was conducted. In that case, a list of frames that are defined before examining the articles in the sample was established from the literature review and pilot readings of the content. The research approach section set out the specifics of each frame and helped identify the procedures adopted in order to collect the articles and analyse each using a coding sheet. Additionally, in the course of documenting the findings in

Chapter Six, examples of each frame and a reflection on why the news content was identified as part of that frame was also provided. Such moves aimed to provide a transparent and reflexive view of the data collection and analysis procedures and demonstrate the rigorousness of the research carried out for this thesis.

Critical findings

These discussions provided a foundation to answer my research questions: How do journalists frame nanotechnology for their audiences? How do the characteristic features of the framing processes change over time? And to what extent does the reporting open opportunities for meaningful, democratic discussion around nanotechnology? The findings chapters set out to answer these questions in detail, providing empirical evidence from quantitative and qualitative research traditions.

Using content and textual analysis, the findings chapters provided an overview of the reporting itself from 1986 to 2010 and discussed the broader contours of the coverage. More specifically, this research identified a rise and fall of reporting on nanotechnology over the 24 years studied. The early reporting was sporadic in nature until a rise in the frequency of articles appearing in both newspapers in the early 2000s and more recently a fall. The rise can be attributed to significant attention from governments and businesses, including the announcement of the National Nanotechnology Initiative in the United States in 2000, concerns raised by Sun Microsystems founder Bill Joy in 2000, and again by Prince Charles in 2003, and official reports from such organisations as the Royal Society and Royal Academy of

Engineering in 2004. Such events were particularly prominent and frequent in the early 2000s. The decline in reporting more recently could be the result of few such events happening since the early 2000s. This particular finding was also recently documented by Dudo and his colleagues (2011), but exclusively in a US context. Without events and pseudo-events to signal nanotechnology's newsworthiness to journalists, nanotechnology falls off the newspaper pages. Additionally, as research has pointed out (see for example Allan, 2008) the slow, incremental pace of science makes it less exciting in journalistic terms. Therefore, smaller developments in nanotechnology are likely to be less interesting journalistically, but the larger, more fantastic developments that would likely receive more attention are at least decades away.

Moving on to where news about nanotechnology appears, this thesis found that news about nanotechnology primarily appears in the news pages, but also the science and technology and business and finance sections of the newspapers. The science and technology sections would be the most likely places to find news about nanotechnology, and is likely written by a specialist reporter and would be read by a particular audience. However, the news pages and the business and finance sections can bring new audiences to the issues around nanotechnology that might otherwise not seek out news about science and technology. Also, journalists without science and technology backgrounds or experience reporting on these topics would also be reporting these stories, which could bring a diversity of voices and views on the topic (Nisbet and Scheufele, 2009). As such, the diversity of journalists involved in the reporting of nanotechnology has the potential to broaden the scope for democratic debate. However, as the findings demonstrated, the reporting overall is similar in its treatment of nanotechnology, so that potential is not realised. Specifically, the newspapers treated nanotechnology very positively and failed to explore risk claims associated with this emerging science and technology to any great extent. This coupled with other findings that will be discussed later, demonstrates a limited engagement with additional views of nanotechnology and suggests a limited engagement with additional voices. When it comes to what makes nanotechnology newsworthy, press releases, book releases and journal publications were the most common news pegs/hooks identified from the entire collection of reporting on nanotechnology. These news hooks provide journalists the timely link they need to justify an article as news at the time of reporting. When nanotechnology was the primary subject of the news, journal articles were the most common news hook identified from the articles. Regardless of whether nanotechnology was the primary or a secondary subject of news, these events/pseudo-events were prevalent in the reporting, which indicates the significant role of public relations tactics in helping to set the news agenda. This contributes to the findings of other scholars' work around the growing presence of PR in the news (see for example Moloney, 2006, Lewis et al., 2008), but specifically discusses it in reference to news about nanotechnology.

Moving on to news values, this thesis finds that overall nanotechnology is newsworthy when a breakthrough happens and when there is a link to politics and economics. This indicates that Hansen's news values for science remain relevant in the context of nanotechnology and despite more than 15 years since publication. When looking at the two newspapers individually, *The Guardian* appears to prioritise conflict/controversy as a news value when it comes to nanotechnology reporting. Alternatively, *The New York Times* reporting most often reflects the link to economics news value. This could indicate what the individual journalists believe about their respective audiences and that the audience wants to read about nanotechnology in the context of conflict or business, respectively. However, a production study would be required to more definitively state such are argument. The contributions of this thesis toward conversations about news values, specifically as it relates to nanotechnology, will be addressed in more detail in the theoretical reflections section of this chapter.

One of the key aims of this thesis was to look specifically at the framing of nanotechnology. In providing definitions for nanotechnology, the most diffuse concept of framing, only 40 per cent of articles provided some kind of definition or description of the field. The thesis analysed these definitions qualitatively, finding that despite "nanotechnology" being the preferred term in the reporting, it was often described as a science. The practicality/functionality of this field was also highlighted in the definitions, especially as it relates building gadgets of some kind. Finally, the scale of nanotechnology was depicted as very, very small and described in both technical precise ways (for example, billionth of a metre) or in more abstract and generic ways (for example, 'unfathomably small'). The findings around the definitions of the field give a snapshot of the framing of nanotechnology, which was analysed extensively quantitatively.

Further, this research found that nanotechnology is reported in primarily positive ways over the entire 24 years studied. Therefore, nanotechnology has eluded criticism and followed the proponents' view of the field. It has been largely described as safe, which is fine so long as nothing goes wrong with nanotechnology. If a significant negative event happens in the field, the overwhelmingly positive nature of reporting now will exacerbate any backlash that occurs. Additionally, the overwhelmingly positive tone of the reporting raises questions about professional norms of objectivity in that risk claims, counter arguments, and a diversity of voices on nanotechnology are all but ignored. Previous research has suggested that because the tone of articles was more positive in nature that it demonstrated how the benefits outweighed risks of nanotechnology (Gorss and Lewenstein, 2005, Faber et al., 2005). These studies have focused on a North American environment exclusively and considered their research framing studies despite a very simple conception of framing theory. Setting that aside, the studies failed to document the claims about benefits and risks of nanotechnology specifically.

This thesis, as briefly mentioned earlier in this chapter, documented the extent to which claims about risks and benefits were reported, as well as identified what risks and benefits specifically were cited in the reporting. It found that specific benefit claims are identified in 56.3 per cent of news articles that discuss nanotechnology, but risks appear in only 26.4 per cent of the reporting. Further, the specific benefit and risk claims cited tend to be more far-reaching and arguably far-fetched. The most common benefits cited in the reporting were medical benefits, of which the top benefit claim identified in news articles was that of nanobots exploring our bodies and repairing damaged cells. Alternatively, the most common risk claim cited was the notion of runaway technology, particularly grey goo. These benefits and risks are more fantastical in nature and may never happen. Where they tend to come from popular culture, these particular benefits and risks may be reported most often because journalists believe it makes nanotechnology interesting and accessible to the audience. However, the price of characterising nanotechnology in this way is that it does not adequately address what is happening now. That is not to suggest that temporality is the key issue. To my mind, it is more an issue that the opportunity for meaningful, democratic debate is limited by a sense that the benefits and risks of nanotechnology are perhaps fictional in nature or so far-reaching that they therefore do not require debate. The imbalance of reporting on 'benefit claims' over 'risk claims' again raises questions about the criticality and objectivity of the reporting.

Moving on to the individual frames identified in the reporting, this thesis identified that when a primary frame for nanotechnology is evident in the reporting, more than half of the articles framed it in one of four ways - as a visionary science and around its future implications; scientific discovery and more procedural science; funding or investment in nanotechnology; and the risks or social implications of nanotechnology. Individually, these frames comprised 10 to 15 per cent of the reporting in the two newspapers, and none had an overwhelming salience. Previous research has also documented the contested nature of framing in nanotechnology news (see for example Stephens, 2005, Weaver et al., 2009, Anderson et al., 2005, Anderson et al., 2009a, Anderson et al., 2009b, Petersen et al., 2009, Wilkinson et al., 2007b). This thesis contributes to that discussion, but also demonstrates a hierarchy of framing that has changed throughout the 24-year period. At times, some article frames prevail over others, which therefore show that frames are not equal in the reporting and there are some preferred interpretations for nanotechnology.

Looking at the reporting in five-year increments over the 24 years studied has demonstrated that the visionary frame and sometimes the discovery frame have been the most common frames identified in the reporting. That is not to say that a dominant frame has emerged because Chapter Six documented how a variety of frames were represented in a number of articles. Instead, the finding demonstrates the complexity of framing, especially when nanotechnology was more frequently featured in the news. When nanotechnology featured in few articles as a primary or secondary subject, there was more likely to be very few frames for nanotechnology and therefore more likely that a particular frame would appear dominant. For example, the visionary frame was the primary frame in 5 of 8 articles reported during the period 1986 to 1990. However, most recently the top frames identified were represented in nearly equal numbers of articles.

Overall, this thesis has documented 24 years of framing nanotechnology in two elite newspapers. It demonstrated the prevalence for a visionary view of nanotechnology that most often was reported in very positive ways. It perpetuates the proponents' position of this emerging field of nanotechnology and lacks a sense of accountability and responsibility. It may at first glance appear to be objective reporting, but the lack of risk claims identified in the reporting and the nature of the benefit and risk claims that are reported fail to democratise science and technology. The next section of this chapter will address in more detail the implications of some of these theoretical findings.

Theoretical reflections on the research

This research broadly contributes to debates around news values, framing, and most specifically the representation of nanotechnology in the press. This section discusses the ways in which the thesis has contributed to these conversations. It begins by discussing the contributions to news values, specifically as it relates to nanotechnology, before going on to discuss the thesis's contributions to framing theory and the representation of nanotechnology in the press.

As noted above, the thesis considered news values for science, finding that the values Hansen (1994) identified remain relevant for nanotechnology. However, looking at the reporting itself, and considering broader debates about news values (see for example Lewenstein, 2005a, Allan, 2008, Weigold, 2001, Priest, 2001, Carvalho, 2007), it appears nanotechnology has failed the news values ‘test’. Nanotechnology rarely appeared on the front page of either newspaper, and it did not sustain coverage for any length of time. For now, it would appear that nanotechnology is not interesting in journalistic terms. The research also documented the event-driven nature of the reporting, including the reliance on academic journals for stories (see Chapter 5, 'Newsworthiness of Nanotechnology'). The latter indicates the influence of public-relations like tactics on the reporting of nanotechnology, which has been identified by other scholars in news reporting more generally (see for example Moloney, 2006, Lewis et al., 2008) and for science (Trench, 2009). Further, nanotechnology has yet to face a controversy or crisis of any great proportion, which can also explain its lack of sustained reporting and minimal front-page exposure.

That lack of significant controversy has also meant that a dominant frame for nanotechnology has yet to form. In the early 2000s, the concerns raised by prominent figures, including scientists and celebrities, had the potential to help solidify a frame. However, the figure, rather than nanotechnology, became the story. This thesis is unique in that it documented the framing before a crisis took place. Framing research has tended to document the dominance of a frame or set of frames around individual issues after a significant event has occurred. That event then acts as a lens for viewing the issue. Additionally, studying framing in the way that this thesis has done helps draw attention to framing as a process. The formation of a dominant frame can be messy and uneven. In the case of nanotechnology, that competition over a preferred definition is on-going. The approach to framing coupled with the longitudinal nature of the study contributes to existing conversations about the framing of nanotechnology in the press, but will be potentially more valuable if/when a significant incident or event happens that thrusts nanotechnology onto the front page. In that case, this research can help scholars understand how the framing of nanotechnology developed in the lead up to the incident and contextualise the frame that then develops.

Further, this research considered both primary and secondary frames identified in the reporting. Framing research tends to explore primary frames because they are so prominent. These frames are often found in headlines, leads and closing paragraphs. As such, they are important to consider. However, secondary frames are also important to explore. These frames are often communicated in a phrase or sentence, thereby making them appear more natural. So, they can be taken for granted. For nanotechnology, it was important to consider the primary and secondary frames because there continues to be a contest over framing. Therefore, the secondary frames offered additional insight into the ways in which nanotechnology is defined for the audience. It also demonstrates the nuances of framing and could help identify counter frames in more hotly contested issues.

Finally, this section will turn to some of the individual frames. Chapter 6 identified that the most salient frames identified in the reporting were visionary; scientific discovery; funding or investment in nanotechnology; and the risks or social implications of nanotechnology. As previously stated, these cannot be considered dominant frames because none were represented in a significant proportion of the reporting. However, they each have their potential implications. The visionary frame presents nanotechnology as this far-reaching, wonderful technology that will solve innumerable problems that society faces today. It was most often reported in positive ways with benefits such as nanobots repairing damaged cells in the body featuring in the reporting. Such benefits are at the least far reaching, if not farfetched. They draw on a language of popular culture and science fiction; therefore, without specifically linking nanotechnology to science fiction, such a frame aligns the field with the realm of fiction. As such, the visionary frame for nanotechnology could suggest that this emerging science and technology is more along the lines of science fiction than real science. Also, such popular culture references may attract public interest in nanotechnology, they are a simplistic way of looking at the potential for nanotechnology and therefore limiting in the potential for fostering debate.

The scientific discovery frame, like the visionary frame, was reported in overwhelmingly positive ways. As Chapter 6 discussed, that frame included articles about individual projects involving nanotechnology, the development of science and technology, and new findings in research. Therefore, it is not surprising that the tone of articles was quite positive. Where nanotechnology is an emerging area of science and technology, focusing on its developments is understandable. However, where the reporting is so focused on the new developments in such positive ways, the reporting lacks a sense of analysis and critical questioning. In this case, the reporting plays a supportive role toward science, and where there is little balance to the articles the news organisations are failing to hold industry and governments to account the relative safety of this science and technology and, as the next paragraph discusses, spending on this emerging field.

Articles that framed nanotechnology around funding and investment discussed the need for funding or the distribution of funds for nanotechnology. This frame was also reported in overwhelmingly positive ways. These articles arguably reflect the funders' perspective on nanotechnology, which would be primarily positive. As with the two previous frames, the reporting lacks balance and fails to meet the professional norms of objectivity. As Chapter 6 discussed, the funding frame focused on the ways in which nanotechnology was going to bring jobs to an area; provide a new technology that will make individuals' lives easier or healthier or better in some way; and help countries stay at the front of the nanotechnology race. These ways of reporting nanotechnology again fail to recognise the potential risk, but also fail to recognise the slow pace of scientific development. Focusing on the latter, I am not suggesting that nanotechnology should not be funded by governments and corporations. However, when considering the potential for debate around these issues, news reporting that lacks critical questioning fails to provide the audience with adequate information in order to participate fully in the democratic process. Instead, such reporting treats the audience as consumers of goods rather than citizens in a democracy.

The risk frame was the only frame that was reported in more balanced ways. Articles that were framed around risk not only highlighted the potential implications of nanotechnology to individuals' health or the environment, but also offered a sense of the potential benefits of nanotechnology. While that more measured approach to the reporting of nanotechnology is welcome, it was rare overall. Claims around risk appeared in just over a quarter of the reporting. Further, framing nanotechnology around issues of risk was even more rare at a rate of 10.9 per cent. However, looking more closely at the reporting of what risk claims were made, they tended to be rooted in science fiction and popular culture, including the idea of ‘grey goo’ and ‘technology run amok’. Such references can attract public attention to the issue of nanotechnology, but such an engagement with risk claims is limited. Therefore nanotechnology is again treated more like science fiction than science, raising questions about the potential for a meaningful debate around its potential risks. A more popular culture approach is expected from tabloid publications. However, if newspapers like *The Guardian* and *The New York Times* fail to provide sufficient analysis and report nanotechnology in a way that provides the audience with a clearer sense of the issues involved, then that is problematic because, as the introduction set out, other news organisations take their cues from these quality newspapers.

A significant amount of uncertainty exists around nanotechnology. This uncertainty is unlikely to be resolved as simply positive or negative for society, and instead will be more complex. Ignoring that complexity and failing to provide a sense of the broader debates around nanotechnology and the organisations involved in these debates curtails discussion around nanotechnology. Journalists should engage with the complexity and resist reporting nanotechnology in simplistic ways. Further, looking at the issue of framing itself, it is understandable that journalists frame complex issues. They do so to help contextualise issues like nanotechnology and provide the audience with shortcuts to understanding multifaceted or complex ideas associated with a topic (see for example Anderson et al., 2005, Cobb, 2005, D'Angelo, 2002, de Vreese, 2005, Scheufele, 2000, Schutz and Wiedemann, 2008, Listerman, 2010, Nisbet, 2010, Reese et al., 2001, Entman, 1993, Scheufele, 1999, Stephens, 2005). Academics and journalists should consider the ways in which nanotechnology is framed and how framing devices can potentially foster debate amongst citizens.

Additionally, the end of Chapter 5 pointed out the limitations of the web reporting of nanotechnology from these two news organisations. The research found that the online reporting was largely a duplication of the print reporting, as the section on online news discussed. There is a limit to the volume of content that newspapers can print, but the web is not constrained by these limits. It is possible for the online editions of the newspapers to provide a network of resources around nanotechnology, leading audience members to original documents that allow them to engage more deeply with the issues associated with nanotechnology. Now, this chapter turns to the limitations of the thesis and the opportunities for future research on the reporting of nanotechnology.

Research Limitations and Suggestions for Future Research

Although the findings discussed above are meaningful and contribute to the body of social science research on science and technology news, this research is not without its limitations. As the study considered only elite newspapers in these two countries, it would be inappropriate to suggest that the findings are reflective or representative of the wider news ecologies in either country. Therefore international comparisons that were drawn in the findings chapters were suggestive in nature and should not be treated as definitive. That said it was not the intention of the research to be able to draw conclusions based on nationally representative reporting and to make comparisons of reporting in the two countries. Instead, the focus was a detailed look at the reporting of two elite newspapers that are known for being influential in their home countries as well as internationally. Also, the longitudinal nature of the research was a key focus of the thesis. That longitudinal approach, as was noted above, provided an opportunity to see the framing process in action.

Additionally, priority was given to the quantitative analysis, which was necessary given the volume of reporting that was analysed in the thesis. However, such a quantitative approach can suggest that framing is a flat and passive process. To the extent that was possible, the thesis documented the complexity of each of these frames and some of the more qualitative decisions that were made in order to categorise the reporting as part of a particular frame. The goal of providing examples from the content was to be transparent in the data analysis process, but also provide more depth to each of these frames. However, future research could adopt a purely qualitative approach to framing or prioritise a qualitative approach to further the findings of this research and provide a deeper sense of the framing of nanotechnology in the news.

Further, this thesis did not engage with journalists or sources in the reporting, which is also true of the literature to date around nanotechnology news. Such a lack of engagement is a limitation of both this research and the research field more widely. However, this thesis was focused intensely on the framing of nanotechnology in the newspaper content over an extended period. That longitudinal focus would have limited the reliability of interviews with journalists and sources as it relates to the earlier reporting in particular. Relying on 24-year-old memories would have been problematic. Future research, however, could speak with journalists, sources, and others in the field of nanotechnology research to reflect on the reporting of nanotechnology for additional insight into the source-reporter relationship and understanding the challenges of communicating nanotechnology to a diverse audience.

Finally, the project presented a number of challenges, including gathering the online reporting and sifting through enormous amounts of data. Specifically, this research used the search engines of the individual newspapers' websites to gather the online sample, which is not ideal. However, no alternative was available to access the online historical content. Further, taking screen shots of the online news can be problematic for researchers who would like to draw on interactive elements within the news. Where the reporting of nanotechnology was the primary focus of investigation, the lack of interactivity was an inconvenience, but not a significant loss. If the sources of news were a more significant focus of this research, it would have been more important to be able to follow links provided in the online articles and blogs. As more news organisations turn to online reporting and more online publications grow in popularity, it would be useful for research if more suitable databases and data collection methods were found so that scholars can more fully explore online news.

In addition to the recommendations cited above, this research and other studies on nanotechnology news raise questions that future research could address. As the literature review discussed, previous research has paid considerable attention to audience studies, especially what people know about nanotechnology and how the news media influences that knowledge and their attitudes toward nanotechnology. Content studies have also been a popular area of study, especially with regard to the risks of nanotechnology. However, a number of studies have focused on the tone of reporting, including those that have considered risk, and did not provide a detailed view of the specific risk claims in the reporting, nor a sense of how they compare with the reporting of benefits. Although this thesis addressed that particular limitation, as well as contributed a detailed sense of framing across more than two decades, it cannot fully close the gap in literature that exists.

As noted above, the research on sources in nanotechnology news could be an opportunity for additional research. Future projects could analyse what sources are identified in the reporting and conversely who does not appear in articles. Also, the visual imagery associated with nanotechnology in the news reporting has not been analysed to date. Research into both can provide further insight into the framing of nanotechnology. In the course of gathering the data for this thesis, the coding schedule documented some of these elements, but more attention was paid to the broader contours of framing in the articles for this thesis. However, identifying what sources are specifically quoted and paraphrased in the reporting over the last 24 years would identify the extent to which the voices in the reporting are diverse and reflect broader debates around nanotechnology. The same can be said for reviewing the imagery in the reporting. This can be done both quantitatively and qualitatively in documenting what types of images accompany articles, who or what are the subjects of the images and how are they represented.

Also, as the literature review indicated, the volume of production studies that seek out interviews with journalists and sources is seriously limited. Additional research in this area could help to address some of the questions raised by this and other content studies. It would also help to reflect on journalistic practice around the reporting of nanotechnology with the benefit of those that are involved in the day-to-day reporting of it. Talking with sources about their views on the reporting further could provide useful insight into the challenges they face in communicating this field to a wide and diverse audience.

Conclusion

In conclusion, the findings in this thesis indicate that nanotechnology could be losing ground as a newsworthy topic. While there was a rise in reporting of nanotechnology from 1986 to 2003, more recently, there has been a lack of reporting. This more recent trend could be the result of few newsworthy events having occurred since the early 2000s. Journalists need events to signal a topic as timely and interesting now, which this thesis also documented in relationship to the reporting of nanotechnology. Additionally, a preferred definition for nanotechnology or dominant frame in the news reporting has yet to emerge. This is also perhaps because no significant development or catastrophe has occurred to crystallise what nanotechnology means and what its impact will be on society - positive or negative.

Instead, news coverage has represented nanotechnology as primarily a safe science and technology with an overwhelming positive tone and a lack of substantive discussion around risk claims. As such, it has eluded criticism and the reporting lacks a sense of accountability, which begs the question about what will happen if some controversy arises. The visionary view of nanotechnology and discussions around benefits and risks as far-off ideas that may never happen further limits the parameters of debate by suggesting that nanotechnology is something that is unfathomably small with unfathomably large benefits or consequences.

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Appendices

Appendix A: List of Factiva Articles Removed from the Study

Number	Publication	Date	Reason
1	NYT	31-May-83	Proper name
2	NYT	6-Sep-83	Proper name
3	NYT	7-Nov-85	Proper name
5	NYT	7 Dec. 1986	Proper name
6	NYT	17-May-87	Proper name
8	NYT	29-Jan-89	Proper name
9	NYT	20-Jul-89	Proper name
10	NYT	20-Aug-89	Proper name
11	NYT	2-Feb-90	Proper name
15	G	8-Nov-90	Generic small
16	NYT	18-Nov-90	Rice
17	NYT	24-Dec-90	Proper name
18	G	20-Feb-91	Proper name
19	G	23-Feb-91	Proper name
20	G	4-Mar-91	Proper name
21	G	12-Mar-91	Proper name
22	G	30-Mar-91	Proper name
23	G	1-Apr-91	Proper name
24	G	1-Apr-91	Proper name
25	G	2-Apr-91	Proper name
27	G	4-May-91	Proper name
28	G	6-May-91	Proper name
29	NYT	7-May-91	Proper name
30	NYT	6-May-91	Proper name
31	G	14-May-91	Proper name
32	G	3-Jun-91	Proper name
33	G	5-Jun-91	Proper name
34	NYT	5-Jun-91	Proper name
35	NYT	6-Jun-91	Proper name
36	NYT	12-Jun-91	Proper name
37	NYT	13-Jun-91	Proper name
38	G	28-Aug-91	Nano-second
41	G	28-Aug	Proper name
42	NYT	25-Dec-91	Proper name
43	NYT	5-Jan-92	Generic small
44	Obs	1-Mar-92	Proper name
45	NYT	22-Mar-92	Proper name
47	NYT	23-Mar-92	Proper name
49	G	21-Oct-92	Nano-second
51	NYT	26-Apr-93	Proper name
53	G	25-Mar-94	Nano-second
54	G	18-May-94	Proper name
56	G	24-Sep-94	Nano-second
58	NYT	11-Nov-94	Proper name
61	NYT	22-Nov-94	Job title
62	NYT	4-Dec-94	List - books
66	NYT	16-Apr-95	List - books
68	NYT	23-Apr-95	List - books
70	NYT	30-Apr-95	List - books
71	NYT	1-May-95	Proper name
73	NYT	7-May-95	List - books
74	NYT	14-May-95	Generic small
75	NYT	11-Jun-95	List - books
76	NYT	8-Jul-95	Proper name
81	G	3-Oct	Nano-second

Number	Publication	Date	Reason
82	G	11-Dec-95	Nano-second
87	G	26-Mar-96	Nano-second
88	Obs	31-Mar-96	Nano-second
90	G	4-May-96	Nano-second
91	NYT	17-May-96	List - books
93	G	25-May-96	Proper name
94	Obs	26-May-96	Proper name
95	G	30-May-96	Nano-second
96	Obs	2-Jun-96	Proper name
98	G	1-Jul-96	List - books
99	G	3-Aug-96	Nano-second
100	NYT	8-Aug-96	Nano-second
103	NYT	15-Sep-96	Author credit only
107	NYT	3-Nov-96	Author credit only
109	G	13-Nov-96	Nano-second
111	G	21-Nov-96	List - books
112	G	21-Nov-96	List - books
113	NYT	3-Jan-97	Proper name
114	NYT	4-Jan-97	Proper name
115	NYT	7-Jan-97	Proper name
116	G	23-Jan-97	Generic small
119	Obs	2-Feb-97	Rice
120	G	3-Feb-97	Proper name
121	G	7-Feb-97	Nano-second
122	NYT	16-Feb-97	List - subjects
123	Obs	2-Mar-97	Nano-second
124	NYT	3-Mar-97	Proper name
125	NYT	14-Mar-97	Proper name
126	G	14-Mar-97	Proper name
127	NYT	17-Mar-97	Proper name
128	NYT	19-Mar-97	Proper name
129	NYT	23-Mar-97	Proper name
130	NYT	6-Apr-97	Proper name
132	G	1-May-97	Nano-second
133	G	10-May-97	Nano-second
134	G	20-May-97	Nano-second
135	G	27-May-97	Author credit only
137	Obs	8-Jun-97	Nano-second
139	G	26-Jun-97	Proper name
140	G	28-Jun-97	Proper name
141	NYT	29-Jun-97	Proper name
142	NYT	30-Jun-97	Proper name
143	NYT	30-Jun-97	Proper name
144	NYT	1-Jul-97	Proper name
145	NYT	1-Jul-97	Proper name
146	G	1-Jul-97	Proper name
147	NYT	2-Jul-97	Proper name
148	G	3-Jul-97	Proper name
149	G	5-Jul-97	Proper name
150	NYT	8-Jul-97	Proper name
151	G	22-Jul-97	Nano-second
152	G	24-Jul-97	Proper name
153	NYT	24-Jul-97	Proper name
154	NYT	25-Jul-97	Proper name
156	NYT	29-Jul-97	Generic small
157	NYT	17-Aug-97	Proper name
158	G	22-Aug-97	Proper name
159	G	27-Aug-97	Proper name
161	Obs	5-Oct-97	Rice
162	Obs	5-Oct-97	Rice
163	NYT	19-Oct-97	Author credit only
164	G	20-Oct-97	Nano-second
167	G	3-Nov-97	Proper name
168	G	4-Nov-97	Nano-second

Number	Publication	Date	Reason
170	NYT	6-Nov-97	Proper name
171	G	2-Dec-97	Proper name
172	G	2 Dec. 1997	Proper name
174	NYT	1-Jan-98	Author credit only
176	G	10-Jan-98	Proper name
177	NYT	1-Feb-98	Proper name
179	G	4-Nov-97	Generic small
180	Obs	1-Mar-98	Proper name
181	G	2-Mar-98	Proper name
182	NYT	17-Mar-98	Proper name
186	NYT	30-Apr-98	Proper name
187	G	30-Apr-98	Proper name
188	NYT	11-May-98	Proper name
189	NYT	17-May-98	Generic small
190	NYT	4-Jun-98	Proper name
191	G	4-Jun-98	Proper name
192	NYT	10-Jun-98	Proper name
195	G	13-Jul-98	No reference
196	G	25-Jul-98	Proper name
197	NYT	14-Sep-98	Proper name
198	NYT	14-Sep-98	Proper name
199	NYT	15-Sep-98	Proper name
200	NYT	16-Sep-98	Proper name
201	NYT	16-Sep-98	Proper name
202	G	16-Sep-98	Proper name
203	G	16-Sep-98	Proper name
204	NYT	17-Sep-98	Proper name
205	G	17-Sep-98	Proper name
206	G	18-Sep	Proper name
207	NYT	19-Sep-98	Proper name
208	G	19-Sep-98	Proper name
209	NYT	20-Sep-98	Proper name
210	Obs	20-Sep-98	List - subjects
211	NYT	29-Sep-98	Proper name
212	NYT	29-Sep-98	Proper name
213	NYT	30-Sep-98	Proper name
214	G	5-Oct-98	Proper name
215	G	6-Oct-98	Nano-second
216	G	10-Oct-98	Proper name
221	NYT	14-Jan-99	Proper name
222	G	22-Jan-99	Nano-second
225	G	8-Mar-99	Nano-second
227	G	30-Mar-99	Nano-second
228	NYT	2-Apr-99	Proper name
229	G	13-Apr-99	Proper name
232	G	2-Jun-99	Nano-second
235	NYT	1-Jul-99	Job title
236	G	2-Jul-99	Rice
237	G	23-Jul-99	Nano-second
238	G	28-Jul-99	Owls
239	G	29-Jul-99	Watt
240	NYT	7-Aug-99	List - subjects
241	NYT	21-Aug-99	Proper name
242	Obs	29-Aug-99	Generic small
246	G	11-Oct-99	Generic small
247	G	11-Oct-99	Duplicate
248	G	14-Oct-99	TOC
248	G	6-Jun-01	Duplicate
250	NYT	28-Oct-99	Proper name
251	NYT	28-Oct-99	Proper name
254	G	2-Nov-99	Generic small
257	NYT	9-Nov-99	Generic small
258	G		TOC

Number	Publication	Date	Reason
260	G	16-Dec-99	List - programmes
261	G	19-Dec-99	Proper name
268	NYT	30-Jan-00	No reference
272	G	17-Mar-00	Nano-second
273	NYT	17-Mar-00	TOC
278	Obs	26-Mar-00	Nano-second
279	Obs		Nano-second
280	G	21-Apr-00	Nano-second
281	NYT	23-May-00	Generic small
285	NYT	4-Jun-00	Generic small
286	Obs	4-Jun-00	Nano-second
287	G	10-Jun-00	List - subjects
289	Obs	2-Jul-00	Nano-second
290	G	6-Jul-00	List - subjects
294	G	17-Aug-00	Nano-second
298	G	2-Sep-00	List - subjects
299	G	9-Sep-00	Generic small
300	G	9-Sep-00	Nano-second
305	G	5-Oct-00	List - subjects
307	NYT	12-Oct-00	Proper name
308	NYT	18-Oct-00	Rice
312	NYT	29-Nov-00	Rice
313	NYT	6 Dec. 2000	Nano-second
315	NYT	8-Dec-00	TOC
316	NYT	8-Dec-00	TOC
318	NYT	11-Dec-00	TOC
319	NYT	11-Dec-00	TOC
322	G	30-Dec	Generic small
335	G	24-Mar-01	Nano-second
336	G	4-Apr-01	Nano-second
343	G	4-May-01	Duplicate
344	G	4-May-01	Duplicate
345	Obs	27-May-01	Generic small
346	NYT	3-Jun-01	List - books
349	NYT	10-Jun-01	Proper name
350	Obs	17-Jun-01	Nano-second
351	G	25-Jun-01	Proper name
352	NYT	25-Jun-01	Proper name
354	G	26-Jun-01	Proper name
355	G	26-Jun-01	Duplicate
358	G	21-Jul-01	Nano-second
361	G	25-Aug-01	Duplicate
371	G	18-Oct-01	List - events
373	Obs	11-Nov-01	Nano-second
374	NYT	2-Dec-01	List - books
376	G	13-Dec-01	Duplicate
377	G	13-Dec-01	List - programmes
378	G	13-Dec-01	List - programmes
379	G	13-Dec-01	List - programmes
380	G	13-Dec-01	List - programmes
381	G	13-Dec-01	List - programmes
385	G	31-Dec-01	Generic small
386	G	31-Dec-01	Generic small
387	NYT	10-Jan-02	Generic small
390	NYT	24-Feb-02	Generic small
391	G	25-Feb-02	Proper name
392	G	25-Feb-02	Proper name
393	NYT	28-Feb-02	Generic small
398	G	27-Apr-02	Nano-second
398	G	27-Apr-02	Nano-second
399	G	27-Apr-02	Nano-second
399	G	27-Apr-02	Duplicate
401	G	9-May-02	Duplicate

Number	Publication	Date	Reason
403	NYT	12-May-02	Proper name
404	G	13-May-02	Duplicate
409	G	24-May-02	Duplicate
410	G	24-May-02	Duplicate
412	NYT	30-May-02	Job title
413	NYT	9-Jun-02	Proper name
416	G	22-Jun-02	List - subjects
426	Obs	18-Aug-02	Nano-second
429	G	27-Aug-02	Duplicate
430	G	5-Sep-02	List - programmes
431	G	5-Sep-02	List - programmes
432	G	5-Sep-01	List - programmes
433	G	5-Sep-01	List - programmes
435	NYT	10-Sep	Generic small
438	G	28-Sep-02	List - programmes
438	G	28-Sep-02	List - programmes
441	NYT	7-Oct-02	Nano-second
442	NYT	10-Oct-02	Proper name
446	G	22-Oct-02	Duplicate
447	NYT	25-Oct-02	Proper name
448	NYT	28-Oct-02	List - subjects
451	NYT	21-Nov-02	Proper name
454	G	28-Nov-02	Generic small
455	G	28-Nov-02	Generic small
458	G	5-Dec-02	Duplicate
459	G	11-Dec-02	Duplicate
464	G	16-Dec-02	Duplicate
475	NYT	10-Feb-03	TOC
478	G	11-Feb-03	Duplicate
481	G	25-Feb-03	Duplicate
484	G	6-Mar-03	Proper name
485	G	6-Mar-03	Proper name
486	G	8-Mar-03	Proper name
487	G	17-Mar-03	Nano-second
490	G	3-Apr-03	Duplicate
493	G	3-Apr-03	Duplicate
497	G	10-Apr-03	Generic small
498	G	10-Apr-03	Duplicate
499	G	10-Apr-03	Generic small
500	G	12-Apr-03	Proper name
501	G	12-Apr-03	Generic small
506	G	17-Apr-03	Duplicate
514	G	6-May-03	Duplicate
517	NYT	11-May-03	Proper name
519	G	13-May-03	List
520	G	13-May-03	Duplicate
521	G	13-May-03	List - subjects
526	G	20-May-03	Duplicate
528	G	22-May-03	Duplicate
530	G	24-May-03	Generic small
532	G	7-Jun-03	Duplicate
535	G	12-Jun-03	Duplicate
539	G	12-Jun-03	Duplicate
542	NYT	13-Jun-03	Duplicate
543	NYT	15-Jun-03	Proper name
547	G	17-Jun-03	List - subjects
548	G	17-Jun-03	List - subjects
552	G	3-Jul-03	Duplicate
553	G	3-Jul-03	Duplicate
554	G		Duplicate
557	Obs	6-Jul-03	List - books
559	NYT	7-Jul-03	TOC
561	NYT	13-Jul-03	List - events
565	G	28-Jul-03	List - books

Number	Publication	Date	Reason
568	NYT	14-Aug-03	Proper name
569	G	14-Aug-03	Duplicate
570	G	16-Aug-03	Duplicate
575	NYT	28-Aug-03	Job title
584	NYT	7-Oct-03	Generic small
585	G	8-Oct-03	List - programmes
589	NYT	23-Oct-03	Proper name
590	NYT	23-Oct-03	Proper name
593	G	30-Oct-03	Duplicate
595	Obs	2-Nov-03	Nano-second
601	NYT	6-Nov-03	Generic small
602	G	6-Nov-03	Duplicate
603	G	6-Nov-03	Duplicate
607	G	25-Nov-03	Nano-second
608	G	25-Nov-03	Nano-second
609	G	27-Nov-03	List - programmes
610	G	9-Dec-03	Duplicate
616	G	18-Dec-03	Duplicate
617	G	18-Dec-03	Generic small
621	G	23-Dec-03	Duplicate
622	NYT	25-Dec-03	Correction - included with original story
624	NYT	1-Jan-04	Job title
625	G	8-Jan-04	Duplicate
628	G	8-Jan-04	Duplicate
631	G	29-Jan-04	Duplicate
633	G	5-Feb-04	Duplicate
634	G	3-Feb-04	List - programmes
638	G	12-Feb-04	Duplicate
641	G	24-May-04	Duplicate
642	G	21-Feb-04	List - programmes
643	NYT	27-Feb-04	Proper name
647	G	4-Mar-04	Duplicate
648	NYT	7-Mar-04	Nano-second
649	G	9-Mar-04	Nano-second
650	G	9-Mar-04	Nano-second
652	NYT	15-Mar-04	List
655	NYT	18-Mar-04	Correction - included with original story
656	G	18-Mar-04	Duplicate
660	G	23-Mar-04	Duplicate
662	NYT	29-Mar-04	List
663	G	30-Mar-04	Duplicate
668	Obs	4-Apr-04	Proper name
671	G	6-Apr-04	Duplicate
672	G	8-Apr-04	Proper name
673	G	8-Apr-04	Proper name
675	NYT	12-Apr-04	List
676	NYT	14-Apr-04	Correction - included with original story
677	G	17-Apr-04	List - programmes
679	NYT	17-Apr-04	List
683	G	8-May-04	Duplicate
687	G	8-May-04	Duplicate
688	G	11-May-04	Duplicate
694	NYT	24-May-04	List
696	G	5-Jun-04	List - programmes
698	G	8-Jun-04	Duplicate
700	G	9-Jun-04	Duplicate
704	G	10-Jun-04	Duplicate
705	G	10-Jun-04	Duplicate
706	G	12-Jun-04	List - programmes
707	G	16-Jun-04	Nano-second
708	G	16-Jun-04	Nano-second
710	G	22-Jun-04	Duplicate
712	NYT	27-Jun-04	Generic small
713	G	30-Jun-04	Duplicate

Number	Publication	Date	Reason
715	G	3-Jul-04	List - programmes
716	G	3-Jul-04	List - programmes
717	G	3-Jul-04	Generic small
720	G	6-Jul-04	Duplicate
722	G	15-Jul-04	Duplicate
726	G	22-Jul-04	Duplicate
729	G	29-Jul-04	Duplicate
732	G	31-Jul-04	Generic small
733	NYT	5-Aug-04	List
734	NYT	5-Aug-04	List
737	G	9-Aug-04	Duplicate
740	G	14-Aug-04	Nano-second
742	G	19-Aug-04	Duplicate
747	G	1-Sep-04	Duplicate
749	G	2-Sep-04	Duplicate
756	G	14-Sep-04	Duplicate
757	NYT	19-Sep-04	Wedding
763	G	28-Sep-04	Duplicate
764	NYT	3-Oct-04	Wedding
767	G	19-Oct-04	Duplicate
771	G	1-Nov-04	Generic small
773	G	1-Nov-04	No nano
776	G	12-Nov-04	Duplicate
778	G	18-Nov-04	Duplicate
786	Obs	12-Dec-04	List
792	G	29-Dec-04	Duplicate
795	NYT	4-Jan-05	Proper name
796	G	4-Jan-05	Duplicate
800	G	14-Jan-05	Nano-second
801	G	14-Jan-05	Nano-second
805	G	30-Jan-05	Duplicate
806	G	27-Jan-05	Duplicate
808	G	2-Feb-05	Title only
809	G	2-Feb-05	Duplicate
811	G	3-Feb-05	Generic small
812	NYT	4-Feb-05	Proper name
813	NYT	10-Feb-05	Proper name
815	G	11-Feb-05	Duplicate
818	G	22-Feb-05	Duplicate
822	NYT	24-Feb-05	Generic small
823	NYT	27-Feb-05	Title only
824	G	7-Mar-05	Online - Cross reference only
826	G	12-Mar-05	Proper name
828	G	14-Mar-05	Duplicate
829	G	16-Mar-05	Nano-second
830	G	16-Mar-05	Nano-second
832	G	24-Mar-05	Duplicate
836	Obs	27-Mar-05	Nano-second
838	G	31-Mar-05	Duplicate
840	NYT	2-Apr-05	Title only
841	Obs	3-Apr-05	List - programmes
843	G	7-Apr-05	Duplicate
844	G	7-Apr-05	Duplicate
848	G	9-Apr-05	Generic small
849	Obs	10-Apr-05	Title only
854	G	26-Apr-05	List - subjects
855	G	26-Apr-05	List - subjects
857	G	28-Apr-05	List - programmes
865	Obs	15-May-05	Generic small
868	G	7-Jun-05	Duplicate
869	G	7-Jun-05	Duplicate
871	G	15-Jun-05	Generic small
872	G	15-Jun-05	Generic small
877	NYT	3-Jul-05	Proper name

Number	Publication	Date	Reason
878	Obs	3-Jul-05	Nano-second
879	NYT	10-Jul-05	Proper name
882	Obs	24-Jul-05	TOC
883	Obs	24-Jul-05	Duplicate
884	Obs	24-Jul-05	List
891	G	18-Apr-05	Duplicate
899	G	10-Sep-05	Generic small
901	G	13-Sep-05	List - programmes
904	G	24-Sep-05	Duplicate
906	F	24-Sep-05	Generic small
910	NYT	8-Oct-05	Proper name
912	G	10-Oct-05	Duplicate
914	G	17-Oct-05	Duplicate
915	G	19-Oct-05	Proper name
916	G	22-Oct-05	Nano-second
918	NYT	25-Oct-05	Proper name
920	G	29-Oct-05	Generic small
921	NYT	29-Oct-05	TOC
922	G	29-Oct-05	Generic small
925	G	14-Nov-05	Duplicate
926	G	14-Nov-05	List - events
927	G	15-Nov-05	Duplicate
930	G	18-Nov-05	Centimeters
931	G	18-Nov-05	Duplicate
933	G	21-Nov-05	Duplicate
935	G	24-Nov-05	Duplicate
936	NYT	26-Nov-05	Correction - included with original story
938	NYT	4-Dec-05	No nano
939	NYT	5-Dec-05	Job title
940	G	10-Dec-05	Generic small
941	G	12-Dec-05	List - events
942	G	12-Dec-05	Duplicate
943	G	20-Dec-05	Duplicate
944	G	20-Dec-05	Duplicate
953	Obs	8-Jan-06	Generic small
956	G	19-Jan-06	List
958	G	19-Jan-06	Duplicate
960	NYT	24-Jan-06	Proper name
962	G	30-Jan-06	Duplicate
968	G	9-Feb-06	Online - Cross reference only
970	Obs	12-Feb-06	Proper name
972	G	24-Feb-06	Duplicate
974	G	22-Feb-06	Nano-second
975	G	23-Feb-06	Duplicate
981	G	11-Mar-06	Duplicate
983	G	14-Mar-06	Duplicate
985	G	18-Mar-06	List - events
987	G	20-Mar-06	Online - Cross reference only
989	Obs	26-Mar-06	Generic small
990	Obs	26-Mar-06	Nano-second
991	G	30-Mar-06	Proper name
992	G	30-Mar-06	Proper name
993	G	1-Apr-06	Generic small
996	G	4-Apr-06	Proper name
997	G	4-Apr-06	Proper name
998	G	13-Apr-06	TOC
1000	G	13-Apr-06	Duplicate
1007	G	25-Apr-06	Duplicate
1008	NYT	27-Apr-06	Proper name
1009	G	29-Apr-06	List - events
1010	G	4-May-06	Nano-second
1015	G	13-May-06	Rice
1017	Obs	14-May-06	Generic small
1022	G	20-May-06	Duplicate

Number	Publication	Date	Reason
1023	Obs	21-May-06	Generic small
1025	G	31-May-06	Duplicate
1028	G	8-Jun-06	Proper name
1029	G	8-Jun-06	Proper name
1031	NYT	27-Jun-06	Title only
1033	G	11-Jul-06	Duplicate
1034	G	11-Jul-06	Generic small
1038	NYT	16-Jul-06	Title only
1040	G	18-Jul-06	List - events
1041	G	18-Jul-06	List - events
1043	G	25-Jul-06	Duplicate
1044	G	10-Aug-06	Title only
1045	G	10-Aug-06	Duplicate
1049	NYT	17-Aug-06	Title only
1051	NYT	27-Aug-06	Proper name
1053	NYT	13-Sep-06	Generic small
1057	NYT	26-Sep-06	TOC
1058	Obs	8-Oct-06	Generic small
1059	Obs	8-Oct-06	Generic small
1060	NYT	10-Oct-06	TOC
1062	NYT	10-Oct-06	TOC
1063	G	10-May-07	Online - Cross reference only
1066	G	21-Oct-06	Rice
1069	NYT	31-Oct-06	Title only
1072	G	10-Nov-06	Duplicate
1073	Obs	12-Nov-06	Nano-second
1075	G	16-Nov-06	Duplicate
1076	G	23-Nov-06	Duplicate
1078	G	24-Nov-06	Duplicate
1080	G	27-Nov-06	Duplicate
1083	G	30-Nov-06	Duplicate
1084	NYT	8-Dec-06	Title only
1093	NYT	22-Dec-06	Title only
1094	NYT	23-Dec-06	Title only
1095	NYT	27-Dec-06	Title only
1096	NYT	31-Dec-06	Title only
1099	G	13-Jan-07	List
1103	G	21-Apr-07	Rice
1105	G	16-Jan-07	Duplicate
1109	Obs	4-Feb-07	
1111	G	9-Feb-07	Generic small
1112	G	9-Feb-07	Nano-second
1113	G	9-Feb-07	Nano-second
1114	G	17-Feb-07	Rice
1116	NYT	25-Feb-07	Generic small
1117	G	27-Feb-07	Nano-second
1118	G	2-Mar-07	Title only
1119	G	2-Mar-07	Job title
1120	G	6-Mar-07	Proper name
1121	G	6-Mar-07	Duplicate
1122	NYT	11-Mar-07	Generic small
1125	G	17-Mar-07	Generic small
1127	G	27-May-07	Duplicate
1129	G	31-Mar-07	List - events
1131	G	4-May-07	List
1132	G	4-May-07	List
1133	NYT	10-May-07	Proper name
1134	G	10-May-07	Online - Cross reference only
1137	NYT	3-Jun-07	List
1139	NYT	4-Jun-07	TOC
1140	NYT	5-Jun-07	Correction - included with original story
1141	G	6-Jun-07	Online - Cross reference only
1143	Obs	10-Jun-07	Proper name
1144	Obs	17-Jun-07	Generic small

Number	Publication	Date	Reason
1145	Obs	17-Jun-07	Duplicate
1146	NYT	21-Jun-07	TOC
1149	NYT	24-Jun-07	Duplicate
1151	Obs	24-Jun-07	Duplicate
1152	G	28-Jun-07	Duplicate
1154	G	30-Jun-07	Generic small
1157	G	5-Jul-07	Duplicate
1158	Obs	8-Jul-07	Proper name
1159	Obs	8-Jul-07	Duplicate
1161	G	17-Jul-07	Nano-second
1162	G	17-Jul-07	Nano-second
1164	G	31-Jul-07	Online - Cross reference only
1165	G	11-Aug-07	Proper name
1167	Obs	26-Aug-07	List - products
1168	Obs	26-Aug-07	Duplicate
1170	G	5-Sep-07	Proper name
1171	NYT	16-Sep-07	Title only
1174	NYT	23-Sep-07	Duplicate
1179	NYT	7-Oct-07	Correction - included with original story
1180	G	18-Oct-07	Duplicate
1182	NYT	21-Oct-07	List - products
1183	NYT	21-Oct-07	Proper name
1184	G	27-Oct-07	Nano-second
1185	Obs	4-Nov-07	Proper name
1186	Obs	4-Nov-07	Proper name
1190	G	13-Nov-07	Generic small
1191	G	14-Nov-07	List
1192	G	16-Nov-07	Generic small
1193	G	16-Nov-07	Duplicate
1195	G	17-Nov-07	Duplicate
1196	Obs	18-Nov-07	List - programmes
1197	Obs	18-Nov-07	List - programmes
1198	G	22-Nov-07	Duplicate
1200	G	28-Nov-07	Duplicate
1203	G	28-Nov-07	Duplicate
1204	G	26-Nov-07	Online - Cross reference only
1205	G	28-Nov-07	Online - Cross reference only
1206	NYT	3-Dec-07	Duplicate
1208	NYT	3-Dec-07	Duplicate
1209	NYT	6-Dec-07	Generic small
1213	NYT	21-Dec-07	Duplicate
1218	Obs	6-Jan-08	Proper name
1219	Obs	6-Jan-08	Duplicate
1220	G	8-Jan-08	Generic small
1221	G	8-Jan-08	Duplicate
1222	NYT	15-Jan-08	Proper name
1223	G	15-Jan-08	Online - Cross reference only
1225	G	26-Jan-08	List - programmes
1226	G	28-Jan-08	Nano-second
1230	G	14-Feb-08	Duplicate
1231	G	15-Feb-08	Online - Cross reference only
1232	G	16-Feb-08	Proper name
1235	Obs	24-Feb-08	Generic small
1237	Obs	24-Feb-08	Generic small
1240	G	26-Feb-08	Duplicate
1242	Obs	2-Mar-08	Generic small
1243	NYT	2-Mar-08	Correction - included with original story
1244	NYT	2-Mar-08	Duplicate
1247	G	13-Mar-08	Duplicate
1249	G	18-Mar-08	Duplicate
1250	G	18-Mar-08	List - events
1252	G	20-Mar-08	Duplicate
1253	G	26-Mar-08	TOC
1255	G	26-Mar-08	Duplicate

Number	Publication	Date	Reason
1258	G	3-Apr-08	Correction - included with original story
1260	G	8-Apr-08	Duplicate
1261	NYT	13-Apr-08	Generic small
1262	NYT	20-Apr-08	Wedding
1266	NYT	1-May-08	Duplicate
1268	Obs	4-May-08	Duplicate
1269	G	8-May-08	Generic small
1270	G	8-May-08	Duplicate
1271	G	14-May-08	Nano-second
1272	G	14-May-08	Nano-second
1273	G	20-May-08	Online - Cross reference only
1276	NYT	21-May-08	TOC
1277	G	21-May-08	Duplicate
1279	Obs	1-Jun-08	Duplicate
1283	G	7-Jun-08	Proper name
1285	G	10-Jun-07	List - products
1287	G	17-Jun-08	Duplicate
1289	G	19-Jun-08	Duplicate
1292	G	30-Jun-08	Generic small
1293	G	30-Jun-08	Duplicate
1295	G	3-Jul-08	Duplicate
1297	G	7-Jul-08	Generic small
1298	G	8-Jul-08	Nano-second
1299	G	8-Jul-08	Nano-second
1301	G	10-Jul-08	Duplicate
1302	G	17-Jul-08	Proper name
1303	G	17-Jul-08	Proper name
1304	NYT	19-Jul-08	Title only
1305	Obs	20-Jul-08	Generic small
1306	Obs	20-Jul-08	Generic small
1309	G	9-Aug-08	Nano-second
1310	G	9-Nov-08	Nano-second
1311	G	11-Nov-08	Online - Cross reference only
1313	G	16-Aug-08	Latin
1315	G	16-Aug-08	Duplicate
1316	G	23-Aug-08	Duplicate
1317	NYT	23-Aug-08	Correction - included with original story
1318	G	29-Aug-08	Music
1319	G	4-Sep-08	TOC
1321	G	4-Sep-08	Duplicate
1322	G	9-Sep-08	Duplicate
1324	G	18-Sep-08	Duplicate
1325	G	18-Sep-08	Duplicate
1326	G	18-Sep-08	Duplicate
1327	G	18-Sep-08	Duplicate
1328	G	18-Sep-08	Duplicate
1334	G	22-Sep-08	Proper name
1335	G	22-Sep-08	Proper name
1338	G	29-Sep-08	Duplicate
1339	NYT	19-Oct-08	Proper name
1340	G	20-Oct-08	TOC
1342	G	1-Nov-08	Duplicate
1343	G	1-Nov-08	Duplicate
1345	G	5-Nov-08	Duplicate
1348	G	14-Nov-08	Generic small
1350	Obs	23-Nov-08	Duplicate
1352	G	27-Nov-08	Nano-second
1353	NYT	4-Dec-08	TOC
1355	NYT	18-Dec-08	Correction - included with original story
1356	NYT	21-Dec-08	Generic small
1357	G	24-Dec-08	Proper name
1359	G	27-Dec-08	Duplicate
1361	Obs	4-Jan-09	Generic small
1362	Obs	4-Jan-09	Generic small

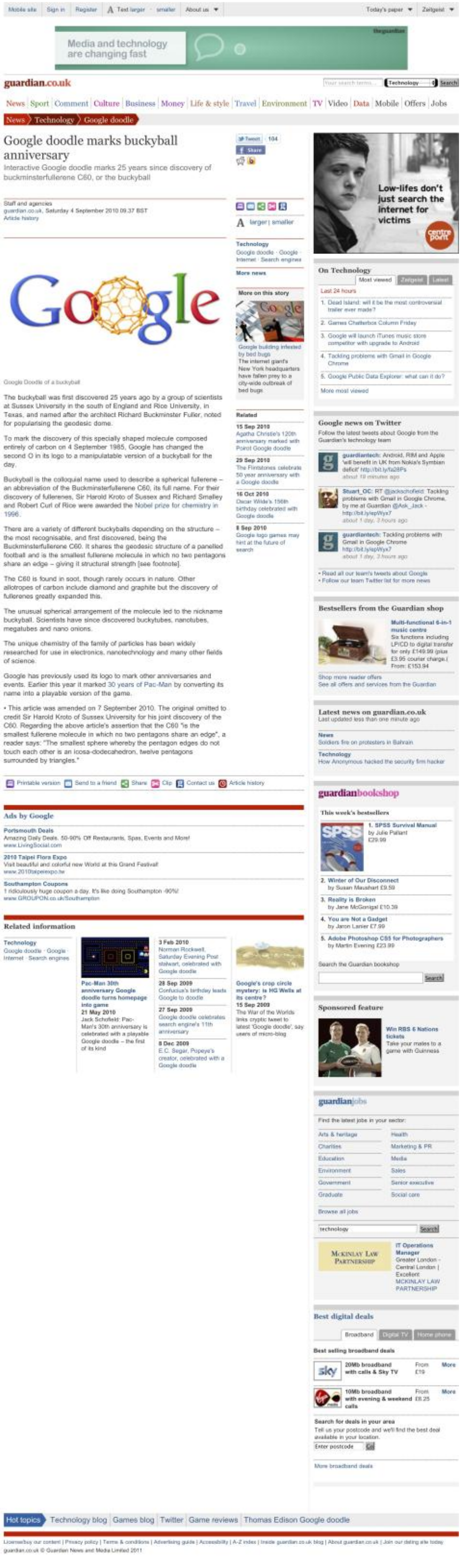
Number	Publication	Date	Reason
1363	G	5-Jan-09	Generic small
1364	G	5-Jan-09	Generic small
1365	G	14-Jan-09	List - programmes
1366	G	14-Jan-09	List - programmes
1367	G	20-Jan-09	Proper name
1368	G	20-Jan-09	Online - Cross reference only
1371	G	3-Feb-09	Online - Cross reference only
1372	G	23-Feb-09	Duplicate
1374	G	4-Feb-09	Duplicate
1375	Obs	8-Feb-09	Duplicate
1379	Obs	8-Feb-09	Duplicate
1380	Obs	8-Feb-09	Duplicate
1381	NYT	15-Feb-09	Title only
1382	G	17-Feb-09	Generic small
1383	G	17-Feb-09	Duplicate
1384	G	20-Feb-09	Title only
1386	G	26-Feb-09	List
1387	G	26-Feb-09	Online - Cross reference only
1388	G	26-Feb-09	List
1389	G	28-Feb-09	Generic small
1390	G	28-Feb-09	Generic small
1391	G	5-Mar-09	Duplicate
1394	G	12-Mar-09	Incomplete
1396	G	23-Mar-09	Duplicate
1398	G	26-Mar-09	Duplicate
1401	G	26-Mar-09	Duplicate
1403	G	27-Mar-09	Online - Cross reference only
1405	G	29-Apr-09	Proper name
1406	G	10-Apr-09	Proper name
1407	G	10-Apr-09	Generic small
1408	G	10-Apr-09	Proper name
1409	Obs	12-Apr-09	Generic small
1410	Obs	12-Apr-09	Generic small
1411	G	20-Apr-09	Online - Cross reference only
1412	G	24-Apr-09	Nano-second
1413	G	24-Apr-09	Nano-second
1414	NYT	28-Apr-09	No nano
1416	G	2-May-09	Duplicate
1418	G	7-May-09	Duplicate
1419	G	12-May-09	Duplicate
1421	G	14-May-09	Duplicate
1423	G	16-May-09	Nano-second
1424	G	19-May-09	Generic small
1425	G	19-May-09	Duplicate
1427	G	1-Jun-09	Online - Cross reference only
1429	G	8-Jun-09	Proper name
1430	G	9-Jun-09	Generic small
1431	G	12-Jun-09	Online - Cross reference only
1432	NYT	14-Jun-09	Generic small
1433	NYT	21-Jun-09	Proper name
1436	G	10-Jul-09	Generic small
1442	G	7-Aug-09	Generic small
1443	G	7-Aug-09	Duplicate
1444	G	7-Aug-09	Generic small
1445	G	10-Aug-09	Duplicate
1448	G	17-Aug-09	Online - Cross reference only
1449	G	20-Aug-09	Nano-second
1450	G	23-Aug-09	Online - Cross reference only
1453	NYT	4-Sep-09	Duplicate
1454	NYT	6-Sep-09	Proper name
1456	G	9-Sep-09	
1459	G	9-Sep-09	Duplicate
1460	G	12-Sep-09	Generic small
1462	G	17-Sep-09	Online - Cross reference only

Number	Publication	Date	Reason
1464	Obs	27-Sep-09	Duplicate
1466	Obs	4-Oct-09	Music
1467	Obs	4-Oct-09	Duplicate
1469	G	13-Oct-09	Proper name
1470	G	17-Oct-09	Proper name
1472	NYT	18-Oct-09	Generic small
1473	NYT	18-Oct-09	Duplicate
1474	G	30-Oct-09	Job title
1475	G	4-Nov-09	Job title
1476	G	5-Nov-09	List - programmes
1477	G	6-Nov-09	Online - Cross reference only
1478	NYT	16-Nov-09	Generic small
1483	NYT	29-Nov-10	Proper name
1484	NYT	8-Dec-09	Title only
1486	G	9-Dec-09	Nano-second
1488	NYT	16-Dec-09	Generic small
1489	G	19-Dec-09	Duplicate
1490	G	19-Dec-09	Online - Cross reference only
1492	NYT	20-Dec-09	Proper name
1492	NYT	20-Dec-09	Proper name
1493	NYT	24-Dec-09	Proper name
1494	NYT	29-Dec-09	Generic small
1497	G	5-Jan-10	Duplicate
1498	G	5-Jan-10	Title only
1499	G	5-Jan-10	Duplicate
1503	G	8-Jan-10	Online - Cross reference only
1505	G	8-Jan-10	Duplicate
1506	G	8-Jan-10	Duplicate
1507	G	8-Jan-10	Online - Cross reference only
1509	G	14-Jan-10	Duplicate
1511	NYT	30-Jan-10	Incomplete
1513	NYT	3-Feb-10	Incomplete
1515	NYT	4-Feb-10	Incomplete
1515	NYT	4-Feb-10	Online - Cross reference only
1516	G	6-Feb-10	Generic small
1517	G	24-Feb-10	Online - Cross reference only
1518	NYT	26-Feb-10	Incomplete
1519	NYT	1-Mar-10	Incomplete
1520	NYT	2-Mar-10	Proper name
1522	NYT	6-Mar-10	Incomplete
1525	G	20-Mar-10	Generic small
1526	G	20-Mar-10	Generic small
1527	G	3-Apr-10	Generic small
1528	G	3-Apr-20	Generic small
1529	NYT	10-Apr-10	Incomplete
1531	NYT	12-Apr-10	Duplicate
1532	NYT	17-Apr-10	Incomplete
1535	NYT	27-Apr-10	Incomplete
1536	NYT	29-Apr-10	Proper name
1537	NYT	3-May-10	Online - Cross reference only
1538	NYT	3-May-10	Incomplete
1539	G	17-Mar-11	2011
1540	NYT		2011
1541	NYT		2011
1542	NYT		2011
1543	NYT		2011
1544	G		2011
1545	NYT		2011
1546	NYT		2011
1547	NYT		2011
1548	NYT		2011
1549	G		2011
1550	G		2011
1551	NYT		2011

Number	Publication	Date	Reason
1552	G		2011
1553	G		2011
1554	Obs		2011
1555	Obs		2011
1556	G		2011
1557	G		2011
1558	G		2011
1559	NYT		2011
1560	NYT		2011
1561	NYT		2011
1562	G		2011
1563	NYT		2011
1564	NYT		2011
1565	NYT		2011
1566	NYT		2011
1567	NYT		2011
1568	NYT		2011
1569	NYT		2011
1570	NYT		2011
1571	Obs		2011
1572	NYT		2011
1573	Obs		2011
1574	Obs		2011
1575	G		2011
1576	NYT		2011
1577	NYT	31-Dec-10	Online - Cross reference only
1578	NYT	31-Dec-10	Online - Cross reference only
1579	NYT	25-Dec-10	Title only
1580	NYT	25-Dec-10	Online - Cross reference only
1582	NYT	20-Dec-10	Duplicate
1583	NYT	20-Dec-10	Duplicate
1584	NYT	20-Dec-10	Online - Cross reference only
1585	G	17-Dec-10	Nano-second
1586	G	17-Dec-10	Nano-second
1587	NYT	3-Dec-10	Proper name
1588	NYT	2-Dec-10	Proper name
1590	G	27-Nov-10	Online - Cross reference only
1595	NYT	4-Nov-10	Generic small
1596	G	3-Nov-10	Online - Cross reference only
1598	G	21-Oct-10	Online - Cross reference only
1599	G	15-Oct-10	Online - Cross reference only
1600	G	30-Sep-10	Nano-second
1601	G	30-Sep-10	Nano-second
1603	Obs	26-Sep-10	Duplicate
1605	G	25-Sep-10	Generic small
1606	G	25-Sep-10	Generic small
1607	G	18-Sep-10	Rice
1608	G	18-Sep-10	Rice
1609	G	8-Sep-10	Online - Cross reference only
1611	G	5-Sep-10	Online - Cross reference only
1612	G	4-Sep-10	Online - Cross reference only
1614	G	19-Aug-10	Generic small
1615	G	19-Aug-10	Generic small
1616	G	16-Aug-10	Duplicate
1618	NYT	15-Aug-10	Generic small
1619	G	12-Aug-10	Online - Cross reference only
1620	G	12-Aug-10	Online - Cross reference only
1621	G	12-Aug-10	Title only
1622	G	28-Jul-10	Nano-second
1624	NYT	23-Jul-10	Generic small
1625	Obs	18-Jul-10	List - programmes
1626	Obs	18-Jul-10	List - programmes
1627	G	12-Jul-10	Nano-second
1628	G	12-Jul-10	Nano-second

Number	Publication	Date	Reason
1633	G	29-Jun-10	Duplicate
1634	G	25-Jun-10	Online - Cross reference only
1635	NYT	17-Jun-10	iPod
1636	NYT	17-Jun-10	iPod
1637	G	16-Jun-10	Online - Cross reference only
1642	Obs	30-May-10	List - programmes
1645	Obs	16-May-10	Duplicate
1647	NYT	7-May-10	Title only

Appendix B: Example of Web page as captured using Papparazzi!



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News › Technology › Google doodle

Google doodle marks buckyball anniversary

Interactive Google doodle marks 25 years since discovery of buckminsterfullerene C60, or the buckyball

Staff and agencies
guardian.co.uk, Saturday 4 September 2010 09.37 BST
Article history

Google Doodle of a buckyball

The buckyball was first discovered 25 years ago by a group of scientists at Sussex University in the south of England and Rice University, in Texas, and named after the architect Richard Buckminster Fuller, noted for popularising the geodesic dome.

To mark the discovery of this specially shaped molecule composed entirely of carbon on 4 September 1985, Google has changed the second O in its logo to a manipulatable version of a buckyball for the day.

Buckyball is the colloquial name used to describe a spherical fullerene – an abbreviation of the Buckminsterfullerene C60, its full name. For their discovery of fullerenes, Sir Harold Kroto of Sussex and Richard Smalley and Robert Curl of Rice were awarded the Nobel prize for chemistry in 1996.

There are a variety of different buckyballs depending on the structure – the most recognisable, and first discovered, being the Buckminsterfullerene C60. It shares the geodesic structure of a panelled football and is the smallest fullerene molecule in which no two pentagons share an edge – giving it structural strength [see footnote].

The C60 is found in soot, though rarely occurs in nature. Other allotropes of carbon include diamond and graphite but the discovery of fullerenes greatly expanded this.

The unusual spherical arrangement of the molecule led to the nickname buckyball. Scientists have since discovered buckytubes, nanotubes, megatubes and nano onions.

The unique chemistry of the family of particles has been widely researched for use in electronics, nanotechnology and many other fields of science.

Google has previously used its logo to mark other anniversaries and events. Earlier this year it marked 30 years of Pac-Man by converting its name into a playable version of the game.

• This article was amended on 7 September 2010. The original omitted to credit Sir Harold Kroto of Sussex University for his joint discovery of the C60. Regarding the above article's assertion that the C60 "is the smallest fullerene molecule in which no two pentagons share an edge", a reader says: "The smallest sphere whereby the pentagon edges do not touch each other is an icosa-dodecahedron, twelve pentagons surrounded by triangles."

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Appendix C: Blank coding sheet used for the newspaper content analysis

Entered into SPSS: ☐ Entered into Nvivo: ☐ Date: ____________

Headline:

____

____

News org: 1. Guardian 2. New York Times 3. Observer
Edition: 1. Online 2. Print
Date Day: ______ Month: ________ Year: __________
Section:
1. Front Page 6. Health 11. Reviews
2. News 7. Business/finance 12. Culture
3. Science 8. Opinion/Comment 13. Not specified
4. Technology 9. Blogs 14. Other: ____________
5. Environment 10. Letters to the Editor

Page /web address: ____
Word count: __________
Author: ____
About author:
1. Gen assign. 4. Guest writer 6. Not specified
2. Biz journo 5. Other ____________
3. Sci journo
Author credit: ____

____

Evidence of photo/graphic: 1. Yes ______________________________ 2. No
News peg:
1. Speech/Press conf. 5. Gov't proceedings 9. Other: ____________
2. Release/announcement 6. Academic conference
3. Policy/Advisory report 7. Industry proceedings
4. Journal publication 8. None

News values:
1. Human /Rel. to daily life 5. Proximity 8. Link to other social context
2. Weird & wacky 6. Link to politics 9. Other: ____________
3. Breakthrough/devel. 7. Link to economics
4. Conflict/controversy

Story topic: 1. Nano or 2. Story with nano ____________________
First reference to nano:
1. Headline 3. 1^{st} Qtr 5. 3^{rd} Qtr
2. Lead 4. 2^{nd} Qtr 6. 4^{th} Qtr

Entered into SPSS: ☐ Entered into Nvivo: ☐ Date: ____________

Nano Definition: 1. nanotech 2. nanosci 3. other ____________

____

____

____

Frame:
Notes/Keywords to identify frame:

____

____

1. Discovery/project 5. SciFi/Pop Cult 9. Celebrities
2. Risk/social implications 6. Policy/Regulation 10. Natural
3. Business/Economy 7. Visionary/far future 11. Other: ____________
4. Funding/investment 8. History

Nano use:
1. Computers 4. Manufacturing 6. None specified
2. Military/Security 5. Other: ____________
3. Medical

Tone:
1. Positive 2. Balanced/measured 3. Negative

Sci fi/fiction references
1. Generic sci fi 4. Other ____________ 5. None
2. Specific sci fi title(s)
3. Sci fi tech
Notes (multi ref?, specific titles?, etc.):

____

____

Nature/Natural references
1. Learning from nature 3. Nature/life as nanotechnologist ____________ 5. None
2. Nano is natural 4. Other
Notes: ____

____

Entered into SPSS: ☐ Entered into Nvivo: ☐ Date: ____________

Nano Sources
Total individual sources: ____________
Sources identified in headline: ____________

First Qtr.	*Second Qtr.*	*Third Qtr.*	*Final Quarter.*
Total ______	Total ______	Total ______	Total ______
Sources ______ ______	Sources ______ ______	Sources ______ ______	Sources ______ ______

Risk:
1. Generic medical ____________ 10. Grey Goo/Self Rep.
2. Generic environ. 6. Specific ELSI 11. Other ____________
3. Generic ELSIs
4. Specific medical ____________ 7. Wait and see 12. None specified
8. Misuse/good to bad
5. Specific environ. 9. Runaway Technology
Risk notes (cause identified?):

____

____

Benefit(s):
1. Tiny/powerful computers 5. Generic med. 9. Improved mil/security
2. Nanobots repairing bodies/cells 6. Specific environ ____________ 10. Cryonics possible
3. Improved drug delivery 7. Specific med ____________ 11. Other ____________
4. Generic environ. 8. Better manuf. 12. None specified
Notes:

____

____

Anticipated Timeframe: ____________________

Who does nanotechnology?
1. Scientists 4. Technicians 6. Not specified
2. Engineers 5.Other: ____________
3.Nanotechnologists

Entered into SPSS: ☐ Entered into Nvivo: ☐ Date: ____________

How are they characterised?
1.Practical/ Serious 3.Pioneer/ visionary 4. Other ____________
2.Playing/ tinkering 5. N.A

Notes:

____

____

Online notes:
Hyperlink words/phrases: ____

____

Destinations:
1. Within news site 5. NGO site 9: Other ____________
2. Government site 6. Journal site
3. University site 7. Magazine site 10. Dead end
4. Industry site 8. Individual's blog/site 11. N/A
Other links on page:
Words/phrases: ____

____

Destinations:
1. Within news site 6. Journal site 10. Dead end
2. Government site 7. Magazine site 11. N/A
3. University site 8. Individual's blog/site
4. Industry site 9: Other ____________
5. NGO site

Notes:

Appendix D: Example of a completed coding sheet

Entered into SPSS: ✓ Entered into Nvivo: Date:

#223

Headline: This week – we're only human...

News org: 1. Guardian 2. New York Times 3. Observer

Edition: 1. Online 2. Print

Date Day: 24 Month: Jan Year: 1999

Section:

1. Front Page 6. Health 11. Reviews
2. News 7. Business/finance 12. Culture
3. Science 8. Opinion/Comment 13. Not specified
4. Technology 9. Blogs 14.Other:
5. Environment 10. Letters to the Editor

Page /web address: 2

Word count: 1510

Author: Charles Jonscher

About author:

1. Gen assign. 4. Guest writer 6. Not specified
2. Biz journo 5. Other
3. Sci journo

Author credit:

Evidence of photo/graphic: 1. Yes 2. No

News peg:

1. Speech/Press conf. 5. Gov't proceedings 9. Other: Book Release
2. Release/announcement 6. Academic conference
3. Policy/Advisory report 7. Industry proceedings
4. Journal publication 8. None

News values:

1. Human /Rel. to daily life 6. Link to politics 9. Other:
2. Weird & wacky 7. Link to economics
3. Breakthrough/devel. 8. Link to other social context
4. Conflict/controversy
5. Proximity

Story topic: 1. Nano or 2. Story with nano

First reference to nano:

1. Headline 3. 1st Qtr 5. 3rd Qtr
2. Lead 4. 2nd Qtr 6. 4th Qtr

Entered into SPSS: ✓ Entered into Nvivo: Date:

Nano Definition: 1. nanotech 2. nanosci 3. other

no definition given

Frame:

Notes/Keywords to identify frame:

1P9 only

nanotechnology Robots to assemble DNA atom by atom post radiation

1. Discovery/project 5. SciFi/Pop Cult 9. Celebrities
2. Risk/social implications 6. Policy/Regulation 10. Natural ?
3. Business/Economy 7. Visionary/far future 11. Other:
4. Funding/investment 8. History

Nano use:

1. Computers 4. Manufacturing 6. None specified
2. Military/Security 5. Other: Robots to assemble DNA & create life
3. Medical

Tone:

1. Positive 2. Balanced/measured 3. Negative

Sci fi/fiction references

1. Generic sci fi 4. Other 5. None
2. Specific sci fi title(s)
3. Sci fi tech

Notes (multi ref?, specific titles?, etc.):

Nature/Natural references

1. Learning from nature 4. Other
2. Nano is natural
3. Nature/life as nanotechnologist 5. None

Notes:

Entered into SPSS: ✓ Entered into Nvivo: Date:

1P9 only

Nano Sources

Total individual sources: 0

Sources identified in headline:

First Qtr.	*Second Qtr.*	*Third Qtr.*	*Final Quarter.*
Total	Total	Total	Total
Sources	Sources 0	Sources	Sources

Risk:

1. Generic medical 10. Grey Goo/Self Rep.
2. Generic environ. 6. Specific ELSI 11. Other
3. Generic ELSIs
4. Specific medical 7. Wait and see 12. None specified
8. Misuse/good to bad
5. Specific environ. 9. Runaway Technology

Risk notes (cause identified?):

Benefit(s):

1. Tiny/powerful computers 6. Specifc environ 11. Other
2. Nanobots repairing bodies/cells 7. Specific med 12. None specified
3. Improved drug delivery 8. Better manuf.
4. Generic environ. 9. Improved milit/security
5. Generic med. 10. Cryonics possible

Notes: nano bots to build life when humans are gone

Anticipated Timeframe: Not specified

Who does nanotechnology?

1. Scientists 4. Technicians 6. Not specified
2. Engineers 5.Other:
3.Nanotechnologists

Entered into SPSS: ✓ Entered into Nvivo: Date:

How are they characterised?

1.Practical/ Serious 3.Pioneer/ visionary 4. Other
2.Playing/ tinkering 5. N.A

Notes: fictitious scenario

Online notes:

Hyperlink words/phrases:

Destinations:

1. Within news site 5. NGO site 9: Other
2. Government site 6. Journal site
3. University site 7. Magazine site 10. Dead end
4. Industry site 8. Individual's blog/site 11. N/A

Other links on page:

Words/phrases:

Destinations:

1. Within news site 6. Journal site 10. Dead end
2. Government site 7. Magazine site 11. N/A
3. University site 8. Individual's blog/site
4. Industry site 9: Other
5. NGO site

Notes:

→ author of article is author of a book that was released a few weeks later

→ nano in a fictitious scenario devised by the author

→ may be based on the book