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# Modern science communication in a global context: Perspectives on nanotechnology from Swedish, Polish and Iranian press coverage

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## Abstract

The study of media coverage of emerging technologies constitutes an important field in Science and Technology Studies. Nanotechnology is one of these emerging technologies. Traditionally, research has focused on media coverage in developed countries, especially English-speaking ones - the United States, Canada and United Kingdom. This thesis breaks with this tradition. It is an attempt to "de-westernize" this area of research by moving the focus towards Sweden, Poland and Iran – countries that differ considerably from each other in terms of economy, culture, religion, technological development or socio-political system. More importantly, these countries have never been studied in this context before. Qualitative content analysis of the articles published between 2004 and 2009 in seven Swedish, Polish and Iranian daily newspapers has been conducted in order to determine cross-national differences in the debates on nanotechnology, in terms of frames, themes, metaphors or sources. A parallel aim was to assess how socio-political differences may influence media reporting on nanotechnology or how the discussion of nanotechnology reflects socio-political differences. The results shows that although media coverage of nanotechnology in Sweden, Poland and Iran largely followed the patterns observed in other countries, there are elements that are characteristic of Poland, Sweden or Iran alone. The most specific one is the use of nanotechnology in order to promote a country's image, enhance its international reputation externally or strengthen national pride internally. Additionally, this research suggests improvements to some of the earlier approaches used in the studies of media coverage of emerging technologies. Considering the current discussions around the importance of 'nano communication', this thesis contributes not only to the study of media coverage and public perceptions of emerging technologies within Science and Technology Studies but also to particular areas of other disciplines such as culture and media studies and philology.

## PUBLICATIONS FROM THIS THESIS

The following papers were based on parts of this work:

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Lemańczyk, S. 2012. 'Between the national pride and the scientific success of the "others": the case of Polish press coverage of nanotechnology, 2004-2009', *NanoEthics*, Vol. 6 (2), pp. 101-115

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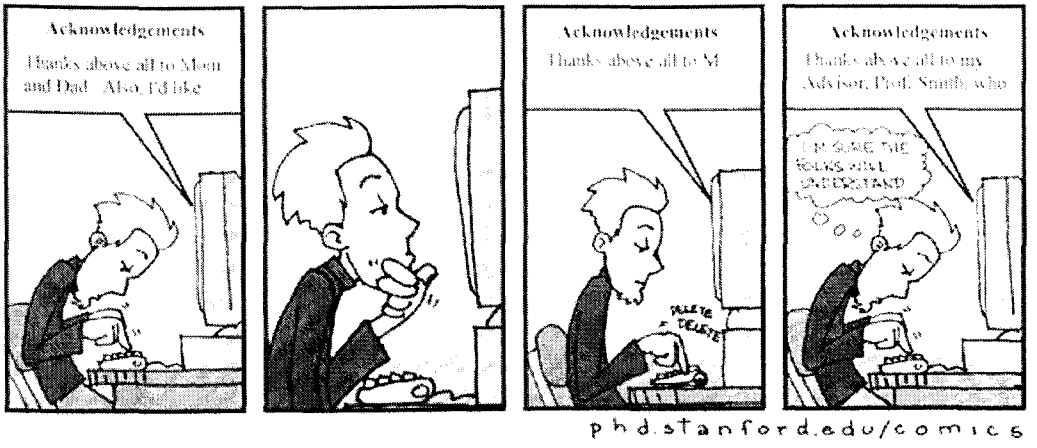


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[1] Cartoon reprinted with permission from Jorge Cham, the author of 'PhD-comics'.

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Szczepan Lemańczyk

Teddington, January 2013

This thesis is dedicated to Alina.

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# 1 INTRODUCTION

'There is plenty of room at the bottom' – these words spoken by the physicist Richard Feynman on 29th December 1959 are widely considered to inaugurate the age of nanotechnology (Toumey, 2005). About half a century later this technology was described in an official White House press release as a technology that will lead to the 'next industrial revolution' (2000). An emerging technology, nanotechnology has been entering new spheres of human activity for more than two decades. As with other emerging technologies, once it entered the public sphere, nanotechnology also attracted the attention of social scientists who became interested in its ethical, legal and social implications. Joachim Schummer, a philosopher from the University of Karlsruhe, stated that:

> Apart from scientists and engineers, policy makers, science managers, business people, journalists, transhumanists, and science fiction authors all talk about societal and ethical implications of nanotechnology (Schummer, 2004, pp. 56–57).

For a short while in the early 2000s nanotechnology attracted significant media attention in the US and in Europe as governments began to invest heavily in the new technology as well as in public engagement and outreach projects designed to familiarise people with the new technology. Many promises were made about its revolutionary impact on society – especially in terms of medicine, and some authors within the science fiction genre began to speculate about the darker side of nanotechnology – especially the possibility of 'grey goo' (self-replicating nanoparticles), and nano-toxicity. As a consequence, studies on media representations of nanotechnology have flourished during the last two decades, as part of social sciences. The main aim of these projects was to gain knowledge about the way nanoscience is discussed in the media, particularly the traditional press (e.g. what frames, themes or tone were used in the debate). This was done partly because an understanding of the public media framing of nanotechnology

might be useful for those trying to engage the general public with the technology. Media debates are the common background against which science communication and science engagement take place. In reports issued in 2010 and 2011, the European Commission highlighted 'nano communication' as one of the strategic areas in the wide field of nano-research (European Commission, 2010a, 2011a).

Most of the former studies (summaries in chapter two) in this area focused on English speaking countries such as the United States, Canada, and the United Kingdom. Eastern and Central European countries as well as countries in Asia and Africa were usually excluded from this research. This 'Anglo-American focus' of research into media representations of nanotechnology is, however, not particular to nanotechnology, It has been observed in the whole field of media studies (Williams, 2005).

My thesis aims to change this pattern and move the research focus towards countries that have never been studied in this context before. It investigates media debates on nanotechnology in Sweden, Poland and Iran. Using qualitative content analysis I study articles published in seven Swedish, Polish and Iranian daily newspapers between 1st January 2004 and 31st December 2009 in order to gain a deeper understanding of the cross-national differences in coverage of nanotechnology.

The project emerged as a result of a combination of factors: my interests in culture studies and social aspects of emerging technologies, my academic background (MA-degrees in Iranian Languages and Polish studies), my understanding of Swedish, Polish and Iranian culture, and my native and near-native ability to speak Swedish, Polish and Persian. A convergence of these factors enabled me to, hopefully, provide, new insight into the study of social aspects of nanotechnology – both in country-specific and cross-national contexts.

This introductory chapter provides the basic information about this works – its rationale, research questions, structure and ethical considerations.

## 1.1 What is nanotechnology?

Although research in the area of nanotechnology has been conducted for almost two decades, there are still discussions among scientists around the definition of this emerging technology. Philip Moriarty, a professor of physics and astronomy and an expert in quantum physics and nanotechnology at the University of Nottingham, defines nanotechnology by focusing on the issue of size:

> Nanoscale science, engineering and technology are concerned with the manipulation of matter on the nanometre length scale, which is now generally taken as the 1 to 100 nm range (Moriarty, 2001, p. 299).

However, the UNESCO report on nanotechnology (2006) points out that alongside this 'size-related' definition, different groups/institutions have used a wide range of different definitions of nanotechnology. These definitions depend on various issues: the aims of the group/institution in terms of nanotechnology, whether these aims are related to medicine, new materials or the environment. These definitions vary also across countries:

> China, Japan and Korea emphasize the focus on materials and especially electronics, while researchers in Africa and Latin America often emphasize the materials in the context of medicine and environmental science. The Royal Society of the UK makes the distinction between 'nanoscience' and 'nanotechnology' where the former includes the 'study and manipulation' of nanoscale particles, and the latter the 'design, characterization and production' of 'structures, devices and systems' at the nanoscale (UNESCO, 2006, p. 5).

Research at the nanoscale has flourished since the middle of 1980s and especially over the last decade. Although scientists have speculated about manipulating atoms since the 1950s, two technological advances in the 1980s enabled them to turn speculation into reality: the invention of the scanning tunnelling microscope (STM) in 1981 and of the atomic force microscope (ATM) in 1985 – microscopes that, crudely speaking, enable scientists to see at the nanoscale by 'handling' atoms. The next steps in the development of nanoscience were the discovery of fullerenes 1985 by Chemistry Nobel Prize Winners Robert Curl, Harry Kroto and Richard Smalley (Adams & Baughman, 2005) and the discovery of carbon nanotubes in the beginning of 1990s (Monthioux & Kuznetsov, 2006). Most recently, in 2010, Andre Geim and Konstantin Novoselov from the University of Manchester received Nobel Prize for their study on graphene. Since 1990s more and more companies and governments in the developed countries started to acknowledge the potential of nanotechnology and begin investments in that field. In 2000 the National Nanotechnology Initiative has been established in order to coordinate and support the research in the broad field of nanotechnology in the United States (Dalton, 2000).During the next decade similar institutions have been established in some other countries, including Islamic Republic of Iran. As can be seen the history of nanotechnology is relatively long. In that respect there is a question to what extent it should be perceived as a 'new' technology. However, considering the level of development of nano-research in the studied countries (discussed in more depth in chapter three), it could be argued that in that context nanotechnology appears as 'new', especially in case of Poland and Iran. Therefore nanotechnology is going to be described in this thesis as 'new', although it should be remembered that on the global scale nanotechnology has much longer history and tradition (especially in the Western world).

The possibility of manipulating atoms and therefore creating functioning mechanical applications may allow progress and significant changes in various

sciences, technologies and many aspects of our live. According to a seminal European Commission's report (2004), nanotechnology will contribute to significant developments in area that are important for scientists and the whole society in general, e.g. electronics, medicine, computing, food production, chemistry, energy, diagnostics, or transportation and mobility. This report was translated into 17 European languages (as well as Arabic and Chinese) and may have influenced the nano-debate across Europe.

The most futuristic visions of nanotechnology, represented often by Eric Drexler (1991; 1986, 2004), include a world changed completely by nanotechnology, where everything (including human organs) could be produced cheaply at home – atom by atom. Colin Milburn (2002), a social and cultural scientist, describes this as a 'posthuman engineering'. Other areas of the potential application of nanotechnology are computing or medicine, where nanotechnological devices would treat various illnesses, such as cancer, without surgical interventions, especially through nanoparticle-based drug delivery systems within nanomedicine (Cavalcanti, Shirinzadeh, Zhang, & Kretly, 2008). In popular culture these medical devices are sometimes called nanobots (Nerlich, 2005a, 2008).

Although Drexler's idea of molecular assemblers and the vision of the 'era of nanotechnology', characterised by Toumey as nanophilia (2004), has been questioned by many scholars (Moriarty, 2005; Smalley, 2001), research on (more realistic) applications of nanotechnology has flourished since the 1980s and many companies and governments have decided to invest in the development of nanoscience (such as founding the National Nanotechnology Initiative in the US). Possibilities of nanotechnological applications are often mentioned in the context of Moore's Law that states that the number of transistors that could be placed on an integrated circuit would double every two years (Schaller, 1997). Observing the development in the computing industry it can be stated that the Moore's Law was proven to be correct although the use of silicon has limitations that cannot

be overcome with the currently available technology. Nanotechnology is claimed to be able to overcome this problem and would therefore allow for the continuing miniaturization in electronics. However, the currently available applications of nanotechnology are far behind the mentioned visions but can be already found in many , including new cosmetics, more effective conductors, new materials, batteries, electronics, food products, paints or clothes (for the more expanded lists see The Project on Emerging Technologies (2012)). Nevertheless, scientists are still looking for new nano-applications such as new ways of drug delivery. It also needs to be stressed that nanotechnology is currently one of the priority research areas in the European Union, the US, Russia and even Iran.

However, just like other emerging technologies (biological technologies, cognitive or neuro-technologies) nanotechnology raises many concerns and many questions about risks, ethics and legal aspects. More recently issues around toxicology have come to dominate the debate. Nanotechnology has often been described in public debates as the 'asbestos of tomorrow' (Scheufele, 2006, p. 24). Other questions are related to darker visions covering such areas as the use of nanotechnology in military combat, the permanent surveillance of society (Stanton, 2007) or even the law of patents (Hunt & Mehta, 2006). As Richard Jones (2004) has pointed out, there still is an almost surreal gap between what this technology is believed to promise (e.g. nanobots) and what it actually delivers (e.g. an improved shampoo or conditioner). This gap is however gradually closing, but more slowly than envisioned, as is the case with many emerging and promissory technologies, e.g. stem cells and tissue engineering (Martin & Rowley, 2009).

## 1.2 Aims and Rationale

Research on media representation of nanotechnology constitutes one of the major arenas of research on social implications of nanoscience. A large number of studies have shed light on nano-debates in the United States, Canada, as well

as the United Kingdom, Germany and other Western European countries by studying these nations' newspaper coverage. However developing countries or Central and Eastern European countries have rarely been investigated in that context (see chapter two). Among Scandinavian countries, Norway and Denmark has been studied before in that context. While there were some studies focused on Sweden (see Chapter two) none of them provided a comprehensive picture of the media nano-debate.

This thesis is a step towards the 'de-westernization' of this area of social sciences and media studies by moving the research focus from Western Europe and North America towards Sweden (Northern Europe), Poland (Central European) and Iran (Middle East) (see Lemańczyk, 2012). It might therefore fill the gap in the existing literature by studying countries that have never been studied in this context before. The novelty of this project is a comparison of three completely different countries in order to find out how differences in the coverage of emerging technology (such as nanotechnology) reflect the different socio-economic, political and cultural differences. These differences require also a new methodological approach that considers the specifics of each country. Such an approach is developed in this thesis and this allows me (towards the end of the thesis) to make suggestions regarding studying press coverage in non-Western countries.

The choice of these three countries is dictated by different factors. Firstly, as mentioned before, there is a lack of comprehensive studies focused on these countries and therefore this thesis fills a gap in the existing literature. Secondly, the debates about science and technology issues in Swedish-, Polish- or Persian-language media have been rarely investigated by social scientists. Thirdly, each of these countries is characterized by different socio-economic, political, religious and cultural conditions, reflected in different approaches to science and science policy. Based on the comparison of annual income, education expenditures, or

rankings published by the United Nations (ITU, 2012; UNDP, 2011) it could be argued that each of these three countries is at a different stage of development - Sweden is a developed country, Iran is a developing country and Poland, as a new member of EU, is situated between these two countries (see chapter three for further particulars). Rankings of the universities worldwide, although not based on strictly scientific sources, suggest that the stage of development of a particular country is likely to relate to the development of modern sciences and technology in that country. Whereas Sweden has an advanced scientific infrastructure that supports research and teaching, scientific research and education are less developed in Iran and, again, Poland falls somewhere in the middle. These country-specific elements that constitute part of the study's justification are discussed in-depth in Chapter three.

Considering the growing importance of studies on the social aspects of nanotechnology (Barben, Fisher, Selin, & Guston, 2008; Seear, Petersen, & Bowman, 2009), this research may not only enhance existing knowledge about the representation of emerging technologies in the mass-media, but it may also fill a gap in the existing literature, covering countries and languages that have not been studied before in this context. Its contribution covers various aspects of science and technology studies as well as particular areas of other sciences such as culture and media studies, or philology. The discussion of the former studies on the subject that situates this study and points out the gaps in the existing literature can be found in chapter two. It also provides a more detailed justification for this study.

The framework for studying the temporal changes to the nano-debates in Sweden, Poland and Iran is based on the 'model of mediated issues development' developed by Nisbet and Huge (2007), which has been used in studies of the US-debates around issues related to biotechnology (see chapter two). This cross-national study of nano-debates will also investigate whether this

model can be applied to the study of other countries, especially non-Western ones. As such, the thesis will also contribute to the literature on social sciences research methods.

The understanding of the current stage of media debates on nanotechnology, their tendencies and cross-national differences, may help journalists, policymakers, industry representatives or NGOs shape their communication of issues related to nanotechnology against a better and more detailed understanding of cultural difference and with an enhanced cultural sensitivity.

Based on the above assumptions I have developed research questions that will be discussed in the next section of this chapter.

## 1.3 Research Questions

The study of media coverage of nanotechnology in Sweden, Poland and Iran can, in principle, contribute to a variety of areas in sociology, media and culture studies. However, considering the broadness of this subject the wide range of issues that could be studied in that context (based on the corpora used in this study) it is necessary to limit and specify research questions that will be investigated by this project.

Since nanotechnology debates in these countries have not been studied before, therefore the first research question is:

> What are the main characteristics of the press coverage of nanotechnology in a particular country? What aspects (areas) of nanotechnology are most often covered by the media?

These questions address such aspects as: themes used in the debate; actors that were active in these discussions; tone of the coverage; focus on risks and benefits; and geographical focus of the coverage. The nature of the potential risks/benefits of nanotechnology and type of nano-applications (even if only 'potential') will be also discussed in that context.

However, apart from investigating what is said about nanotechnology and by whom, it is important to understand 'how' is it said. Therefore the next question is:

> How were the nano-debates framed in the Swedish, Polish and Iranian press? How did the use of particular frames change over the time?

Framing is a way to organise a story or a new idea in a way that makes it meaningful and fosters understanding (see section 2.3.1). Gamson and Modigliani state that frames suggest what a particular controversy 'is about, the essence of the issue' (Gamson & Modigliani, 1987, p. 143). Based on framing typologies used in the similar studies in other countries (Arias, 2004; Gorss & Lewenstein, 2005; Nisbet & Lewenstein, 2002) I will study the frames used in the discussion around nanoscience. Changes to their use across the studied time period will be investigated using a framework from a study by Nisbet and Huge (2007), which is presented in more detail in section 2.4. In that context I will also refer to the use of different themes or activities by particular actors.

The use of frames can be related to the use of metaphors, which are generally employed to make unfamiliar or abstract issues familiar more concrete, in this case nanotechnology, a technology which deals with phenomena that are totally invisible to the human eye. Therefore the next research question is:

> How have metaphors been used in the press coverage of nanotechnology in each of the three countries and are there similarities and differences?

Based broadly on concepts first introduced by Lakoff and Johnson (1980, 2003), I will search for and analyse the metaphors used in the nano-debates in each country. This analysis will enhance the qualitative insight of this research project.

The study of themes, frames, metaphors and actors, will not only deliver information about particular characteristics of the debate in the three countries, but it will also provide insights into cross-national differences. Therefore the last questions are as follows:

> What are the similarities and differences across nano-debates in the studied countries? And are these differences mainly due to political and economic context or are there other, more unexpected features of coverage that can be found?

This comparison constitutes one of the main goals of this thesis. Country-specific debates are discussed separately across the thesis, forming a background for the comparison conducted in the last two chapters. The aim of these questions is to find out how socio-political differences may affect the coverage of an emerging technology (here, nanotechnology). The comparison will also investigate whether the same framework can be used for studying media coverage in different countries. Is a single frame applicable in all cases or do different countries (with different cultures) require slightly different approach, e.g. in terms of framing typology?

## 1.4 Thesis structure

The thesis is divided into seven chapters. The first chapter is the introduction that informs the aims, rationale of the study and provides the background information about nanotechnology and its importance for society.

Chapter two provides background to this research project. Firstly, it discusses the theoretical underpinnings of this study (including the discussion of such issues as 'metaphors' and 'frames') and presents the chosen framework for studying media debates on nanotechnology in Sweden, Poland and Iran. As in other studies in the field, the chapter discusses the relationship between the public and media. Finally, the chapter contains the review of the literature on the debates

on emerging technologies, especially nanotechnology, 'drawing a map' of existing knowledge in this area, pointing to gaps in the literature and research. I will also describe the potential contribution of my research to the existing literature. In such way it strengthens the justification for this study. Discussion of former studies also provides background for particular methodological decisions that are later outlined in chapter four.

Chapter three presents the profiles of each of the studied countries. Since this study aims to investigate the differences between Swedish, Polish and Iranian nano-debates, it is necessary to examine each country's socio-economic and political background. In separate sections I provide information about issues that are relevant for media debate on nanotechnology in each country (i.e. elements that potentially may influence and shape this debate). These issues cover such aspects as science policy, development of nanotechnology and country's nano-policy, media policy and press market, as well as basic information about political system and economy. That knowledge will enhance our understanding of cross-national differences and country-specific characteristics of the nano-debates, discussed in later chapters.

Chapter four deals with the methods and research design. It will discuss methods chosen (i.e. content analysis and metaphor analysis) and sampling strategy. All choices are justified with reference to previous studies in the area or to the circumstances that affected this research project (e.g. access to particular sources).

Chapter five presents the results of the analysis of Swedish, Polish and Iranian press articles, using the methods described in chapter four. The results of the content analysis will be discussed separately for each country, discussing various elements that were considered in the analysis, i.e. frames, themes, actors, general tone, focus on risks/benefits, and geographical focus of the articles. The chapter also covers metaphors used in the nano-debates.

Chapter six contains the discussion of the results, which is conducted within the framework presented in chapter two. It will look at changes to the debates across time, especially in terms of framing. It will look at both country-specific characteristics and cross-national differences across the studied countries. Apart from frames, it will also consider other elements such as actors or geographical focus of the articles. All of that will provide background for the discussion of the applicability of the chosen framework for the studies on media nano-debates in culturally and economically different countries. The chapter will also discuss use of the National-frame - a frame that has been observed during the analysis of the corpora. Finally, the chapter will also discuss cross-national differences in use of particular metaphors that were found in the corpora. The use of metaphors will be also discussed in the context of the changes to the nano-debates across the studied time period.

Chapter seven, the final chapter of this thesis, will bring together the observations made in previous chapters in order to answer research questions. The results of analysis and discussion conducted in chapter six will support the discussion of findings and conclusion drawn. The chapter also provides an examination of the study's limitations, points out eventual improvements to the study design and makes suggestions regarding the directions of future research in that area.

## 1.5 Ethical issues

The research on media coverage of nanotechnology in Poland, Sweden and Iran followed the ethical guidelines provided in 'University of Nottingham Code of Research Conduct and Research Ethics' published and authorized by the University Research Committee in January 2010. Any problematic issues were discussed with the Research Ethics Officer in the School of Sociology and Social Policy and my supervisors.

The research did not involve any human participants and it was wholly based on publicly accessible data. I acknowledge the fact that my views, social and ethnic background, experience, and education may inform and affect the process of interpreting and analysing the data. To minimize that bias, I followed the above mentioned ethical guidelines and consulted my supervisors on decisions regarding the analysis, data collection and results,

The relevant ethical questionnaire has been completed, approved by my supervisors and submitted to the School of Sociology and Social Policy in June 2010.

# 2 LITERATURE REVIEW

The following chapter presents a review of the existing literature covering the subject of this study. Previous studies on media nano-debates are discussed in the context of the theoretical framework of this study and the questions related to the role of media in shaping public opinion. The literature review has been used both to shape the theoretical and philosophical framework in which the work for the thesis has been carried out and to inform the methods that have been used. It should be stressed however that many of the studies that will be discussed lack both theoretical and methodological reflection.

The first section of this chapter provides a brief discussion of the philosophical standpoint of this research. The second covers research on public attitudes towards nanotechnology, looking at the ways these attitudes differ across countries and cultures. However, it should be stressed that this thesis does not engage in attitude research, but focuses instead on one factor that can influence attitudes, namely media coverage of nanotechnology. The third section is a discussion of media's role in the process of communicating science to the public, which includes clarification of such terms as framing and metaphor. This is followed by a review of the earlier studies on media nano-debates across the world. Section four presents the theoretical framework for this study. The chapter ends with a summary highlighting the main observations from each section and the gaps in the existing literature, supporting the justification for the current study presented in the Introduction.

## 2.1 Philosophical standpoint

As a qualitative study conducted within an interpretivist framework, this research applies an approach that is rooted in social constructionism, which has a long tradition within Science and Technology Studies (Barnes, 1996; Bijker, 1993; Hacking, 1999; Latour & Woolgar, 1979). The focus is therefore not in finding some 'objective truth' about a topic but instead examining the ways and means

that people use to make sense of a topic, that is to say, the methods they use to interpret or construct a topic so that it makes sense to them (P. Berger & Luckmann, 1991; Harrington, 2005). The process of constructing meaning is affected and influenced by a range of factors such as one's personal experiences, cultural background or psychological predispositions.

Social constructionism has also been applied in other studies dealing with media debates on science and technology issues, including Gamson and Modigliani's (1989) study of the debate on nuclear energy in the United States. In this context framing plays a significant role in the process of constructing social reality since, as observed by Hallahan 'it helps shape the perspectives through which people see the world' (Hallahan, 1999, p. 207).

A complete study of the way people construct meanings about particular issues would need to cover both processes, i.e. media discourse and public opinion. This research, like much of previous research in the field, focuses on media coverage because of technical, financial and time constraints. Nevertheless, Gamson and Modigliani (1989) justify such an approach (although they acknowledge its limitation) stating that it allows the study of the way changes in media coverage provide 'essential context' for understanding and interpreting the results of studies focused on public opinion (e.g. surveys).

This study follows this research strategy focusing exclusively on media discourses in Poland, Sweden and Iran. In that context it will be crucial to investigate whether cultural differences have influence on the construction of meaning around nanotechnology. Of course, in order to describe these discourses completely, the study needs to be supported with additional explanations regarding such issues as the relation between public opinion and media, or the way journalists construct media content, upon which people may base their understandings of nanotechnology. These questions, including notions of framing

and metaphor, are discussed in the following sections of this chapter, together with the discussion of former studies in the field.

## 2.2 The Public

> Most scientists and most citizens believe that although the products of science can be used for good or evil, science itself is detached from and not responsible for the social consequences of its own discoveries. In this view, research on the structure of matter remains untarnished no matter how grotesque the results of an atom bomb detonation or how dangerous the storage of atomic waste (Maynard-Moody, 1995, p. 5)

The above quote from Steven Maynard-Moody, a Professor of Public Administration at the University of Kansas, describes a point of view that was (and sometimes still is) characteristic for many academics, politicians or members of the general public. Although, one can argue about whether this was still a dominating attitude in 1995, when these words were written, the fact is that it was a dominating conception of the relationship between science and society during the post-World War II decades characterized by the growing research development in the US and many Western European countries. In the book 'Selling Science' Dorothy Nelkin (1987) observes at that time there was 'the widely held belief that science is distinct from politics and beyond the clash of conflicting social values' (p. 71), which resulted in almost overwhelmingly positive media coverage of science and technology.

However, this attitude started to be challenged in the 1970's with the rise of the public concerns around the use of nuclear power, the ozone controversy and with later controversies related to biotechnology, GM-Food, animal and human diseases, in particular epidemics and pandemics, and most recently the climate change debate. In many cases the controversies among the public resulted in particular political decisions and regulations. In the context of the countries

studied it is worth mentioning the Swedish referendum on nuclear power in 1980 and the cancellation of the construction of the first Polish nuclear plant in 1989. These decisions were results (at least partially) of public protests. Another example is the debate around GM-Food that affected the sales of GM-Food products (Cobb & Macoubrie, 2004).

In response scientists, industry and policy-makers pointed out two main elements responsible (according to them) for the rise of the controversies. The first one was the 'public's ignorance', the lack of subject-specific knowledge that results in a lack of acceptance for the new technology ('deficit model'). In their critique of this model of the public Nisbet and Scheufele (2009) have outlined concisely the main assumptions of this pervasive perception of public understanding or rather not understanding of science:

> (...) after formal education ends, science media should be used to educate the public about the technical details of the matter in dispute. Once citizens are brought up to speed on the science, they will be more likely to judge scientific issues as scientists do and controversy will go away. In this decades-old 'deficit' model, communication is defined as a process of transmission. The facts are assumed to speak for themselves and to be interpreted by all citizens in similar ways. If the public does not accept or recognize these facts, then the failure in transmission is blamed on journalists, 'irrational' public beliefs, or both (pp. 1767-1768).

The last sentence of the quote above leads to the second element that was supposed to be responsible for causing public concerns regarding emerging technologies and various scientific issues – the media. According to this view, media coverage has a direct effect on people's opinion on particular issues (the 'magic bullet' effect). However, as observed by many scholars, both of these

assumptions have been found to be (at least partially) unproven. Neither a high level of scientific knowledge nor exposure to scientific media coverage automatically results in high support for some specific technology (or 'irrational' rejection of others). Susanna Priest argues that:

> (...) media audiences make active choices about what to read or watch and how to interpret it, and opinion formation is a complex process involving values, beliefs, priorities, concerns, allegiances, associations, and patterns of trust. It is not in any way a simple function of what a news story tells a reader to think. (Priest, 2003, p. 7).

Brian Wynne (1992), who studied the Cumbrian farmers' response to the restrictions introduced after the Chernobyl disaster, has also highlighted the importance of one's values, cultural background and experiences in the formation of his/her attitude towards a particular technology or scientific controversy. In this context Susanna Priest (2008a) adds another element to the critique of the 'deficit model' and related approaches to science communication:

> One of the other wrong turns that can be taken in thinking about public opinion is the unexamined assumption that 'the public' is a homogeneous mass, the very 'mass' that is incorporated in the term 'mass media.' In fact there are many publics for any given issue, some consisting of stakeholders and some not, and each public has unique values and concerns' (Priest, 2008a, p. 230).

This observation refers directly to the concept that each person perceives the world (not only science and technology issues) in a different way influenced by one's own experience, life history or beliefs.

However, the role of media in the formation of public (or 'publics') opinion and the shaping of public perception cannot be ignored. Since the media are still the main source of information about science and technology, they play an important role in influencing the public image of emerging technologies, affecting funding decisions as well as public and political support (Goodman & Goodman, 2006; Schäfer, 2012; Weingart, 2005). Goodman and Goodman (2006) point out that especially people without any prior knowledge in a particular subject gain their knowledge from the media, especially newspapers. Additionally, Nelkin (1987) has observed a relationship between the coverage of scientific controversies and the drop in consumption of particular products (e.g. produced using a controversial technology). However, at the same time opinion polls showed a high level of people's trust in science and the scientific community (Nelkin, 1987). Therefore the media may play a significant role in the initial stages of the debates on emerging technologies, when no prior experiences with these technologies exist and people do not yet know who to trust. Nelkin argues that when people lack any pre-existing knowledge that would help them to evaluate the issues independently, 'the press, as the major source of information, in effect defines the reality of the situation for them' (p. 77). Similar observations have been made by other researchers studying the debates on nanotechnology (Brossard, Scheufele, Kim, & Lewenstein, 2008; Scheufele & Lewenstein, 2005; Te Kulve, 2006; Ten Eyck, 2005). A more in-depth discussion of media coverage of science, especially nanotechnology, can be found in section 2.3.

Another issue that needs to be considered when discussing this question in the context of this research project is cross-national differences. An example could be the differences between US and European public attitudes towards GM-Food, with Europeans displaying more negative attitudes towards this question than Americans. Among the elements that affected these differences, Priest (2003) mentions such cultural aspects as different approaches to food consumption or the question of land ownership. Of course, she also points out the differences

across various European countries. Even in the context of this debate Priest (2003) dismisses the idea of the media's 'magic bullet effect', although she acknowledges the differences between the European and US coverage of GM-Food, pointing out the broader range of issues covered by media in European countries (compared to the US).

The GM debate in Europe became a recurrent trope in science and media discourse around nanotechnology, especially the call 'to avoid another GM debacle'. Some scientists, (Berube et al., 2010; Einsiedel & McMullen, 2004) argue that if politicians and researchers want to avoid the pitfalls and consequences of that debate, they need to develop a new way of communicating the potential risks and benefits of nanotechnology to the public. Similar recommendations are made in a report published in 2010 by the European Commission that states 'communication on nanotechnology is critical for Europe and particularly European institutions' (European Commission, 2010a, p. 19) and suggests that it is important to understand 'what', 'how' and 'to whom' one should communicate about nanotechnology.

### 2.2.1 Public perceptions of nanotechnology

From the very beginning of the development of nanotechnology within universities and spin-offs, voices could be heard that warned policy makers and scientists that they needed to avoid a GM-type debacle (Berube et al., 2010). Nanotechnology has become a showcase for what many regard as a solution to this problem, namely 'upstream engagement' (which is not unproblematic in and of itself however). The hope is that the earlier one talks openly about nanotechnology, the better the chances are of avoiding the GM debacle, namely the full-scale rejection of a technology by great parts of the general public. As argued by Susanna Priest (2008a) :

> Comparisons between the two are common. Current attention to the level of public receptivity for nanotechnology, the

> emphasis on early attention to possible environmental and health effects, and the search to find opportunities for 'upstream' engagement - that is, to find ways to give voice to public desires and concerns at an earlier point in the development process -all result from experience with biotechnology, particularly the genetically modified (GM) food debate. (...) Certainly there are important things we can learn from biotechnology about nanotechnology and public opinion (Priest, 2008a, pp. 220–221).

Nanotechnology therefore became a popular case study for STS scholars researching emerging technologies, public engagement and public perception of risks and benefits.

Studies in this area have been widely conducted in recent years, investigating, in particular, differences between public perceptions in different countries (Einsiedel, 2005; Gaskell, Ten Eyck, Jackson, & Veltri, 2005) (as such differences in perception contributed for example to differences in accepting GM in Europe and the US), as well as between people holding different religious beliefs (Brossard et al., 2009) (as these beliefs or values might impinge on differences in perception and uptake). Most recently, Chris Toumey (2011) has investigated various religions' answers to nanotechnology, observing that while religious beliefs may influence people's attitude towards nanotechnology, a particular religion's approach towards nanotechnology does not determine it unequivocally.

These studies showed that public attitudes towards nanotechnology are generally positive, especially in the United States and Canada where the percentage of people supporting the development of nanotechnology varies from 52% to 83% (Einsiedel, 2005; Priest, 2008b; Scheufele & Lewenstein, 2005). However, Gaskell et al. (2005) observed considerable differences in public perception of nanotechnology between US and European countries (15 EU

countries and Norway). While 50% of the US public answered positively when asked 'will nanotechnology improve our life?', only 29% of European citizens surveyed shared this opinion. At the same time 53% of Europeans answered 'don't know', while in US this answer was given by 35% of respondents. Doubts about nanotechnology making life better (answer: 'it will make things worse') were only expressed by 4% (US) and 6% (Europe) of respondents. Authors also draw attention to the differences among the European publics with the highest percentage of the supporters of nanotechnology (answer: 'will improve') in Luxembourg (45%) and lowest in Ireland (18%). Ireland also had the highest percentage of people who answered 'don't know' (68%). The highest percentage of negative answers ('will make things worse') was observed in Norway (15%).

Sweden was also included in this research and the answers to the questions mentioned above were as follows: 'don't know' – 48%, 'will improve' – 43%, 'no effect' – 7%, 'will make things worse' – 2% (Gaskell et al., 2005). This locates Sweden in the top of 'nano-optimistic' European countries and at the bottom of the 'nano-pessimistic' countries, since 2% was the lowest result among all surveyed countries. According the Eurobarometer survey (2006) 67% of Swedes support the development of nanotechnology, which confirms the above observations. The same report shows that Sweden has the highest percentage (among all EU-countries) of people interested in science and technology issues.

In case of Poland, the mentioned Eurobarometer report (2006) suggest that 46% of Poles declare their support for the development of the nanotechnology and around 50% declare interest in science and technology questions. It shows that the level of this support is lower than in the case of Sweden (although still relatively high). In 2011 the European Commission published a report 'Communicating nanotechnology to European youth', which included a survey conducted among young people from each EU-country. The report suggests a high support for nanotechnology among European youths (European

Commission, 2010b). Polish and Swedish youths were included in the study but it needs to be observed that the sample sizes for these two countries were relatively low (5 for Poland, 3 for Sweden).

The only available research on public perception of nanotechnology in Iran was conducted by Farshchi et al. (2011) and it suggests that public awareness of nanotechnology is limited. According to his study, almost 80% of Iranians have heard very little or nothing about nanotechnology. Interestingly the author observed that most of the people questioned believed that nanotechnology would have positive effects and that the benefits outweigh the risks (Farshchi et al., 2011). It must be stressed that this survey was conducted in Tehran, so knowledge about nanotechnology in smaller Iranian cities or countryside remains unknown. It is impossible currently to compare these results with any earlier studies, since as stated by the authors 'risk perception studies are very rare in Iran' (Farshchi et al., 2011, p. 3517). Additionally, Hosseini and Razaei (2009) conducted a study focused on agricultural researchers' attitudes towards nanotechnology. It was found that most of the surveyed researchers declared very low knowledge of nanotechnology. The authors observe that

> This finding stands in contrast to Iran's ranking among the world's pioneering countries in nanotechnology innovation and is contrary to some other high technologies such as biotechnology, genetic modification, and precision farming (Hosseini & Rezaei, 2011, p. 523).

However, in terms of risks and benefits perception 75% of respondents claimed that benefits of nanotechnology outweigh the risks.

## 2.3 Media

As observed in section 2.2 the question of the mass-media's influence on public opinion is a complex one and there is no direct relation between the coverage

and people's attitude towards particular issues, including science and technology. Nevertheless, it has also been highlighted that the mass-media may affect peoples' attitude towards new emerging technologies, when very little or no knowledge and experience, regarding a particular issue, exist among the public. Therefore, studies of the media coverage of emerging technologies have attracted interest from social scientists, funding bodies, governmental institutions and the European Commission, which on numerous occasions has highlighted the importance of nano-communication. However, as argued by Nisbet and Scheufele (2009), before informing the general public, we must first understand what types of knowledge about a particular technology, the general public (or particular groups or 'publics') already have; and this knowledge depends heavily on the information provided by the media (Scheufele & Lewenstein, 2005).

Among various media outlets scholars have highlighted the importance of the press in the process of shaping peoples attitude towards nanotechnology (Anderson, Allan, Petersen, & Wilkinson, 2005; Friedman & Egolf, 2005; Long, 1995; Stephens, 2005; Zimmerman, Bisanz, Bisanz, Klein, & Klein, 2001). Anderson et al. state that:

> the press play a potentially crucial role in framing newly emerging issues, mainly by helping to establish the initial parameters of debate, by identifying certain news sources as pertinent and credible, and by providing topic-defining reference points (Anderson et al., 2005, p. 202).

On the other hand, science journalists, who play (to some extent) the role of gatekeepers or mediators between scientists and the general public, are dependent on their sources. These sources often compete with each other to gain media attention (e.g. pro-technology industry or government vs. anti-technology activists). As observed by Priest (2008a) these activists 'tend to get

the most attention because these are the groups seeking out that attention' (p. 231). Similarly, institutions (sources) that have the resources to maintain public relation or public information offices or also more likely to have their opinions and views covered by the media (Priest & Gillespie, 2000). Additional factors that influence the content of science and technology news is the media culture in a particular country and the country-specific socio-political and economic context. When discussing the debates on biotechnology in the US and Europe, Priest and Gillespie (2000) point out that unlike the European press, the US mainstream press in most cases over-represents the stakeholders positions, while the European press is trying to present a broader range of views and perspectives on the issue. Crucial here are the questions of media ownership, media regulation and science policy, since they may indicate the extent to which government or other institutions are involved in the process of science communication. In the context of Sweden, Poland and Iran these issues are discussed in chapter three.

As previously mentioned, in the early stage of emerging technology development, the media have the ability to shape (to some extent, of course) people's attitudes. Among the various way of achieving this goal, two seem to play a significant role in the context of this study and these are: framing and the use of metaphors.

### 2.3.1 Framing

Framing is a way of making some issues more salient or characterizing them in a way that would cause some specific associations among the audience. However, this should not be confused with such terms as 'agenda setting' or 'priming' (Scheufele & Iyengar, 2012). According to the 'agenda setting' model the public is more likely to perceive some issue as important if it is discussed more frequently and prominently by the media. 'Priming' is related to the agenda setting model and assumes that once an issue became more important in the public's minds

then it could be used as 'the standards by which governments, policies and candidates for public office are judged' (Iyengar & Kinder, 1987, p. 63).

On the other hand, framing is a way to organise a story or an idea (especially a new one) in a way that would give them a meaning that would be understandable for people who do not know the idea or concept. According to the definition (very often used in other framing studies) offered by Gamson and Modigliani frames are the 'central organizing idea or story line that provides meaning to an unfolding strip of events (...) The frame suggests what the controversy is about, the essence of the issue' (Gamson & Modigliani, 1987, p. 143). As will be shown in section 2.3.3, frames have been widely studied in the context of nanotechnology (Arias, 2004; Arnaldi, 2008; Donk, Metag, Kohring, & Marcinkowski, 2012; Gorss & Lewenstein, 2005) as well as biotechnology (Herring, 2010; Nerlich, Dingwall, & Clarke, 2002; Nisbet & Lewenstein, 2002). The work that laid the foundations for the framing studies in the area of social sciences was Erving Goffman's 'Frame Analysis' (1986), first published in 1972. Goffman argues that when an individual faces a particular event 'he tends, whatever else he does, to imply in this response (and in effect employ) one or more frameworks or schemata or interpretation' (Goffman, 1986, p. 21), that he calls 'primary frameworks'. In such way an individual is able to understand the new information and make sense of the world around him (Scheufele & Tewksbury, 2007).

Scheufele and Iyengar (2012) link framing to the 'human tendencies to make sense of seemingly unrelated pieces of information by detecting underlying patterns that were consistent with pre-existing schemas in their minds' (pp. 12-13). As argued by Entman (1993), framing allows one to 'select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation' (p. 52).

While themes are strictly related to the content of the particular text (i.e. 'what is the story about'), frames are giving information about the way this particular news is presented (i.e. 'how is the story told'). Different news reports, containing similar information about some issue, may present in completely different ways. Framing also helps shortening the size of a news item by reducing the complexity of a particular issue (Scheufele & Tewksbury, 2007). Nisbet and Lewenstein (2002) state that '[f]rames also serve as working routines for journalists that allow journalists to quickly identify and classify information, packaging it for audiences. These organizing devices are especially useful when journalists are thrust into unfamiliar territory' (p. 361). However, other actors (e.g. government, industry, NGOs) active in the debate on some issue may also have interest in framing it in a particular way (to construct their version of 'reality'). Since these actors also often play a role as news sources for journalists they may have influence on the way media coverage is framed (Priest, 2008a). Once a frame starts to exist in the public sphere it shapes the debate around a particular issue and the attitude of the general public. Cobb (2005) observes that 'one of the most important qualities about how a new issue is perceived is how it is initially framed. In turn, how an issue is initially framed is often crucial to determining winners and losers in policy debates' (p. 223). Of course, journalists also have to tune into familiar frames that exist already in the public sphere so as to tell their stories about nanotechnology successfully. This in turn may reinforce and entrench existing frames, making same more salient and more used.

However, it is worth highlighting the earlier observation about media influence on public, which can be here expressed through the comment made by Nisbet and Scheufele (2009), who state that:

> Media frames might help set the terms of the debate among citizens, but rarely, if ever, do they exclusively determine public opinion. Instead, as part of a 'frame contest', one interpretative

> package might gain influence because it resonates with popular culture or a series of events, fits with media routines or practices, and/or is heavily sponsored by elites (p. 1770).

### 2.3.2 Metaphors

When discussing something unfamiliar or unknown, such as emerging technologies, the use of metaphors is unavoidable, as metaphors make the unfamiliar or abstract familiar or concrete, for example by 'framing' the structure of the atom as a solar system. Journalists in particular have to be proficient metaphor users and connoisseurs of popular frames and stories.. The metaphors scientists and journalists use are important in shaping how an issue is perceived and ultimately handled. As observed by Dorothy Nelkin (1987):

> by their choice of words and metaphors journalists convey certain beliefs about the nature of science and technology, investing them with social meaning and shaping public conceptions of limits and possibilities (p. 11).

However, before discussing the use of metaphors in the context of science and technology it is worth starting with a short introduction and definition of this term. One of the first seminal metaphor researchers in the 20th century, Ivor Armstrong Richards (1936) describes metaphor in the following way:

> In the simplest formulation, when we use a metaphor we have two thoughts of different things active together and supported by a single word, or phrase, whose meaning is a resultant of their interaction (p. 36).

For a long time metaphor was studied as a merely decorative or rhetorical device, mainly in the context of poetic analysis. However, since the 1980s authors such as Lakoff and Johnson (1980, 2003) have pointed out (echoing some predecessors in the 19th and early 20th century (Nerlich & Clarke, 2001) )that

metaphor pervades thinking and talking and structures how we think and talk about issues in ordinary life, but also in science. They argue that while most people 'think they can get along perfectly without metaphor' (Lakoff & Johnson, 1980, p. 454) and perceive metaphors as 'characteristic of language alone, a matter of words rather than thought or action' (pp. 453-454), metaphors are actually 'pervasive in everyday life, not just in language but in thought and action' (p. 454). According to Lakoff and Johnson 'our ordinary conceptual system, in term of which we both think and act, is fundamentally metaphorical in nature' (p. 454). Lakoff (1993) distinguish also between two terms: 'metaphor', which is a 'cross-domain mapping in the conceptual system', and 'metaphorical expression' that is actually 'the surface realization of such a cross-domain mapping' (p. 203). Following works of Lakoff and Johnson, Staffan Carlshamre, professor of Philosophy at Stockholm University, states that 'cognitive metaphors act as sources of metaphorical expressions' (1988), e.g. a relationship is a journey – we have come to a crossroad in our relationship, this is the end of the road, we have to go our separate ways

Todd and Harrison (2008) point out that 'by categorizing the world for us, metaphor creates cognitive frames that may have real-world consequences' (p. 479) . The use of metaphors also allows people to assimilate information about new phenomena into familiar frames, something that is of special importance in trying to communicate and understand advances in science which are not easy to convey. In the 17th century, advances in clock or watch technology enabled scientists and ordinary people to conceptualise the universe as a clockwork and therefore to understand, at least for a while, how it works. In the 20th century people think they know how the brain works because they can liken it to computers, and so on. In the context of nanotechnology visionary images and metaphors of 'nanobots' on the one hand and 'grey goo' on the other propelled nanotechnology into the public sphere around 2003. In this place it is worth referring to Dorothy Nelkin's (2001) observations about the use of metaphors in

the process of communicating science to the general public. Although her paper was mostly focused on metaphors used in the debate on genetics, the following quote seems to be applicable to other fields of science and technology especially that it refers also to the earlier discussion on media influence over public:

> By their choice of metaphors, scientists, their public relations strategists, and science writers, convey certain beliefs about the nature and importance of science and technology, and their limits, impacts and implications. Although people interpret scientific information and ascribe meaning to metaphors according to their personal experience and previous knowledge, metaphors are powerfully persuasive tools (Nelkin, 2001, p. 556).

It can therefore be argued that metaphors and images can be effective instruments to create expectations about the future, expectations that can be positive or negative (Lösch, 2008) and can have economic and political consequences. The metaphors that are used to frame nanotechnology depend on the cultural context in which they are created and used, the person who used them to communicate, and also depending on the metaphors that are culturally salient in a community or nation, something that might differ from nation to nation and language to language (Kövcses, 2005).

In the context of this cross-cultural research it is worth referring to the notion of 'discourse metaphor' introduced by Zinken, Hellsten and Nerlich (2008) who suggest that metaphor is not predominantly a cognitive phenomenon, as stated by Lakoff and Johnson, but also, and perhaps more importantly, a social and cultural phenomenon. Unlike conceptual metaphors (e.g. 'arguments are war'), that are considered to be universal, discourse metaphors (e.g. 'selfish gene') are influenced by particular cultural, scientific and social issues as well as context of the debate, which can differ among different societies and nations, and over time

they may evolve and adapt to new socio-political circumstances. Some of these metaphors are also invented by key actors, such as Richard Dawkins (1989) in the case of 'the selfish gene' and instantly reframe thinking about biology and genetics. Similarly, the metaphor of 'grey goo' invented by Drexler (1986) reframed thinking about nanotechnology for a while. Those metaphors 'need to be explored in the cultural context in which they are used, specifically, in terms of their sociocultural situatedness' (Zinken, Hellsten, & Nerlich, 2008). Nerlich states also that 'sociocultural situatedness is a crucial factor in the functioning and dynamics of metaphor. Metaphors do not appear from nowhere. They are not autopoetic, but evolve over time under certain contextual circumstances. We claim that this dynamic quality is shared by conceptual and discourse metaphors. They differ from each other only in degree, with discourse metaphors being more contextually sensitive and variable than conceptual metaphors which seem to be more stable over time and across cultures' (Nerlich, 2005b, p. 72).

The use of metaphors in media debates has been a subject of many studies like studies on conversations about cancer (Semino, Heywood, & Short, 2004), the language of banking (Bielenia-Grajewska, 2009) or the genome (Nerlich & Hellsten, 2004), 'microbiome' (Nerlich and Hellsten 2009) and more generally in the context of the biotechnology-debate (Hellsten (2002), Holmgren (2008), Nelkin (2001), Nerlich, Dingwall & Clarke (2002), Petersen (2005), Zwart (2009), to provide only a small number of examples. The study of metaphor has especially proliferated in the context of the media study of biotechnology. Surprisingly, the number of such studies in nanotechnology context is still very limited – an exception is the study of the British press debate by Petersen et al. (2008). Another example could be the study of nano-images (Nerlich, 2012a).

Methods for conducting metaphor analysis are still a subject of discussion among scholars and the approach used in this study will be discussed in section 4.2.

### 2.3.3 Media coverage of nanotechnology

Alongside the studies of public perception, social scientists have studied media coverage of nanotechnology. As mentioned in section 2.2, although there is no direct relation between the media content and people's opinions, the media may influence people's attitudes towards an emerging technology in the early stage of the debate. Knowledge about media coverage at this stage may facilitate understanding of public opinion on a particular question or issue related to the emerging technology. Therefore, considering the fact that nanotechnology is still in its early stage of development, studies on media coverage of nanotechnology have been proliferating since the beginning of the 21st century. Most studies covered the United States, Canada, the United Kingdom (Allan, Anderson, & Petersen, 2010; Anderson et al., 2005; Faber, MacKinnon, & Petroccine, 2005; Fitzgerald & Rubin, 2010; Friedman & Egolf, 2005; Gorss & Lewenstein, 2005; Laing, 2005; Stephens, 2005; Weaver, Lively, & Bimber, 2009; Wilkinson, Allan, Anderson, & Petersen, 2007), Germany (Donk et al., 2012; Grobe, Eberhard, & Hutterli, 2005; Zimmer, Hertel Rolf, & Böl, 2008), Denmark (Kjærgaard, 2008), The Netherlands (Te Kulve, 2006), Italy (Arnaldi, 2008), Spain (Veltri, 2012), Norway (Kjølberg, 2009) and Slovenia (Groboljsek & Mali, 2012)[2]. Additionally, Dudo, Choi and Scheufele (2010) conducted a study of 21 US newspapers focusing on the nano-food only. The sources that were most frequently used were both national and regional daily newspapers, as well as weekly magazines and, more rarely, web-pages. Other research projects included studies on visual representations of nanotechnology used in the media (Nerlich, 2005a, 2008).

Although some authors used quantitative content analysis (Dudo et al., 2010), most of the researchers applied a qualitative approach to their studies with a preference for qualitative content analysis and frame analysis. The descriptions of study design, data collection and analysis (where provided by the authors)

[2] A detailed list of the papers focused on media nano-debates is presented in Appendix 1

Te Kulve observed that with the development of the debate on nanotechnology, the views presented in the media became more contrastive and the reporting patterns became more antagonistic.

However, the question of potential harm and risks associated with this technology did not dominate the press coverage and the overall tone was positive. This predominantly positive tone has been observed in all countries where media coverage of nanotechnology has been studied.

Further to differences between various countries, some scholars also focus on differences between particular newspapers. Anderson et al.'s (2005) study of media coverage of nanotechnology in the UK press showed that articles related to nanotechnology appear more often in 'elite newspapers'; this pattern has also been found in the US by Gorss and Lewenstein (2005). Furthermore Zimmer et al. (Zimmer, Hertel Rolf, et al., 2008) also focused on the main actors in the debate on nanotechnology in German newspapers.

In the context of this study it is worth referring to Groboljsek and Mali's (2012) study of media coverage of nanotechnology in four Slovenian dailies, the only available study that investigated these questions in the context of former communist countries. The coverage was mostly positive, with a low number of articles presenting nanotechnology in a negative way. The majority of articles (over 90%) discussed nanotechnology in a scientific context, 5.5% of the articles were focused on economic aspects and 2.7% of the articles on politics. The ELSI-frame was not used at all. According to the authors 'this indicates that nanotechnology in Slovenia seems to be in an early stage of coverage' (Groboljsek & Mali, 2012, p. 43). Almost half of the analysed articles discussed nanotechnology in the context of Slovenia itself.

One overarching observation regarding media coverage on nanotechnology across the world is that it appears more limited than other debates on emerging technologies, e.g. biotechnology, readily observed when comparing the number

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of published newspaper articles. Nanotechnology has simply not achieved what Nisbet and Huge (2007) describe as 'celebrity status' in media. As they argue:

> Some issues achieve celebrity status as they go through these cycles [of media attention], but other issues – even in their peak years of attention – still rest relatively modestly on the overall media agenda (p. 197).

Issues that achieved celebrity status, apart from events such as 9/11 or presidential elections, include the stem-cell debate or debates around various aspects of biotechnology, which has often been compared to the debate on nanotechnology.

### 2.3.4 Comparison to biotechnology

The comparisons to biotechnology or the GM-Food debate have been made by many researchers (Allan et al., 2010; Einsiedel & Goldenberg, 2006; Gorss & Lewenstein, 2005; Schuller, 2004; Zimmer, Hertel, & Böl, 2008). Gorss and Lewenstein (2005) conclude that news on nanotechnology tends to be framed in a similar way as news on biotechnology did, albeit that the 'progress' frame was more prevalent in the debate on biotechnology. Arias (2004) also found the framing of nanotechnology is comparable, with some exceptions, to the framing of the news on biotechnology at the beginning of its development. According to Friedman and Egolf (2005) newspapers tend to compare nanotechnology with biotechnology, considering them as technologies that have a 'bad' reputation. However, only 31% of US and 40% of UK articles studied by Friedman and Egolf highlight risk similarities between biotechnology and nanotechnology. This difference between US and UK coverage reflects the previously mentioned general difference between US and European publics in the perception of new technologies.

Einsiedel and Goldenberg (2006) state that the controversies that arose during the debate on biotechnology should be considered by scientists and policy makers and therefore:

> the social tools for nanotechnology innovation and governance need to be conceptually developed; otherwise, the physical research and development dimension will continue to outpace the social nanotechnology development (p. 29).

In the study of media coverage of nanotechnology in German newspapers Zimmer et al. (2008) suggest that discussion about nanotechnology is now at its initial phase and unlike biotechnology it still does not cause too many concerns, i.e. there is no 'Dolly the sheep' or 'Frankenfood' of nanotechnology yet. It should be stressed that, from the outset nanoscientists were keen to avoid what was widely called the 'GM debacle' (Schuller, 2004). They therefore engaged with social scientists much more and much earlier than during the GM debate. This has come to be known as 'upstream engagement' (Macnaghten, Kearnes, & Wynne, 2005; Rogers-Hayden & Pidgeon, 2007).

### 2.3.5 Media coverage of nanotechnology in Sweden, Poland and Iran

Research studying modes of presenting nanotechnology in Swedish, Polish or Iranian newspapers is rather limited, despite the fact that, at least for Sweden and Iran, there are a few public attitude surveys (see above). The only exception is the Swedish debate on nanotechnology, which has been covered by Hans Fogelberg (2008) and, more recently, Max Boholm (2012; 2013). Fogelberg's paper focuses on Swedish nano-policy and the way that research on nanotechnology has been developed in Sweden since the beginning of 1980s, but it does contain one paragraph on media coverage of nanotechnology in the Swedish press. Neither the methods nor results of the study are discussed in any depth in the paper (presumably because it is not the main aim of the paper). Nevertheless, Fogelberg points out that most newspaper articles were focused

on the benefits of nanotechnology and its possible technological application. According to the author, discussion of potential risks is rather limited. I have discussed with Dr. Fogelberg the Swedish nano-debate through an email exchange. He added that the debate on nanotechnology in the Swedish press is extremely limited and if nano appears in daily newspapers this is usually a repetition of news from foreign newspapers, especially British ones. Studies conducted by Boholm (2012; 2013) used keyword analysis in order to study the associations between the words 'risk' and 'nano' in Swedish press coverage between 1988 and 2010. He found different ways of describing potential risks related to nanotechnology (divided into five groups) and observed that in that respect the Swedish coverage is similar to the US or UK coverage of nanotechnology[3].

No studies on media coverage of nanotechnology have been conducted in Poland or Iran. Relevant members of the academic staff from the universities in Gothenburg, Uppsala, Umea, Torun, Krakow, Warszawa, Warwick and Teheran, were contacted in order to find any relevant literature in this area. However, no one could suggest any research focused on that subject.

The only publications referring to Sweden, Poland or Iran in the context of nanotechnology, apart from strictly scientific papers, are dedicated to nano-policy and the development of nanotechnology in these three countries (discussed in chapter three) or scientific research in the fields of nanoscience and nanotechnology, e.g. number of published papers (Li et al., 2008).

## 2.4 Framework for this study

So far, this chapter has discussed the ways in which the media (and in particular newspapers) potentially influences people's attitudes towards nanotechnology

[3] Please note that the papers reporting Boholm's study were published in 2012 and 2013, i.e. the first towards the end of this research project and the second after the submission of this thesis.

(e.g. the use of particular frames). In section 2.3.3 I have pointed out some general characteristics of nano-debates across the world observed by various social scientists. Following this path this study will investigate frames, themes and tone of Polish, Swedish and Iranian nano-articles, as well as longitudinal changes to the coverage.

However, before more closely discussing the model applied by Nisbet and Huge (2007) it is necessary to reflect on two earlier works that constitute its base. Firstly, I would like to refer to the work of American economist Anthony Downs (1972), who studied the changes in media attention to particular issues and was looking for reasons as to why some issues gain significant media attention, while others attract scant attention. Downs states that an issue (e.g. nanotechnology) remains in a pre-problem stage until it is triggered by some dramatic event or alarming discovery, which attracts the attention of the mass-media and wider public. This is followed by a period of enthusiasm about the ability to find the solution for the new problem. However, gradually the actors involved realize that the solution will inevitably involve significant costs (not only in financial terms) and the diffusing knowledge as to these difficulties leads to the 'gradual decline of intense public interest' (p. 40). Finally, during the post-problem stage attention levels are relatively low (and coverage is not as dramatic as before) but, as argued by Downs, 'the issue now has a different relation to public attention than that which prevailed in the pre-problem stage' (Downs, 1972, p. 40). The regulations, policy implementation and new institutions introduced as a result of the growing attention to a particular issue usually come into existence during the post-problem stage. Once an issue went through this cycle it is more likely to attract public and media attention in the future. Downs observes that policymakers and the media prefer to focus on the dramatic aspects of an issue in order to sustain public interest, particularly where attention levels have the potential to affect particular policy and financial decisions. An example is NASA's activity which attracted significant attention through the 1960s as a result of

increasingly dramatic and exciting events. However, since of the late 1960s the level of media attention and consequently 'NASA's Congressional appropriations plummeted' (Downs, 1972, p. 42).

Ho, Scheufele and Corley (2010) argue that the low frequency (in terms of number of articles) and mostly positive media coverage of nanotechnology suggests that it is in the initial stage of the issue attention cycle (at least in the US). This study will also refer to Downs' characterisation by trying to identify on what stage of this cycle are the debates on nanotechnology in Poland, Sweden and Iran. However, as mentioned above, the Downsian issue-attention cycle is only one element of the model that will be used to investigate how newspapers report on developments in nanotechnology in these countries.

The second work that is significant in this context is by Steve Hilgartner and Charles Bosk (1988), who argue that the level of attention to a particular issue is not a result of objective conditions but is affected by the socio-political and economic context in which they emerge. As they observe 'public attention is a scarce resource, allocated through competition in a system of public arenas' (p. 55). In other words, various 'operatives' (politicians, journalists, members of the public etc.) compete between each other for public and media attention for a particular issue, framing and interpreting it in a way that is most suitable for them. As observed by Nisbet and Huge (2007) 'the interpretation that comes to dominate public discourse has profound implications for the future lifecycle of the issue, for the interest groups involved and for policy decisions' (p. 196), which relates to the earlier observation about the significance of the way an issue is interpreted and reported in the initial stage of the debate. As mentioned above, the competition between various 'operatives' takes place across various public arenas that have limited attention capacities ('resource constraints'). Consequently only a limited number of issues can attract attention at any one

time, a result that accelerates the competition between various issues (or rather the operatives seeking to highlight them).

In analysing press coverage of nanotechnology in Sweden, Poland and Iran, I will combine both concepts – Downs' 'issue-attention cycle' with Hilgartner and Bosk's observations discussed above. This combinatorial approach was adopted by Nisbet and Huge (2007) in their study of the US debate around plant biotechnology. They overlay the issue-attention cycle with understandings of the 'policy venue where the debate takes place' (p. 196), drawing out competing strategic actors framing issues in specific ways, as well as 'the context relative to other competing issues' (p. 197). This leads the authors to the conclusion that the peak coverage of an issue does not necessarily mean it has achieved a 'celebrity status' in media, since this is affected by other issues and mechanisms. Nisbet and Huge (2007) called this approach 'a model of mediated issue development' (p. 196).

The two main 'arenas' highlighted by Nisbet and Huge in their study are the overtly political policy arena and the administrative policy arena. It covers not only the physical space (e.g. Parliament) but also the particular context in which an issue is discussed. The first arena is more pluralistic, characterised by the participation of a diverse range of actors including NGOs or representatives of the general public. This allows them to be more visible and heard and therefore to have greater influence over political decisions. The discussions in these venues are more likely to occur when the issue is framed dramatically (frames related to ethics/morality, scientific uncertainty, risk, public engagement etc.) and often attract widespread public/media/policymakers attention. However, overtly political arenas are often unsuitable for handling technical decisions and as a result these issues are directed toward administrative venues where relevant regulations and policies emerge and may be implemented. This frequently occurs during periods of lower attention where the number of actors participating in the

debate or having an influence over the policymaking process is more limited, and substantive expertise becomes more salient (manifest in, for example representatives of industry and the scientific community). This limited scope of participation (which better facilitates consensus) is characteristic for the administrative arenas, where 'things happen incrementally and scant attention follows' (Nisbet & Huge, 2007, p. 198). As argued by Nisbet and Huge these actors prefer a technical framing (frames related to scientific progress and background, regulatory or policy background, economic prospects, ownership) of the issue since a focus on the technical helps 'dampen the public excitement'.

I will use Nisbet and Huge's model of 'mediated issue development' which is itself based on the studies summarised above, and apply it in the study of media coverage of nanotechnology in Poland, Sweden and Iran. This will include the study of coverage in these countries between 2004 and 2009, frames used during that time, the context of the debates and actors active in the media discussion around nanotechnology. The presented model will help mapping the changes to the debate (in terms of frames, actors etc.) and the changes to the venues (administrative or overtly political), in which nanotechnology is discussed in each country. The latter is especially important for mapping the way these debates reflect the socio-economic and political differences between the three countries. Finally, I will evaluate to what extent this model, which was developed and found appropriate in the US-context, can be used to investigate debates in countries that differ from the United States in terms of political culture or decision-making processes. Failure in this respect may suggest that we may need a modified model for studying debates in non-Western (especially non-US) media.

## 2.5 Summary

The aim of this chapter was to position the current research amongst other studies in the field as well as anchor the study in a theoretical framework.

The conducted literature review has highlighted some characteristics of the existing coverage as well as identified potential gaps. Because of the differences between various types of research it is difficult to arrive at one overall conclusion. However, it can be observed that both public perception of nanotechnology and the coverage of nanotechnology in the media are generally positive, albeit with some limited discussion of its risks. Looking towards the subject of this research, it is important to stress the existence of differences between particular countries. It can be observed that media coverage and public opinion on nanotechnology is more positive in the US than Europe or Canada, with European media focusing more frequently on potential risks or negative consequences of nanotechnology development.

An important finding is that research is focused almost exclusively on English-speaking countries, with only a few exceptions, such as Italy, Netherlands, Norway or Germany. The dominating focus on Western media, especially US and UK (described sometimes as 'US-UK duopoly' (Thussu, 2009)), can be observed in all fields of media studies (Hepp & Couldry, 2009).

The small number of articles covering non-English speaking countries leads to specific limitations such as lack of a wider time perspective and lack of comparability with other/former studies. A notable exception are the broad range of studies conducted in Germany (Donk et al., 2012; Grobe et al., 2005; Zimmer, Hertel Rolf, et al., 2008).

The literature review shows that researchers studying media coverage of nanotechnology have focused mostly on frames, themes, actors active in the debate or visual representations of nano. It also appears that research the use of metaphors as one of the most important framing devices was rather limited (in contrast to studies of debates about biotechnology debate).

The study of the literature confirms the observations made by Seear et al. (2009) who report this area of study is being undeveloped, pointing to considerable gaps

in research covering 'the role of the media and popular culture in framing the perceived benefits and risk of nanotechnology' (p. 27). The review points out two main gaps in the existing knowledge. Firstly, there is a lack of studies covering non-Western countries (e.g. Poland and Iran) and a limited number of studies focused on Sweden. The mentioned study by Boholm (2012; 2013) was almost exclusively focused on nano-risks in Swedish media between 1988 and 2010. This study, although covering shorter period of time, looks at to other aspects of the debate, i.e. themes, frames, tone of the articles or actors active in the Swedish nano debate. Secondly, studies of metaphors used in the process of communicating nanotechnology were rather limited.

In terms of philosophical standpoint, this study draws on the social constructionist approach, focusing in particular on the construction of meanings (and therefore also realities) within the traditional press. It is based on the assumption that there is no 'true' meaning of nanotechnology that one could discover, but that all meanings are culturally, politically and socially situated. However, this does not mean that there are no overlaps in the meanings attributed to nanotechnology across time and space, under pressure from actors that have more influence over agenda setting than others, for example.

This study also assumes that there is no proven direct relationship between media content and public opinion, since this process is influenced by a range of other factors (e.g. personal experience). Nevertheless, it acknowledges that media may (to some extent) influence the way people perceive technology and science, especially in the early stages of the debate. The theoretical framework for the study of media debates on nanotechnology in Poland, Sweden and Iran is rooted in the model of mediated issue development (Nisbet & Huge, 2007), itself based on the works of Downs (1972) and Hilgartner & Bosk (1988). However, it should be emphasized that the main contribution of this research to STS literature is not the development of new theoretical frameworks. The novelty of

this work lies in its empirical findings, which are analysed using methods that have been routinely (as showed in this chapter) used in studies on media coverage of nanotechnology.

The gaps discussed above provide a background for the justification of this study that will enhance our knowledge about media debates on nanotechnology in particular, and emerging technologies in general. The main contribution to the existing literature is moving the research-focus from Western and English-speaking countries towards other areas of the world, most notably Iran and Poland – countries that have never been studied in that context before. The comparison of the debates on nanotechnology in Western and non-Western world (especially Iran) is also a valuable contribution this research will made to the existing literature. Therefore, the significance of this study should not be limited to media studies only, since it is applicable to various areas of culture studies and social sciences.

The choice of Nisbet and Huge's framework (2007) will help to map the temporal changes to the studied debates and will strengthen the cross-national comparison of these debates. Additionally, while applying this framework, I will try to find out whether the same approach can be used in studies of the debates in Western (i.e. North America, Western Europe) and non-Western countries. Therefore, it is hoped that this study will also contribute to the methodological and theoretical literature.

# 3 SCIENCE POLICY, NANOTECHNOLOGY AND MEDIA – COUNTRY PROFILES

The process of communicating nanotechnology, as well as any other issue, differs across nations and cultures. Robert McKenzie (2006) who conducted a systematic in-depth comparison of media from four continents stresses that:

> People experience media in radically different ways across the countries of the world because each country has a unique set of conditions that influence the accessible media content (p. 2).

Elements that may affect the content of media include the socio-political situation, economy, culture, religion, history or language. Therefore while studying media debates on nanotechnology it is necessary to locate them in a country-specific context. This will not only help understanding the results of the analysis, but will also enable researchers to compare how different countries, especially their media, deal with an emerging technology like nanotechnology.

This chapter aims to provide such context for the study of nano-debates in the press in Sweden, Poland and Iran. Three main elements have been chosen as a background for the contextualisation of media coverage relating to nanotechnology in these countries:

- Science Policy – the emergence of science policy in each country; what are its characteristics (strengths, weaknesses); research and higher education; organisation of research and research funding;
- Nanotechnology - level of nano-development (research, patents, nano-companies); specific policies relating to nanotechnology;
- Media – media policy; ownership; legislation; main characteristics of the press market.

Additionally, basic statistical information about each country will be provided (GDP, HDI, ICT-diffusion index). I will now go on to justify the choice of the three

countries under study, focusing on differences in science policy, media and nanotechnology.

## 3.1 Sweden

For over two hundred years Sweden has not been involved directly in any military conflict. This laid a foundation for political stabilisation and led to rapid economic development, especially after World War II. Sweden is a parliamentary monarchy with a king as head of state and an elected parliament. Since 1996 the country has been a member of the European Union.

Table 3-1 Sweden - basic facts

| | | | |
|---|---|---|---|
| **Population** | 9 million | **Literacy** | 99.9% |
| **GDP per capita (2009)** | $37,400 | **HDI-rank** | 7 |
| **Educational expenditures (% of GDP)** | 7.1% | **ICTDI-rank** | 4 |

### 3.1.1 Science Policy

The Swedish science and research sector has been developed heavily since the end of World War II. Tage Erlander, Swedish Prime Minister between 1949 and 1969, argued that 'Sweden should not fall behind' the other developed countries and instead the country 'should be at the front' of scientific research (Erlander, 1976, p. 26). Since that time it has undergone a series of reforms and structural changes. Initially, research was financed by the government and conducted mostly by state-owned universities[4] and some research institutes related to the defence sector, giving scientists significant autonomy in decisions regarding resource allocation (Edqvist, 2003; Hallonsten, 2011). The reforms introduced in the second half of 1970s aimed to strengthen the central planning system in the area of science policy. Three discipline-specific and one interdisciplinary research councils have been established. These institutions became responsible for the

[4] At that time only Stockholm's School of Economics, was privately owned Higher Education institution in the country

allocation of research funding and encouraging research-collaborations between Swedish universities.

In the 1980s privately financed research started to play a more significant role in Sweden. Large companies such as Ericsson, SAAB, Astra, Pharmacia or Asea (now ABB) started to invest heavily in their research and development activities. Consequently research was divided into two branches – state funding in universities and private funding in companies. Around this time Swedish universities started to be criticised for being too focused on traditional disciplines and for their isolation from both industry and foreign research institutions (Benner & Sörlin, 2007, p. 35). This critique overlapped with two other related factors: the economic crisis that hit Sweden in the beginning of 1990s and political changes in the country. After the general elections in September 1991, the new right-wing government sought the solution for country's economic problems in privatisation, cuts and deregulation. These concepts were applied in science policy reform that aimed to: free universities and researchers from state's regulation, minimise the state's role in research funding, strengthen evaluation criteria, introduce the competitive system of research grants, and encourage collaboration between research institutions and industry. This system was highly influenced by the model applied in the United States of America (Lundequist & Waxell, 2010) where government was aiming to stimulate innovate research and new collaborations, particularly between research institutes and industry. The fact that Sweden was facing economic problems was an additional argument for moving the science policy towards the mentioned US-model, since it would move (at least partially) the responsibility for research funding from the state to private foundations.

The new system started in 1994. The existent discipline-oriented research councils were replaced by the Swedish Research Council (VR), mission-oriented agencies (in areas such as engineering, environmental research etc.) and semi-

private foundations. The largest three foundations were the Foundation for Strategic Research (SSF), the Foundation for Strategic Environmental Research (MISTRA) and the Bank of Sweden Tercentenary Found (RJ). The total initial capital of these foundations was ca. £850 million (Benner & Sörlin, 2007) which was divided among the three mentioned foundations (SSF – 60%, MISTRA – 25%, RJ – 15%).[5]

The new system soon faced a serious crisis. Firstly, in 1995 the new government constituted by the social-democratic party proved to have completely different views on science policy to the former government. Secondly, the reforms faced critique and resistance from the academic community, related to one of the main aims of the reform, namely that universities should do research that would contribute to the economic growth of the country (Benner & Sörlin, 2007). The new government decided to cut the budgets of research councils and the mission-oriented agencies (Benner & Sörlin, 2007). The government expected the semi-private foundations to compensate these savings but the foundations did not comply. In response the government implemented new cuts to disciplines close to the core areas of foundations' activity, and later Parliament changed the legal status of the foundations. The state gave itself the right to appoint members of the foundations' boards and, as such, allowed government to influence the foundations' decisions.

The system stabilized after 1998. Universities still remained the country's main research institutions but needed to implement some changes to their policy and organisation. Since research councils and foundations preferred collaborative research university researchers started to work more closely with private companies. The funding of research institutions became more diverse than it was before. Nevertheless, the system has been criticised by many Swedish academics who claimed that foundations' quite instrumental policy – of seeing science as a

[5] Other seven foundations were established in the later stages of the reform.

tool for solving particular problems - led to a decay in 'curiosity driven research' and the promotion of more 'mediocre' researchers and 'mediocre' research projects, who nevertheless met the criteria set by foundations (Nilsson & Rose, 2000).

In the 2000s the government increased investment through research councils and inevitably the impact of the research foundations as has been weakened. Currently, the private sector is investing three times more in research than the state does. Nevertheless, the state remains the main source of funding for research conducted at the universities. Most public funding is distributed through four research councils and agencies: the Swedish Research Council (VR), the Swedish Research Council (FORMAS), the Swedish Governmental Agency for Innovation Systems (VINNOVA), and the Swedish Council for Working Life and Social Research (FAS). In 2010 the total research investment in research of these four institutions was at the level of £700 million. Other public sources of funding include local municipalities, state institutions (e.g. Rail Administration) or private foundations such as Knut and Alice Wallenberg Found (invested ca. £376 million during the last five years) or Cancer Found (ca. £37 million in 2011).

The largest of the research funding agencies is VINNOVA. Its aim is 'to increase the competitiveness of Swedish researchers' (VINNOVA, 2011) and to encourage collaborations between academia and industry. It is also responsible for coordinating the funds available through the EU Framework Programme for R&D, a further significant source of funding (as in all other EU-countries).

The main recipients of grants and research funding are Sweden's largest universities: Uppsala University, Lund University, Gothenburg University, Linköping University, Royal Institute of Technology, Stockholm University and Chalmers University of Technology in Gothenburg (Benner & Sörlin, 2007).

As can be observed the research funding is very diverse in Sweden, which is also showed below (see Figure 3-1) on the example of research funding at Chalmers University of Technology in Gothenburg.

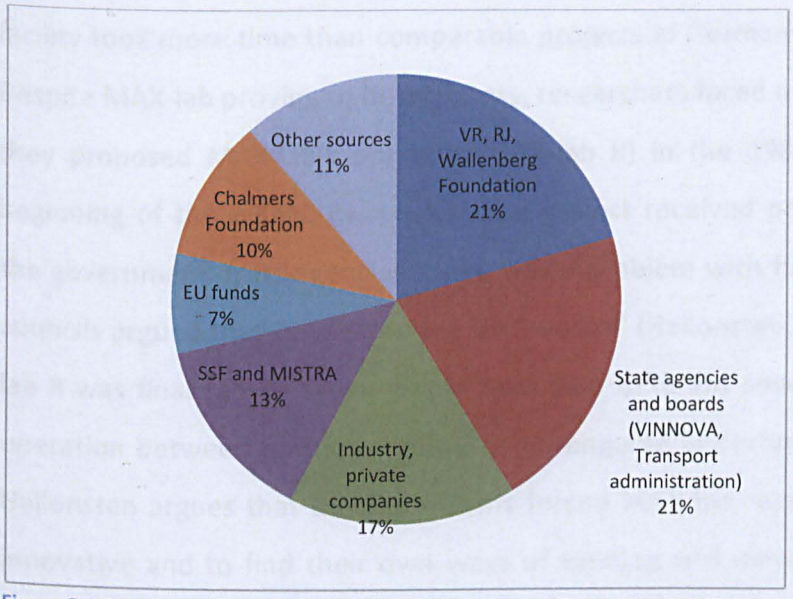


**Figure 3-1 Funders of research at Chalmers University of Technology, 2003**
**Source:** (Granberg & Jacobsson, 2006)

Diversity and fragmentation in research funding has become one of the main challenges in Swedish science policy, often raised by Swedish academics who argue that despite good results (quality of projects, number of publications etc.) the whole of Swedish science is constantly struggling to ensure a stable and long-term funding stream (Lundequist & Waxell, 2010; Vetenskapsrådet, 2004). This problem can be observed especially in focus when studying large-scale projects such as MAX-lab – the first Swedish Storage Ring for Synchrotron Radiation. Located in Lund, MAX-lab is currently one of the world's major physics research laboratories. Hallonsten (2011) suggests that the history of MAX-lab highlights all of the problems inherent in Swedish science – the lack of a centrally-steered research policy, problems with decision making in questions that involve more than one agency or institution, and problems with ensuring long-term funding. The idea of constructing a Swedish synchrotron first arose in the 1970s and became a subject of a lengthy debate amongst Swedish scientists and politicians.

It also revealed the main weakness of Swedish science policy – the lack of any central steering body. As observed by Hallonsten (2011) in the case of a large-scale, long-term project involving significant funding, there was simply nobody who could take the decision. Consequently the construction of this research facility took more time than comparable projects in Germany, China or the USA. Despite MAX-lab proving to be a success, researchers faced many problems when they proposed MAX-lab's upgrade (MAX-lab II) in the 1980s and later in the beginning of the 2000s. Even when the project received political support from the government or its agencies, there was a problem with funding. The research councils argued that it was 'too big for Sweden' (Hallonsten, 2011). Finally MAX-lab II was financed by seven grants from four different sources. The lack of co-operation between funders resulted in an ongoing underfunding of the project. Hallonsten argues that these problems forced MAX-lab researchers to be more innovative and to find their own ways of running and managing their facilities, which on the other hand led, according to Hallonsten, to MAX-lab's success as one of the world's leading research institutions.

The constant organisational changes of the research institutions became a way of Swedish universities to adapt to the new funding reality shaped by the research councils and foundations established in 1990s. Local Centres of Excellence became an important element of the Swedish research landscape, and there are further projects that involve collaboration between university and industry.

### 3.1.2 Nanotechnology

In Sweden, research into nanotechnology started in the 1980s (then as a part of Micronics). Until the mid-1990s the field developed relatively quickly and this development was based on a cooperation of research institutions with industry or the Swedish Defence Research Agency (FOI) (Fogelberg, 2008). However, this process slowed down in the mid-1990s as a result of economic difficulties, changes to Swedish research policy and the globalisation of economy and

industry (Fogelberg, 2008). Until that time, the Swedish companies were cooperating with Swedish research centres in a form of 'social contract' (Fogelberg & Sanden, 2008), but the globalisation process weakened ties, particularly as representatives of the industry did not find nanotechnology a potentially profitable technology. The latter resulted in a shortage of funding for nano-research. As showed earlier, on the example of MAX-lab (Hallonsten, 2011), the organisation of Swedish research funding made it harder to finance large scale projects, and nanotechnology is a demanding research field in terms of resources needed.

In Sweden there is no institution that coordinates funding and research activities in the field. In 2008 the Swedish state allocated ca. £40 million to nano-research, mostly through the Swedish Research Council and VINNOVA (2009). Another institution is the Swedish Chemical Agency (Kemikalieinspektionen), which is focused mostly on risks related to nanotechnology and the safety of nano-products. Despite the significant rise in state funding for nano-research since 2001, resources are still considered insufficient. According to VINNOVA's report (2009) there are twenty state universities and one private university that are involved in nanoscience related research. The most important centre for the nanoscience research is Lund, home of the University of Lund as well as many research institutions or companies focused on nano-applications. Other important nano-research centres include: Uppsala University, Stockholm University, Chalmers University of Technology in Gothenburg, Gothenburg University, Linkoping University and Royal Academy of Technology (KTH). There are about eight independent institutes that are active in the area of nano-research but their activity is much more limited than that in universities (Perez & Sandgren, 2008).

In terms of number of published nanoscience-related papers, Sweden is ranked 19th in the world (Devereaux, Mogoutov, Theoret, & Allard, 2008) with Swedish scientists publishing 8425 papers between 1996 and 2010 (see Figure 3-2).

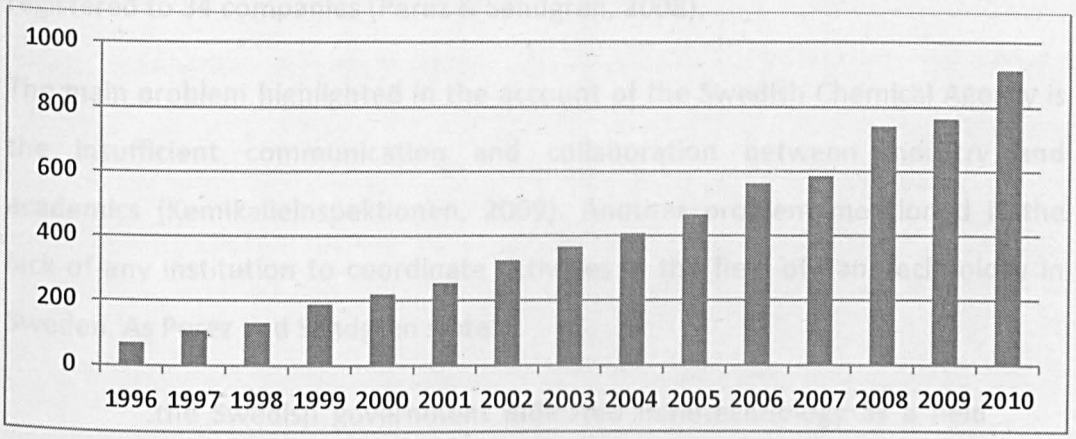


Figure 3-2 Number of Swedish nano-related articles published in ISI journals, 1996-2010
Source: ISI Web of Knowledge, searches conducted on 18th July 2012

The majority of these papers were published under categories such as physics, chemistry, science and technology, biochemistry and molecular biology. According to Perez and Sandgren (2008), six Swedish institutions are among 100 European institutions publishing most papers in the area of nanotechnology.

As is the case with other fields, funding of nanotechnology is diverse. Apart from VINNOVA, nanoscience-based research is given significant support by SSF (ca. £7 million in 2005), VR (ca. £5 million) and the Knut and Alice Wallenberg Foundation (ca. £8 million). EU sources also play an important role in funding research – both within the Framework Programmes (FP6 and FP7) and through structural funds (Swedish-Danish *Nano Øresund* Project)

The Swedish Chemical Agency report (2009) states that the market for nano-products is developing very quickly in Sweden. In 2006 there existed a total of 85 Swedish nano-companies, 34 of which were 'pure' nanotechnology companies with operations built around nanotechnology' and '51 [that] use nanotechnology to a greater or lesser extent to facilitate existing activity' (Perez & Sandgren, 2008, p. 19). These companies were mostly active in such areas as biotechnology,

electronics, instruments, materials and surface engineering. Most of them are concentrated in three areas: Stockholm-Uppsala, Malmo-Lund and Gothenburg. Until 2004 Swedish companies had 133 patents in the nanotechnology field, registered to 34 companies (Perez & Sandgren, 2008).

The main problem highlighted in the account of the Swedish Chemical Agency is the insufficient communication and collaboration between industry and academics (Kemikalieinspektionen, 2009). Another problem mentioned is the lack of any institution to coordinate activities in the field of nanotechnology in Sweden. As Perez and Sandgren state:

> the Swedish government indicated nanotechnology as a field with industrial potential where Sweden was at the forefront. The government also confirmed the field to be of strategic importance in the longer term. At the same time, it was emphasised that the picture of involvement by research and industry within the field is fragmented. Despite this, Sweden does not have a politically approved, nationally coordinated strategy; in fact, proposals that were laid out were rejected in parliament (Perez & Sandgren, 2008, pp. 30–31).

The situation described by Perez and Sandgren translates to a general problem of science policy in Sweden – the lack of a clear structure for decision making and problematic coordination any large scale projects. There are some EU regulations as well as regulations of the Swedish Chemical Agency, but these are limited mostly to the toxicity of materials and according to Perez and Sandgren (2008) are still insufficient (considering the broadness of this field).

Despite the lack of Swedish equivalent to the US National Nanotechnology Initiative, there are some networks that bring together nano-researchers and industrial representatives. The largest one is the Swedish Nano Network ('Svenska Nanonätverk'), which aims to promote nanotechnology and encourage

collaborations and contacts between universities and industry. Another network is The Swedish Micro and Nano Fabrication Network, research-specific network that aims to coordinate use of nano-laboratories at Swedish main universities. Swedish scientists are also active in over 60 international networks, the main one being 'Nano Øresund Project' which aims to coordinate activities in the area of nanotechnology in the Swedish and Danish parts of the Oresund region. There are also some smaller regional nano-networks that gather local universities and some locally based companies, mostly in the Lund area (Perez & Sandgren, 2008).

### 3.1.3 Media

Press freedom has a relatively long history in Sweden that dates back to the 18th Century. There is no state censorship on the content of newspapers (an exception was the time of the World War II). The Swedish Ministry of Culture is responsible for the whole area of media policy (including television, newspapers, radio and internet).

#### *3.1.3.1 Press legislation*

Unlike radio and television, which is a subject of government legislation, the newspaper market is largely self-regulated through journalists' organizations and associations, including the Association of Swedish Journalists (SJF), which established a set of voluntary rules for all journalists. The only state institution that plays an important role in the newspaper market is the Press Subsidies Council (Presstödsnämnden), the governmental agency responsible for distributing the state's subsidy amongst newspapers. Currently ca. 80 daily papers receive this subsidy, worth a total of SEK 435 million (ca. £41 million) in 2009 (Weibull & Jönsson, 2008). Nevertheless, this subsidy represents about 3% of the total newspapers' revenues and is particularly important for smaller individual newspapers.

### 3.1.3.2 Press market

The Press has enjoyed a very strong position in Sweden, with local newspapers having a traditionally important role. According to Weibull and Jonsson (2008) almost 75% of Sweden's adult population read daily newspapers. In terms of ownership most of the Swedish newspapers are owned by Swedish companies. As observed by Weibull and Jönsson (2008), a typical feature is regionally based chains of newspapers.

Table 3-2 Main Swedish daily newspapers

| Newspaper | Type | Circulation |
|---|---|---|
| Dagens Nyheter | National broadsheet | 345,000 |
| Sveska Dagbladet | National broadsheet | 200,000 |
| Aftonbladet | Tabloid | 377,000 |
| Expressen | Tabloid (including local editions in Gothenburg and Malmö | 303,000 |
| Göteborgs Posten | Regional broadsheet (Gothenburg area) | 245,000 |
| Sydsvenskan | Regional broadsheet (Malmö area) | 123,000 |
| Metro | Free daily | 643,000 |

Source: Presstödsnämnden (2009)

Among these newspapers only the national daily broadsheets 'Dagens Nyheter' and 'Svenska Dagbladet' have regular scientific sections. Most Swedish newspapers, including all of the mentioned titles, are accessible through the Internet.

## 3.2 Poland

Until 1989 Poland was a communist country, which had consequences for politics, economy and science. Poland is currently a republic with an elected president and parliament. Since 2004 Poland has been a member of the European Union.

Table 3-3 Poland - basic facts

| | | | |
|---|---|---|---|
| **Population** | 38.5 million | **Literacy** | 99.8% |
| **GDP** | $17,400 | **HDI-rank** | 41 |
| **Educational expenditures (% of GDP)** | 5.5% | **ICTDI-rank** | 49 |

### 3.2.1 Science Policy

Twenty years after the political changes that initiated a democratization process, the country's communist past still affects Polish science and research. Therefore it is necessary to present a short modern history of Polish science policy in order to understand the problems that research in Poland is facing today.

During the communist period (1945-1989) the financing of science and research, like most other activities, was centralized. Government made decisions about research strategy and allocation of funds. There were no non-governmental or private institutions that funded research. Three different institutions were responsible for science and research activities: universities, the Polish Academy of Sciences and industrial research institutes. Universities (as well as polytechnics, agriculture universities etc.) were mainly responsible for teaching at both undergraduate and postgraduate levels, as well as conducting some basic research. An institution that was more focused on research was the Polish Academy of Sciences, which had local divisions around the country. Its employees enjoyed some privileges compared to their colleagues working at universities (e.g. better financial resources and equipment or easier international travels[6]). The main research institutions, attracting about 80% of all research funds, were industrial R&D institutes governed and financed by different governmental agencies, industry or ministries (e.g. the Ministry of Agriculture, the Ministry of Health, or the Ministry of Steel Industry). However, the system was quite inefficient and the cooperation between various research institutions and industry did not work very well. As a result many new developments,

[6] During the communist rule in Poland any international travel needed to be authorised by the Ministry of the Internal Affairs; people were not allowed to keep passports at home.

improvements or patents were not applied by the industry. Karczewski (1993) observes that many Polish researchers and scientists did research only 'for research's sake', very often without considering any practical aspects of their work. Another problem of this system was the fact that money was mostly allocated according to the officials' private interests, usually supporting 'their' institutes, universities or research groups.

The fall of the communist system began in 1989, affecting not only the political system but also the economy and any other areas that were controlled by the state. During the first two years of the socio-economic transition many state-owned companies were closed. Because of the technological difference Polish industry could not compete effectively with the industry of more developed economies. As a result the R&D institutes lost their main partners which, quite often, had been financing their research (through the respective ministry). At the same time the economic situation of the country worsened and science (due to the lack of any private funding bodies) was severely affected by the cuts imposed by the government. Expenditures on R&D fell by 30% between 1989 and 1992 and 22% of researchers lost their jobs.

The first attempt to 'westernize' Polish science was the establishment of the Committee for Scientific Research (KBN), a top-level institution designed to be responsible for all scientific research in the country. Although it was financed by the state and its head was actually a member of the government, it was autonomous. KBN members were scholars from different institutions who elected the head and authorities of KBN. KBN was autonomous in its decisions, including allocation of funds that were divided into six funding streams. Most of the money was invested in the maintenance of the existing institutes. It can be argued that the main strategy at that time was to preserve the existing network and infrastructure which, in 1994, comprised 225 industrial research units, 82 institutes of the Polish Academy of Sciences and 800 groups in higher education

sector until industry would be able to fund the research again. According to various scholars (Acha & Balazs, 1999; Chataway, 1999) the grants given for particular research projects were mostly treated as a side-activity necessary for keeping their institutions alive. One of the most important changes that were introduced with the establishment of KBN was the development of an element of competition between Polish researchers through a grant-based funding system. Decisions about funding were no longer made by bureaucrats or politicians but by the scientific committee that was judging the quality of a particular project.

The reform also introduced the peer-review system and Poland's first attempts to evaluate its science against the wider scientific world. Witold Karczewski (1993), head of KBN between 1991 and 1995, states that the results of these evaluations were a rather 'unpleasant surprise' for many Polish scholars, who were not used to any comparative rankings , refusing to even send their papers or proposals to foreign reviewers. Until 1989 research was funded by the state and in most cases nobody was asked for results. Another important problem was a rather limited knowledge of English among Polish academics. Therefore the new system initially faced a strong resistance from some scholars (Karczewski, 1993).

However, the reforms did not lead to substantial changes, mainly due to the limited funding available. The state was actually the only research financing body in the country. In the 1990s the private sector was still developing and was simply too weak to support research on a scale comparable to the UK or Germany. The industry was unable to invest in research and development and very often the companies were not interested in such activity due to uncertainty about the company's future. Most of the large companies (mostly in such sectors as mining, the steel industry, textiles or machines) were state owned struggling with financial problems that often led to bankruptcy. As a result KBN was financially supporting the industrial research institutes in order to preserve them,

so in the future they could again provide services for industry which would, in turn, finance their activity. In such a way smaller resources could be allocated in research projects (including research grants). However, when giving the grants the committee usually favoured institutions focused on basic science rather than technological applications of research projects. Chataway (1999) relates this to the fact that the committee consisted mostly of university teachers and 'commercialisation is viewed with a great suspicion' (p. 359). As can be seen, it was different from the situation in Sweden, where the research funding became more diverse in the 1990s and a strong emphasis was placed on supporting research projects in the areas of technology (especially in collaboration with industry). Still, the background and ideas behind the Polish reform were quite similar and one could argue that these were based on the US-model. However, due to the socio-economic context in Poland as well as a different academic culture its implementation did not give the results expected.

However, the main problem relating to Polish science policy was the lack of any proper strategy. Arogyaswamy and Kozioł (2005) argue that even when authorities set strategy, it was not followed (even by the government itself). Chataway (1999) also observed that eventual actions or changes were most often introduced on the initiative of a particular institute rather than as a consequence of governmental strategy. Eventual collaboration between researchers and industry (if it occurred at all) was usually as a result of the initiative of scientists, not industry. The dominant strategy was to sustain the *status quo*, with grants as an ancillary activity necessary for maintaining research institutes. Therefore, the first decade after the transition in Polish science has been widely described in the literature as a 'decade of stability' when nothing much changed in the country's science policy and academic activity. According to Jabłecka and Lepori (2009), this lack of reform resulted in stagnation, caused by general economic challenges and academics' uncertainty about the results of any reform.

Acha and Balazs (1999) argue that this situation was characteristic of most Central and Eastern European countries at the time and was caused by scientists, policymakers and politicians who remained anchored in the old system (i.e. the one that existed until 1989) when discussing any changes to science policy.

Many scholars studying Polish science policy refer to politicians, policymakers and researchers as key factors shaping science policy in the country. Between 1989 and 2000 Poland had ten prime ministers and the parliament was split into many parties (29 in 1991) with no party having more than 20% of seats. As argued by the Polish historian Antoni Dudek (2007) this situation resulted in an inability to pass any far-reaching strategy or conduct any reform, not only in the area of science. Secondly, as noted by Jabłecka and Lepori (2009) the lack of any further reforms was related to the fact that there was:

> lack of a clear institutional separation between the design of policy, the allocation of funds and the beneficiaries, meaning that those who benefited from the funding system at the same time controlled the reform process (p. 706).

In the 1990s, because of the financial problems of industrial research institutes, universities started to play more significant role Polish research. After 1990 it was possible to establish private higher education institutions. In the same time the stated-owned universities[7], although not privatised, were given greater autonomy. In 2005 there were 427 higher education institutions in Poland and 301 of them were the private ones (Sojkin, Bartkowiak, & Skuza, 2012). Most of the private universities were focused on teaching undergraduate courses only – usually in subjects such as social sciences, psychology, learning sciences, politics, business and management, not natural sciences. Therefore it can be argued that

[7] Until 1989 all universities, with the exception for the Catholic University and catholic seminars, were state-owned.

the 'higher education boom' (as it is often called in Poland) did not contribute to significant changes in the structure of Polish scientific research.

Major changes came with the introduction in 1997 of the Constitution Law, which triggered changes in the science policy, since it affected the legal status of KBN. Most of the KBN's responsibilities were handed over to the newly created Ministry of Science. KBN remained an advisory body (with some responsibility for research grants) and finally ceased to exist in 2004. This meant that research funding was centralized and was fully controlled by the government. It was similar to the situation in Sweden, where the new government was aiming to recover control over research funding and weaken the role of semi-private foundations.

Since Poland joined the European Union in May 2004 Polish science was given a new source of funding possibilities that were accessible through Framework Programmes and other funding streams, allocated by the Ministry of Science. In 2007 the government established the National Research and Development Centre (NCBIR) whose role was to coordinate funding of the strategic research programmes, set by the government.

Further changes were introduced in 2011 with the reform of the whole science and higher education system, introduced by the liberal government. The main aim of this reform was to decentralise the way science was governed and financed. Therefore almost all funding decisions were given to the NCBIR and the newly created National Science Centre (NCN). The Polish Academy of Science (PAN) is also going to be reorganised and the existing R&D units will be a subject to evaluation; depending on performance, particular institutes will continue to exist, may be reorganised or even closed down. However, the reform and its consequences will not be discussed further in this thesis since the timeline for this research project is January 2004 to December 2009, when science and research was governed according to the former regulations.

The study of the level of investment in research and science in Poland shows a steady growth in allocated resources since the fall of communism in 1989, particularly after accession to the European Union. According to the report of the Ministry of Science and Higher Education research and development activities are still mostly financed by the government (58%). Most Polish researchers (92%) are working in the public sector, since most of the universities and research institute are owned by the state. Despite the growing number of private higher education institutions in Poland only a few of them are focused on any research activities. Among 590 University (or other HE institutions) research units only 22 are parts of five private universities. However, while the number of state R&D institutes has dropped (from 228 in 1999 to 190 in 2006), the number of private companies investing in research has grown (228 in 1995 to 573 in 2006). Business is also responsible for a third of investment Polish science and research.

Despite recent changes and reforms, the position of Polish science is not very strong. Only 1% of papers published in scientific journals are written by Polish scientists and only 0.02% of the most cited papers are Polish ones. Among patents registered in the EU, US and in Japan, just 0.02% are attributable to the Polish researchers. According to Arogyaswamy and Kozioł (2005) there is only one patent per million inhabitants in Poland while in Hungary it is 12, and the average across the European Union is 126. This can be related to the level of government's financial support for science (especially when private investment is still relatively low), since only 0.07% of Polish GDP is allocated in research and development activities. Of these resources 75% is spent on the maintenance of existent institutions and 25% is allocated in grants for new research projects.

Polish scientists are currently mostly active in such science areas as physics, chemistry, mathematics and astrophysics. Less popular areas (in terms of number of published papers) are biology, medicine, humanities and social sciences. In the case of humanities and social sciences Polish scholars are almost exclusively

active in Poland only, with a very limited number of papers published in international journals.

### 3.2.2 Nanotechnology

In Poland, research in the area of nanotechnology started to emerge at the beginning of the 21st century. Since 2004 governmental institutions have begun to stress the importance of nanotechnology, which was considered to be one of the strategic sciences (Mazurkiewicz et al., 2006). In 2006 the Ministry of Science and Higher Education prepared a national strategy for the development of nanotechnology; however it remains unclear whether the objectives have been achieved. As in Sweden, there is no centralised nano-policy or a central institution that would coordinate the research. Most of the research projects were started on a particular scholar's or institution's initiative. While there is no central official institution that would coordinate any activities in the field of nanotechnology, the role of such institution is held (to some extent) by the 'NanoNet' Foundation. It is a non-governmental organisation founded in 2006 to support the development of nano-education, promote nanotechnology, and help establishing links and collaborations between companies and researchers. It also delivers up-to-date information about nanoscience and nano-achievements around the world through the web-portal www.nanonet.pl. However, it is mostly financed (through donations) by private companies with rather limited support from the state institutions and therefore, it does not have the same abilities as for example National Nanotechnology Initiative in the US.

The financial resources allocated in Poland in the nano-area are relatively small (£1.7 million in 2006), especially when compared to other EU-countries (The Netherlands – £37 million, UK – £107 million, Germany – £265 million). However, the amount of money allocated to nano-research has doubled between 2004 and 2006 (Mazurkiewicz et al., 2006). Most research projects are financed directly by the Ministry of Science and Higher Education through different governmental

agencies. Since 2005 some projects have also been financed by the Ministry of Regional Development, which is coordinating the EU-funding processes. Still, recent research shows that more than 40% of Polish research institutions or companies active in nanotechnology do not receive any EU-funding at all.

Research in the area of nanotechnology is carried out in six universities, the Polish Academy of Science (PAN) as well as several independent research laboratories (Mazurkiewicz et al., 2006). The main research centres in this subject are: Warszawa, Poznań, Wrocław, Kraków, Łódź, and Katowice, which are also the biggest academic centres. However, research in this field is also being developed in cities such as Gdańsk, Szczecin, Koszalin, Lublin, Rzeszów, Toruń and Białystok

According to Devereaux et al. (2008) Poland occupies 17$^{th}$ place in the ranking of countries that published most nano-related papers in ISI journals. The searches conducted with the use of the ISI Web of Knowledge shows that Polish scientists have published 7903 papers (category: Science and Technology) between 1996 and 2010 (see Figure 3-3).

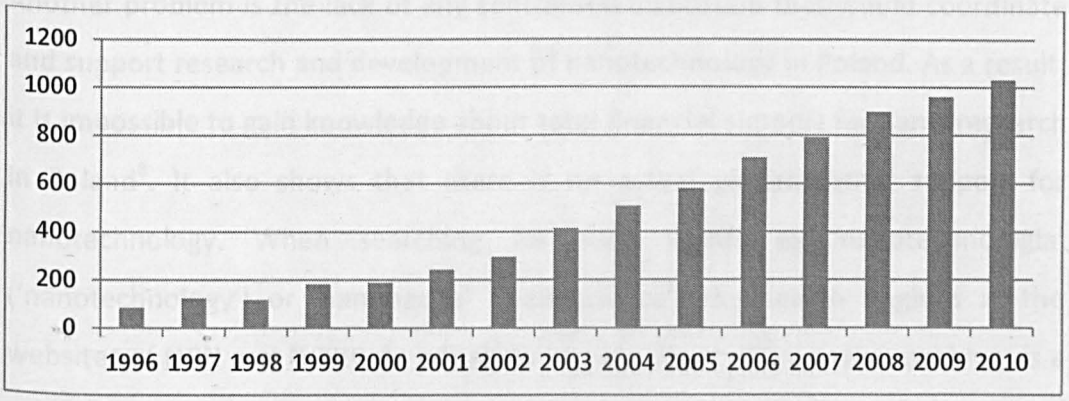


Figure 3-3 Number of Polish nano-related articles published in ISI journals, 1996-2010
Source: ISI Web of Knowledge, searches conducted on 18$^{th}$ July 2012

Although the number of published papers is growing, it is lower than in other EU countries or US. Most of the papers are related to subjects such as Physics, Material Sciences, Chemistry, Engineering, Optics, and Metallurgy.

There are 70 Polish companies that are active in the area of nanotechnology, although most of them mainly import technical solutions from other countries (Grabiec, Kuźmicz, & Napieralski, 2009a). Polish companies that are trying to implement nanotechnology in their production are mostly focused on electronics, chemistry, cosmetics and textiles. As in the case of other research areas, private companies' activity in the field of nanotechnology is still limited (especially when comparing to other EU countries). In 2006 there were only three nano-research projects financed by the industry (Mazurkiewicz et al., 2006).

However, Polish nanotechnology faces the same problems as Polish science in general. The first one is the financial limitations. Secondly, there is still a lack of sufficient number of good quality equipment. These two problems are being gradually addressed (or at least are 'partially solved') through the changes in the level of financing of nano-research, especially through the programmes co-financed from the EU resources (e.g. 7th Framework Programme). New, fully equipped nano-laboratories have been constructed in Szczecin, Gdansk, Lodz, Rzeszow, Warszawa and Lublin.

Another problem is the lack of any centralised institution that would coordinate and support research and development of nanotechnology in Poland. As a result, it is impossible to gain knowledge about total financial support for nano-research in Poland[8]. It also shows that there is no actual governmental support for nanotechnology. When searching for such words as 'nanotechnologia' ('nanotechnology') or 'nanonauka' ('nanoscience') the search engines at the websites of NCN and NCBIR do not show any results at all[9]. Another problem is a

[8] The Ministry of Science and Higher Education was unable to provide information about funding allocated in the area of nanotechnology, according to the email I received from Mr Bogdan Szkup from the Ministry for Science and Higher Education (Departament Instrumentów Polityki Naukowej) on 14th July 2011.

[9] Searches have been conducted on 10th August 2012

result of the lack of specific nano-policies and the very limited collaboration between industry and research centres (Grabiec, Kuźmicz, & Napieralski, 2009b).

### 3.2.3 Media

Since the fall of communism in 1989 the free press market has been developing rapidly in Poland. It consists of both new titles established by private publishers in the 1990s and state-owned newspapers and magazines that have been privatised. Since April 1990 there is no central institution controlling press content (censorship). The Polish constitution, adopted in 1997, guarantees freedom of the press, prohibits any preventive censorship and forbids any licensing requirements for the press (as in the case of the radio and television).

#### *3.2.3.1 Press legislation*

The press market is regulated by the Press Law introduced in 1984. After the political changes in 1984 some parts of it were changed but it is still criticised by many journalists as unsuitable to the current political system (Sadurski, 1996).

As in Sweden, there is no regulatory body overseeing the press market, although most of the newspapers and magazines are part of the Polish Association of Publishers (Polska Izba Wydawców) and Press Distribution Controlling Association (Związek Kontroli Dystrybucji Prasy). There are three journalists' professional associations in Poland and the Media Ethics Council that comments on any controversial situations related to journalists' activity.

#### *3.2.3.2 Press market*

The Polish press, especially daily broadsheets and opinion weeklies, plays an important role in public debates. According to a survey conducted in 2009 around 80% of Poles read newspapers (Lara, 2008). The main Polish daily newspapers are presented in Table 3-4.

Table 3-4 The main daily newspapers in Poland

| Newspaper | Type | Circulation |
|---|---|---|
| Gazeta Wyborcza | National broadsheet | 300,000 |
| Rzeczpospolita | National broadsheet | 117,000 |
| Fakt | Tabloid | 400,000 |
| Super Express | Tabloid | 183,000 |
| Dziennik Gazeta Prawna | National broadsheet | 85,000 |
| Nasz Dziennik | National broadsheet | 150,000* |
| Metro | Free daily | 375,000 |
| Echo Miasta | Free daily | 305,000 |

Source: ZKDP (2009) (* excluding 'Nasz Dziennik', which provides the circulation numbers on its webpage)

In some areas, especially around large cities such as Kraków, Gdańsk or Poznań, the local dailies are also very popular, but their role and circulation is smaller than in Sweden.

According to Lara (2008), who studied the media in post-communist Poland, most of the Polish press is owned by foreign companies. Despite this, all of the newspapers and magazines mentioned in the Table 3-4 belong to various Polish publishers. The only exceptions are 'Fakt' and 'Dziennik Gazeta Prawna' that are owned by German company Axel Springer. Until February 2011 the daily broadsheet 'Rzeczpospolita' was partially owned by the state (49%) and controlled by British company 'Mecom'.

Among the daily newspapers only 'Gazeta Wyborcza' and 'Rzeczpospolita' contain a regular scientific section. All of the mentioned newspapers and magazines are currently accessible online.

## 3.3 Iran

Until 1979 Iran was a monarchy with almost absolute rule of the shah and his supporting party. After the Islamic Revolution, Iran became a theocracy with the Supreme Leader as a head of state, who has large influence on the legislative

process as well as on most of the decisions made by the government or parliament. He also has control (or at least strong influence) over the Assembly of Experts and the Guardians Council – two main ruling and legislative bodies in Iranian politics. In that context, the roles of the elected president and the parliament are rather limited. The Islamic Republic of Iran is accused by many governments for the violation of human rights, censorship, elections falsification, and prosecution of the political opponents.

Table 3-5 Iran - basic facts

| | | | |
|---|---|---|---|
| **Population** | 66,4 million | **Literacy** | 77% |
| **GDP** | $12,800 | **HDI** | 88 |
| **Educational expenditures (% of GDP)** | 5.1% | **ICTDI** | 114 |

### 3.3.1 Science Policy

> Iranians have a positive attitude towards science, so there is no major cultural barrier to the evolution of S&T. Scientific advances are easily accepted within the religious and political spheres. Yet, despite this positive attitude, science is neither an important part of economic life, nor considered an intellectual right (Ashtarian, 2010, p. 349).

Although through the ages Iranian scientists, such as Avicenna (ca. 980–1037), have contributed significantly to the development of the world's knowledge (which is often highlighted by the official Iranian propaganda), modern Iranian research institutions are relatively young. The first Iranian university, the University of Tehran, was established in 1928. In total almost 30 higher education institutions were created in Iran in 1979 (Mehrdad, Heydari, Sarbolouki, & Etemad, 2004). Because of the close US-Iranian relations (between 1940s and 1970s) all new universities were modelled on the American universities and very often in close co-operation with the US-institutions (Koenig, 2000). The outbreak of the Islamic Revolution (1978-79) and the war with Iraq (1980-1988) affected negatively the development of Iranian higher education and research facilities.

Between 1978 and 1984, the number of scientific papers published by Iranian scientists (i.e. working at Iranian universities) fell by 80% and original levels of publications (i.e. from 1978) were only reached again in 1997 (Moin, Mahmoudi, & Rezaei, 2005).

In the same way as economy or education, science policy has been subject to central planning that became a significant element of the policy and decision making process in Iran, both before and after the Revolution (as in Poland). However, it is not only the government that have the ultimate and exclusive power to set goals in such areas as science policy. New goals and strategies can also be set by the Supreme Leader who is the head of state, who has political and religious authority and has more influence than the President of Iran.

As pointed out by Koenig, 'although Islamic revolutionary leaders backed higher education, their emphasis was on mass education rather than 'elitist' research' (Koenig, 2000, p. 1485). There were ca. 30 higher education institutions in Iran in 1978 (Mehrdad et al., 2004). Today approximately three million students are studying at over 100 state Iranian universities (42 of them are medical universities) and almost 300 private universities. It is worth mentioning that over 60% of the students are women (Ashtarian, 2010).

The religion-based law, politics and ideological issues were additional elements that affected the development of Iranian science after the Islamic Revolution. The political tensions with some Western countries, led to the international isolation of the country, not only in terms of diplomacy and economy, but also in the area of science. The once strong relationships with US universities ceased to exist. Religious regulations led to many changes in academia and science policy. One of Iranian physicists stated that 'back then, people talked about 'Islamic physics' and 'Islamic science'. It took a long time for them to understand that physics is physics and science is science' (Koenig, 2000, p. 1484).

The situation started to change in the 1990s, especially after the presidential election in 1997 won by Mohammad Khatami (considered to be a reformist). The new policy included a rise in public expenditures on research – from 0.55% of GDP in 1999 to 0.67% in 2007 and an opening towards Western scientists and research institutions. Iranian scientists started to collaborate with foreign scientists especially from state-members of the Organization of Islamic Countries (Ashtarian, 2010). Despite the lack of diplomatic relations, the number of collaborative US-Iranian scientific papers rose from 388 in 1996 to 1831 in 2008 (Coghlan, 2011). In November 2000 the first (after Islamic Revolution) official delegation of US scientists visited Iran, although this fact was not mentioned at all in the Iranian media (Koenig, 2000).

One of the results of the new approach towards science introduced by president Khatami (1997-2008), and to some extent continued by his successor Mohammad Ahmadinezhad, was a steadily rising number of Iranian patents and scientific papers published by Iranian scientists. According to a UNESCO Science Report written by Kioomars Ashtarian (2010), the number of Iranian scientific articles rose by 123% between 1995 and 2005. Iranian scientists publish now more papers each year than the researchers from such countries as Pakistan, Malaysia or South Africa. As will be seen in the example of nanotechnology the number of published papers became one of the main fields of comparison with other countries and a showcase of national pride. An example of this attitude is a paper by Mehrdad et al. (2004), where the authors claim that that 'Iran which ranks 4$^{th}$ among the Islamic countries in terms of publication output, seems to outperform the advanced industrialized nations!' (p. 83).

Nevertheless, Iranian science is still struggling with the same problems as during the first fifteen years of the Islamic Republic, namely central planning, which not only ignores many socio-economic aspects but is also time-consuming (Ashtarian, 2010). The 'grand policies' (such as the ten-year nanotechnology plan) are

developed by the Expediency Council, which submit them to the Supreme Leader, who communicates it later on to the parliament or government. The goals of these plans are to be achieved through the development of additional 'action plans' or 'policy packages' (Ashtarian, 2010). In case of S&T development, each branch is supervised by a separate executive council. Since 2000 such councils have been established in the fields of nanotechnology (discussed in the later part of this chapter), biotechnology, fuel cell technology, animal cloning, as well as information and communication technologies (Ashtarian, 2010). The areas of responsibility of these councils frequently overlap with existing institutions.

Apart from bureaucracy, the main problem of the science and technology development in Iran is the fact that goals and priorities on the science agenda are set independently by politicians, administration officials or academics, without considering the socio-economic context or without broader cooperation with other Iranian research institutions and industry (Ashtarian, 2010). At the same time over 74% of resources allocated in research come from the government, 14% from the business sector (including industry), and 11% higher education sector (Ashtarian, 2010). However, the main Iranian universities are state-owned and over 60% of industry is controlled (in some way) by the state. Therefore, it can be argued that the state has a monopoly in the field of research funding. An extreme example of politicians' influence over science are promises of promotion to scientists who submit papers to journals indexed by the Islamic World Citation Database (Ashtarian, 2010).

Despite the country's openness during the Khatami's presidency, the collaboration between Western and Iranian scientists is still very limited. Iran became subject of several economic sanctions and embargos on import of various products. According to Mehrdad et al. (2004) it is related not only to radio-labelled compounds but even subscriptions of many popular science

journals published in the US. The sanctions became more severe during the presidency of Mohammad Ahmadinezhad (from 2005), who supports the development of the Iranian nuclear programme. Since the very beginning of the Islamic Republic, Iran's answer to the sanctions and international isolation has been the call for country's 'independence' and 'self-sufficiency'. Instead of importing technologies from abroad, Iran aims to develop its own technologies that should give the country a full independence from foreign suppliers. Therefore, higher education and (later) research became important element of government's strategies and policies. However, these policies, combined with the bureaucracy, resulted in a rather chaotic structure of research funding and innovation policy. Science policymaking is executed and coordinated by dozens of ministries, institutions or state agencies, which results also in complicated, very often overlapping, legislation (Ashtarian, 2010). Additionally, the idea of relying mostly on the country's own resources (human, economical, technological etc.) results in situations where Iranian scientists are re-inventing devices or technologies that have already been invented, patented and implemented in other countries. Another issue is the lack of legal regulation of patent and intellectual property protection, which complicates collaboration between Iranian and foreign scientists.

As in many countries, a huge problem faced by Iranian science is the lack of sufficient financial resources. This is a result of many issues – economic sanctions, limited involvement of private companies and the centralisation of research policy lead by the politicians. The funding is often allocated in the selected institutions while other units (in the same research field) suffer from the lack of necessary equipment (Koenig, 2000), which is quite similar to the situation in Poland during the communist regime.

Nevertheless, successes of Iranian scientists are always highlighted in the Iranian media. The two most often indicators that politicians and journalists are referring

to when measuring the scale of this success are the number of universities or the number of students enrolled each year. However, high numbers do not translate into a higher position of this institution. Although the popular 'university rankings' cannot be treated as wholly representative (e.g. the very often questionable methodology), it is worth mentioning that the only Iranian universities listed by these rankings are the University of Tehran (301-400 rank Academic Ranking of World Universities 2011; 501-550 rank in the QS World University Ranking 2011) and Sharif University of Technology (601+ rank in the QS World University Ranking 2011). At the same time, the Iranian economy has been found unable to absorb so many graduates. The Iranian media and authorities are also focused on the number of published scientific papers, which has risen considerably since mid-1990s. However, a careful study of ISI Web of Knowledge database shows that most of these papers are published in journals with a low impact factor and many of them are rarely cited.

### 3.3.2 Nanotechnology

The development of nanotechnology is a typical example of Iranian science policy. According to Ghazinoory et al. (2009):

> The current focus on nanotechnology in Iran started in 2001 with a letter from an Iranian scientist (resident in America) to former Iranian president Khatami[10]. In that letter the scientist emphasized the importance of nanotechnology to Iran's future. President Khatami turned over the letter to the Technology Cooperation Office (TGO) which labelled nanotechnology as critical (p. 245).

Over the next two years this question was a subject of studies and analyses. Following the government's and Supreme Leader's acceptance, a strategic 10-

[10] Mohammad Khatami was Iranian president between 1997 and 2005

year plan for nanotechnology development was approved. The Iranian Nanotechnology Initiative Council (INIC) was established in 2003 and it works under the direct supervision of the President of the Islamic Republic. Initially a £12million budget was set for the development of nano-research with an additional £8 million for the support of new nano-companies (Farshchi et al., 2011). INIC is responsible for the promotion of nanotechnology (including education), development of infrastructure, preparation and introduction of new strategies and policies in the area of nanotechnology as well as coordination and supervision of Iranian nano-research (Iranian Nanotechnology Initiative Council, 2012).

INIC hosts a nano-related website (www.nano.ir) and issues a monthly magazine NANO@IR in Persian (monthly) and English (quarterly), that aims to popularize nanotechnology as well as inform about the councils achievements in that field. The website is supposed to deliver information on issues related to nanotechnology (both in Iran and abroad), as well as to foster networking between the Iranian and foreign nano-scientists.

INIC, university researchers and politicians are focused on Iran's position in nanotechnology among other countries. According to some authors (Ahmadvand, 2009; Farshchi et al., 2011) considering the development of the research on nanotechnology in the end of 2000's Iran was ranked as 15 in the world and first among Muslim countries. This position is usually measured by the number of published papers or university students in the field of nanotechnology. According to Figure 3-4 there has been a considerable growth in published nano-related papers, especially after 2003 (when the INIC has been established).

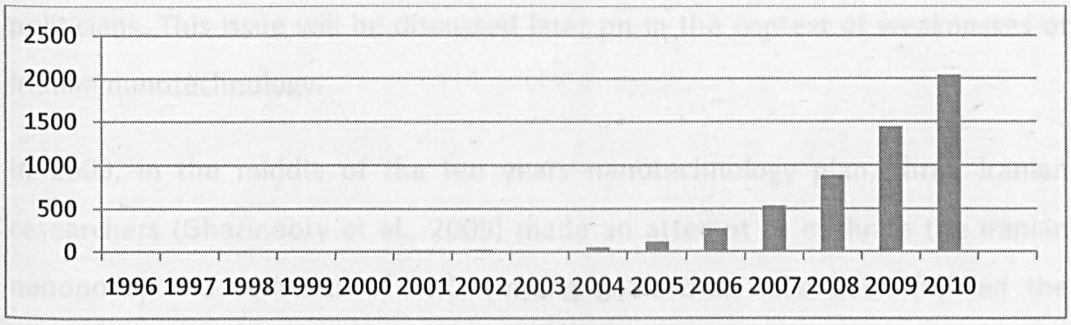


Figure 3-4 Number of Iranian nano-related articles published in ISI journals, 1996-2010
Source: ISI Web of Knowledge, searches conducted on 18th July 2012

The rise in the number of students and researchers in the field of nanotechnology was another goal set by the INIC. In 2009 there were 153 students that started PhD or MSc courses in nanotechnology (Ahmadvand, 2009). According to Farshchi et al. (2011) there are over 7300 Iranian nano-scientists working at 144 faculties or research centres within 58 Iranian universities. The main and one that is considered to be the most prestigious research centre is the Institute for Nanoscience and Nanotechnology at Sharif University in Tehran. INIC provides also nano-related courses for high school students and organizes educational campaigns directed to the common public and children. Iranian nano-researchers are mostly active in the areas of materials science, physics, chemistry, polymer science, biochemistry, pharmacology, instrumentation, metallurgy and spectroscopy. There are 33 'exclusive nano-labs' supervised by INIC and 30 nano-products that are already produced in Iran (Farshchi et al., 2011). In terms of patent registration, Iran occupies 27th place in the world.

According to nanowerk.org (an online nanotechnology portal) there are currently eight Iranian companies that deliver nano-products to the market. Among Iranian nano-products there are medicines, fertilizers, filters, water treatment technologies, nanofibres, as well as nanotechnology instruments. In 2006 researchers from the Research Centre for Sciences and Technology in Medicine finished their work on first Iranian-designed Scanning Tunnelling Microscope (STM), which is now produced and sold on the market. This is an example of the mentioned 'self-sufficiency' that is often highlighted by Iranian media and

politicians. This issue will be discussed later on in the context of weaknesses of Iranian nanotechnology.

In 2009, in the middle of the ten years nanotechnology plan, three Iranian researchers (Ghazinoory et al., 2009) made an attempt to evaluate the Iranian nanopolicy and activities of INIC. Among goals that have been fulfilled the authors mention the introduction of masters and doctoral programmes in nanotechnology, establishing the national network of nano-laboratories, the growing number of publications, and the rising public awareness about nanotechnology (Ghazinoory et al., 2009). However, there were areas where INIC failed to achieve its goals, e.g. lack of coordination of actions undertaken by various actors, limited collaboration, lack of relevant legislation and regulation, low number of patents, no discussion around ELSI (Aala, Larijani, & Zahedi, 2008; Ghazinoory & Ghazinouri, 2009).

Authors of this analysis argue that INIC failed to inform the society about the risks/benefits of nanotechnology but in the same time state that one of INIC's successes was 'rising public awareness about nanotechnology' (Ghazinoory et al., 2009, p. 246). The study conducted by Farshchi (2011) suggests that public awareness of nanotechnology is rather limited. According to his study, almost 80% of Iranians have heard very little or nothing about nanotechnology. Interestingly the author observed that most of the questioned persons believed in positive effects of nanotechnology and its development (Farshchi et al., 2011). It must be stressed that this survey was conducted in Tehran, so knowledge about nanotechnology in the smaller Iranian cities or countryside remains unknown. Nevertheless, the results suggest that the level of awareness of nanotechnology among the public is definitely lower than among Swedish or Polish citizens.

Gahzinoory et al. (2009) suggest two main reasons for the problems related to the development of Iranian nanotechnology. The first one is related to the fact

that this program was developed in a similar way to other Iranian development programs, i.e. it was a subject of central planning. At the stage of planning and designing country's nano-strategy, the policy makers were aware of the weaknesses of earlier development plans (e.g. in the area of biotechnology) and made attempts to avoid some of the mistakes. However, during the process of implementation these failures and mistakes have been very often repeated and as a result many goals of INIC have never been accomplished. This was often caused by the lack of sufficient funding. This leads to the second element that affects negatively the development of Iranian nanotechnology – political changes in the country in the mid-2000s.

In August 2005 Mohammad Ahmadinezhad became the president of the Islamic Republic of Iran, succeeding Mohammad Khatami, who, as mentioned before, was personally involved in the development of Iranian nanotechnology. According to Ghazinoory et al. (2009), the new president and his government paid less attention to this project, which resulted in a declining support for nanotechnology. Ahmadinezhad's open support for the development of the nuclear energy in Iran, its foreign policy and often controversial utterances, lead to the country's increasing isolation and new sanctions that have been imposed by many Western countries (especially US and EU-members). The isolations and sanctions affect negatively the development of Iranian nano-research. Another significant problem of Iranian nanotechnology as well as the whole Iranian science is the migration of researchers to the universities and industry in developed countries. The Iranian private sector is actually non-active in the area of nano-research, which is financed in 96% by the government through the Ministry of Science, Research and Technology. At the same time most of the companies that are active in this field are state-owned or in some way controlled by the state.

### 3.3.3 Media

> Iran is one of the few countries that maintain a very specific and distinct cultural and media policy. The source of such a policy is the constitution of the Islamic Republic of Iran (Malek & Rad, 1994, p. 93)

The Iranian politicians and religious authorities have a significant influence over the media market in Islamic Republic of Iran. According to the constitution the radio and television broadcasting must be state-owned (Dehghan, 2009; Malek & Rad, 1994) and at the same time it is forbidden to use satellite antennas that would allow watching foreign TV-programmes. Although the Iranian law accepts the existence of privately owned newspapers, they are subject of government's censorship (as well as the state-owned media). Censorship affects mostly such topics as politics, religion, women's rights (specially the way they are perceived in Europe or US), materials considered as pornography and all elements that 'insults Islam'. The institution responsible for the control over media is the Ministry of Culture and Islamic Guidance (www.press.gov.ir), which also controls the Islamic Republic News Agency (www.irna.ir). However, it needs to be stated that censorship and state control of media were also present during the times of Pahlavi dynasty (1925-1979). The time of the system transition (1979-1980) was a short period of a relative press-freedom (Malek & Rad, 1994).

#### *3.3.3.1 Press legislation*

Like radio and television, the four main Iranian newspapers ('Kayhan', 'Ettela'at', 'Hamshahri' and 'Iran') are state owned (Dehghan, 2009). As mentioned above, Iranian law allows existence of privately-owned newspapers but the Ministry of Culture and Islamic Guidance has right to close down any newspaper at any moment. During the first three years of the presidency of the pro-reformist Mohammad Khatami (1997-2005) there was a significant rise in the number of published newspapers, which resulted in a situation when 'the press in Iran was by far the freest and most dynamic in the entire Middle East, with the exception

of Israel and perhaps of Lebanon' (Tarock, 2001, p. 600). However, since many of these newspapers were critical towards the political system of the Islamic Republic, the Supreme Leader had initiated in 2000 a long-lasting action against the independent press, which resulted in a closure of most of these newspapers (called 'enemies of the Islamic Republic' (Tarock, 2001, p. 586)). Until recently a common practice was regular closure of private newspapers that were usually reopened after a while under a new title (Giełżyński, 2001). The situation of the privately owned newspapers is also worse since the state-owned ones receive significant state's financial and technical support (Dehghan, 2009). The Association of Iranian Journalists was dissolved by the Ministry of Culture and Religious Guidance in 2008 and there is currently no independent (and legal) professional body that Iranian journalists could join. Dehghan (2009) argues that recent surveys show that restrictions to press-freedom are main issues that affect negatively the satisfaction and motivation of Iranian journalists.

#### *3.3.3.2 Press market*

As previously stated, the press market is dominated by four daily broadsheets: 'Kayhan', 'Hamshahri', 'Ettela'at' and 'Iran'. Information about the number of newspapers and periodicals published currently in Iran was unavailable, but appropriate emails have been sent to the Ministry of Culture and Islamic Governance. The list of the main Iranian dailies can be found in Table 3-6.

Table 3-6 The main daily newspapers in Iran

| Newspaper | Type | Circulation |
|---|---|---|
| Iran ایران | Nationwide | N/A |
| Hamshahri همشهری 'Citizen' | currently distributed only in the area of Teheran[11] | 400,000 |
| Ettela'at اطلاعت 'Information' | Nationwide | 500,000* |
| Kayhan کیهان 'Globe' | Nationwide | 400,000* |
| Resalat رسالت 'Mission/Prophecy' | Nationwide | N/A |

*-Source: Malek and Rad (1994), Abrahamian (2008)

[11] During my stay in Iran in Autumn 2010 I was still able to purchase 'Hamshahri' in other cities than Tehran, such as Ahvaz, Hamadan, Esfahan and Yazd.

In most cases, the information about circulation was unavailable at the time of writing, but I have sent emails to the editors asking about that data. All of the presented newspapers are state-owned. It needs to be stated that although most of these newspapers have nationwide circulation, these are often unavailable in the countryside. The main source of information for ca. 80% Iranian citizens is state-owned television and radio (Freedom House, 2011). In his study of the Iranian media Mohammad Rawan (2001) argues that outside the big cities the 'modern mass-media cannot replace the traditional media, mosque, and *minbar*'[12] (p. 192). However, it remains unclear what consequences it may have for science communication, since Rawan's study was focused on communicating political, religious and socio-economic issues. All five newspapers can be accessed through the Internet. 'Hamshahri', 'Iran' and 'Resalat' contain separate scientific sections.

## 3.4 Summary

The aim of this chapter was to provide background of the media debate about nanotechnology in Sweden, Poland and Iran. It discussed the characteristics of science policy, media market and the stage of the development of nanotechnology in each of these countries. It is possible to point out main characteristics and differences between the studied countries through reference to these three sections. Knowledge about these differences will contribute to the understanding of the cross-national differences. Each of these three countries is at a different stage of development - Sweden is a developed country; Iran is a developing country; and Poland, as a new member of EU, is situated between these two countries. In terms of socio-political systems, Sweden is on one side of the scale as a democratic country with almost 200-year' long history of development of democracy and civil society, while on the other side is the Islamic Republic of Iran, which is a country with very limited democracy and the (in

[12] *Minbar* is the place (pulpit) in the mosque were imam/prayer leader sits and lectures

reality) absolute power of the Supreme Leader. Poland can be located between Sweden and Iran. As a member state of the European Union Poland is a democratic country but the democracy in Poland is relatively young and civil society is still being developed.

Science policy reflects, to some extent, the political differences, which has been discussed in this chapter. Swedish research institutions and scientists are to a large extent independent from the government and are given freedom in choosing research priorities, strategies or collaboration partners[13]. There is a wide range of funding bodies - private and public. At the same time this freedom and limited government's involvement result in the lack of any central state institution that would coordinate larger scientific projects, including nanotechnology development. On the other hand, Iranian research is subject to state control and central planning. Government controls all activities, collaborations and (as the only funding body) decides about research priorities (grand policies). Researchers and research institutions' autonomy is extremely limited. Unlike Sweden, where NGOs and various activists participate in the debates around science and technology issues, such groups or organizations cannot exist in Iran without authorities' approval - all existing organizations are controlled by the state. Again, Poland can be located in-between these two countries. The law guarantees scientists the autonomy regarding the choice of research priorities, collaborations etc. In the same way as in Sweden, there is a lack of institutions that would coordinate research in particular areas (including nanotechnology), since research is perceived as scientists' area, not government's. However, this approach has a relatively short history in Poland - until 1989 it was the government that made all decisions regarding research priorities or funding. There was also a lack of any non-governmental funding agencies or interest groups that would support the development of some

[13] Of course, the choice is very often affected by the policy of funding bodies.

research areas. Although the democratization process after 1989 led to the greater autonomy of researchers it did not change the Polish science as expected. Because of economic problems, industry or private funding bodies are not able to finance larger research projects. Research institutions are depending on state's support (including EU-funding) and therefore, the state remains the main research funding body in the country. However, despite that, the government is not able to enforce directly any research-strategies, due to research institutions' autonomy.

The development of nanotechnology can be easily related to the above observations. In Iran, nano-research is coordinated by the Iranian Nanotechnology Initiative Council that was established as a part of governments' nano-'grand policy'. Poland and Sweden lack any such central institution. What distinguishes Poland from Sweden is the fact that the Polish government is responsible for most of the nano-research funding. In Sweden, the structure of funding is more diverse, with strong positions of private and semi-private institutions. In terms of nano-research, Sweden seems to be the most developed country amongst the three, with MAX-lab as an example of large, world-class research facility. Research in Poland and Iran is still being developed (e.g. construction of new nano-labs in Poland). Iranian nano-research is also affected negatively by current political tensions and sanctions introduced by many Western countries. This complicates the development of nano-scientific research in Iran. An attempt to solve this problem is the idea of Iran's self-sufficiency, with the construction of Iranian own STM as a typical example of this policy. However, it leads to the situation when many efforts (involving significant financial and human resources) are made to re-invent devices or technologies that are already available on the global market.

The studied countries are also different in terms of media policy and media market. An extreme example is the Islamic Republic of Iran, where the media

market is controlled and mostly owned by state. All large newspapers are state-owned and their content is the subject of censorship. There is no state-censorship in the case of Swedish or Polish media and the press is mostly owned by private companies. A characteristic feature of the Swedish press is the strong position of regional newspapers. In Poland, despite the high number of regional and local newspapers, their position is usually weaker than the national newspapers (with a few exceptions). The Iranian press market is dominated by national broadsheets. However, it needs to be stressed that unlike Poland and Sweden, these newspapers are distributed mostly in the capital-area and around bigger cities.

The differences summarized above provide additional justification for studying nanotechnology debates in these three countries. As mentioned in chapter two, most former studies were focused on Western-countries, especially English-speaking ones. Authors of former studies have shown the significant differences between the coverage and public perception of nanotechnology in (for example) US, Canada and UK. This chapter has pointed out some differences between Swedish, Iranian and Polish socio-political systems, science policies, technology development and media markets. It could be assumed that these differences may translate into country-specific characteristics of the coverage of emerging technologies (e.g. nanotechnology) and their understanding may be significant for future science communication activities in particular country or on a cross-national level.

The data presented in this chapter, especially the information on the press-market in each country, will be used as a justification for various methodological decisions discussed in the next chapter. This also provides a background for the discussion of the results and final conclusions.

# 4 METHODS AND DATA

The study of the media debate about nanotechnology in the Polish, Swedish and Iranian press has been conducted using qualitative content analysis and metaphor analysis. This chapter will critically discuss these two methods, as well as the rationale of their choice for the purpose of this project. Aspects related to study design and sampling will be also covered in this chapter.

As mentioned in chapter two, most studies dealing with media coverage of nanotechnology are based on a qualitative research design, in line with much of previous research into biotechnology, for example. It can be observed (e.g. through the description of the research process), that most of the former studies in the area used some version or other of qualitative content analysis or a method that can be located 'on-the-edge' of content analysis and some other qualitative (or quantitative) approach (Anderson et al., 2005; Arias, 2004; Arnaldi, 2008; Gorss & Lewenstein, 2005; Grobe et al., 2005).

The application of the similar approach will allow positioning this research among other high quality studies and will allow comparison of differences in the coverage of nanotechnology in particular countries. It will also strengthen the validity and reliability of this research project. Finally, qualitative content analysis has been chosen, since it was most suitable for the purposes of this study and for answering the posed research questions

Qualitative content analysis will be complemented by metaphor analysis. In contrast to qualitative content analysis, this approach has not been widely used before for studies of media debates about nanotechnology but it has been used in studies of press coverage of biotechnology or GM-food and was proven because it enables the researcher to reveal latent aspects of science communication.

## 4.1 Content Analysis

Content Analysis is an approach that allows a systematic text analysis that quantifies information and various aspects of textual data giving statistical information about emergence of particular coded features. Krippendorff states that 'content analysis is a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use' (Krippendorff, 2004, p. 18). This method has been widely used in studies of media, propaganda, documents and any other kind of texts. Studies of newspapers' content, using content analysis, were developed on a large scale in the 20th century and flourished together with the development of computer software that allowed a fast and relatively cheap way of analysing large amounts of text.

According to Weber (1990), content analysis can be applied to: reveal international differences in communication content, detect the existence of propaganda, reflect cultural patterns of particular societies, or describe trends in communication content. Berger points out that 'content analyses are most valuable when they have either a historical perspective or a comparative perspective – or both perspectives' (A. A. Berger, 2000, p. 177). Other advantages of this method are its transparency (i.e. a coding scheme that allows eventual replication), flexibility and ease of use. Content analysis, in contrast to other social science research methods, is an unobtrusive method that does not involve personal interactions between researcher and participant, i.e. the subject of the research is not aware of it and cannot react, answer or make a comment.

However, this unobtrusiveness results in some limitations of content analysis. Unlike other qualitative research methods, such as interviews, focus groups or participant observation, it is not possible to gain more in-depth knowledge that goes beyond the written text. Despite this critique of content analysis, it needs to be stated that the research purpose of this research project is the study of the

newspaper articles only. Such aspects as journalists, scientists or readers opinions on questions of public perception of nanotechnology or science communication, although considered in some studies on media debates on nanotechnology are not the subject of this study. This approach, i.e. focus on texts only, is a common feature of much of the analysis of media coverage of nanotechnology to date. Understanding the nano-media landscape in hitherto unknown countries may enable future researchers to carry out studies using a variety of methods other than content analysis.

Alan Bryman (2004) points out such weaknesses as authenticity, credibility and representativeness of the studied documents, problems with interpretation of the text by coders. Most of these arguments refer to such aspects as sampling and coding, which will be discussed later in this chapter.

Other critiques were related to the quantitative character of the method and the fact that content analysis fails to answer 'why'-questions, which is related to the quantitative character of content analysis (Bryman, 2004; Hansen, Cottle, Negrine, & Newbold, 1998). This leads us to the discussion on the distinction between quantitative and qualitative content analysis.

### 4.1.1 Qualitative content analysis

As observed by Hsieh and Shannon (2005), content analysis was initially used by researchers as either a qualitative or quantitative method and the quantitative approach, i.e. consideration of content analysis as a purely quantitative method, started to dominate in the second half of 20$^{th}$ century. Even today, authors of Research Methods handbooks (Bryman, 2004; Gomm, 2008; Hansen et al., 1998) locate content analysis usually in chapters dedicated to quantitative methods. Hansen et al. (1998) state even that 'content analysis is by definition a quantitative method' (p. 95). The analysis of a text using such a quantitative approach consists of categorizing the content of the text according to the set coding scheme (coding into variables) and analysis using statistical tests.

However, despite the method's relative popularity in media studies, it does not allow the researcher to reveal the latent content of the texts, it does not give any in-depth information, and, as mentioned above, it does not allow answering 'why' questions. As observed by Shoemaker and Reese (1996) 'Reducing large amounts of text to quantitative data (...) does not provide a complete picture of meaning and contextual codes' (p. 32).

Bryman (2004) suggest that this limitation can be overcome, to some extent, by combining this method with some qualitative method, e.g. interviews. However, in the context of this research project, adding such an approach would encounter several practical problems – in terms of time, costs and most of all accessibility of potential interviewees/participants (especially in the context of Iran). Additionally, such an approach has not been implemented in most other studies in the field.

An approach that combines quantitative methodological rigour with the flexibility, ability to conduct more in-depth analysis and possibility of answering 'why'-questions, offered by qualitative methods is qualitative content analysis. This method emerged as answer to the shortcomings of a purely quantitative approach. According to Alan Bryman (2004) qualitative content analysis has become 'probably the most prevalent approach to the qualitative analysis of documents' and 'as a strategy of searching for themes in one's data lies at the heart of the coding approaches that are often employed in the analysis of qualitative data' (Bryman, 2004, p. 392-393). Nevertheless, it is worth mentioning that in media studies, where content analysis has gained high popularity, many researchers are not trying to separate qualitative content analysis from the quantitative one, seeing them as 'complementary and part of a continuum of analysing text' (Macnamara, 2003, p. 5). As observed by Macnamara (2008) or Weber (1990), qualitative content analysis is preferred by researchers interested

in cross-national comparisons as well as in the socio-political and economic context of the analysed texts.

In qualitative content analysis the text is categorised and classified through the process of coding. However, unlike in quantitative content analysis, there is no one pre-established coding scheme. The codes and categories are developed during the process of analysis and are subject to the researcher's constant revision. As in other qualitative research methods, the researcher is not testing a hypothesis (e.g. through the use of particular statistical test) but is developing it, since the themes emerge during the process of analysis. The researcher also has to consider such aspects as the credibility of the source (e.g. is it published in a scientific journal or the scientific section of a tabloid), socio-political and economical context, as well as eventual audience characteristics, since it aims to uncover the latent meanings and factors that may affect the readers and their perception of the discussed subject (Macnamara, 2006). Many of these aspects are often not considered in a purely quantitative analysis.

Critiques of this approach have suggested that since it relies solely on the researcher (the researcher is the main analytical tool) and researcher's interpretations of the text, it is hard to achieve scientific reliability, which can be easily (to some extent) measured in the case of quantitative content analysis (Macnamara, 2003). Secondly, since it relies on researchers' reading, it is a time-consuming method and therefore it cannot deal with larger samples. This leads to the question of non-representativeness of this method that does not allow any generalization, which is a popular argument against the qualitative methods in general (Bryman, 2004).

Although, reliability and validity criteria cannot be applied to qualitative studies in the same way as in quantitative research, some of these suggested 'limitations' of qualitative content analysis can actually be regarded as assets. According to many scholars (Hansen et al., 1998; Macnamara, 2003; Shoemaker & Reese,

1996) a good research design combines those aspects of the two types of methods that are best suited to the study in hand.

One of its most important aspects is the flexibility of this method. Although, one can use some set of pre-established categories (Macnamara, 2003; Zhang & Wildemuth, 2009), in general codes and categories should emerge from the text during the analysis. As observed in the literature review many previous studies on media coverage of nanotechnology have used some sort of pre-established coding schemes. However, none of these research projects have investigated the Polish, Swedish or Iranian press. The strict use of the same pre-established categories for the analysis of the each corpus could result in omitting some potentially relevant country-specific features of the coverage. Furthermore, the analysis of the Polish, Swedish and Iranian corpora resulted in developing categories that were not observed in the existing literature on the subject. This thesis therefore combines both approaches to coding – using a pre-established (but flexible) coding scheme that was enhanced and revised during the process of analysis (Miles & Huberman, 1994).

Although qualitative methods are not focused on quantity of specific themes or topics, qualitative content analysis allows to see what item (e.g. theme) is more popular across the whole corpus or how the popularity of a particular theme changed across the time. However, unlike quantitative content analysis this method does not involve any examination of the data with the help of the statistical tests.

Overall, it can be argued that qualitative content analysis, as a rather inductive method, is the most suitable method for this project – a cross-national study that aims to develop a hypothesis and find new characteristics of the studied press coverage (e.g. frames).

In the following sections, I will discuss the way this flexible combination of quantitative and qualitative approaches within content analysis has been applied

in this study, also referring to problems that emerged during the process of sampling, coding and analysis.

### 4.1.2 Sampling Strategy

The sampling strategy in this study has been developed after careful study of the approaches used by other researchers dealing with media coverage of nanotechnology. Of particular importance were the criteria for choosing particular titles, equality in terms of number of studied titles, and availability and access.

The first question that should be discussed in the context of the study of media coverage is the timeline. Hansen et al. (1998) distinguish two possible strategies: studies of specific events (such as the London Riots 2011, the Fukushima Nuclear Disaster in 2012 or the War in Vietnam in the 1960s) or studies of 'more general types of coverage – not specifically tied to certain dates or periods' (Hansen et al., 1998, p. 102). In the latter case authors suggest studying press coverage over a longer period of time in order to obtain a 'reasonably representative' sample, that would not be 'skewed or biased by the personal preferences or hunches of the researcher, by the desire to 'prove' a particular preconceived point, or by insufficient knowledge of the media and their social context' (Hansen et al., 1998, p. 103). It also helps to avoid the cycles and seasonal variations that are typical for the media.

Nanotechnology and the debate around it can be characterised as 'general type of coverage'. Unlike the Gulf War or the Three Mile Island accident it does not have a clear 'start' or an 'end'. However, debates about issues like nanotechnology or biotechnology consist of 'event-like' periods, when particular issue is more intensively discussed in the media than at other periods.

The timeline for this study is the period between 1st January 2004 and 31st December 2009. Previous studies show that the highest number of nano-related newspaper articles in Northern America and Western European countries were

published in 2004 and 2005 (Arias, 2004; Clarke, Friedman, & Hoffman-Goetz, 2005; Devereaux et al., 2008; Grobe et al., 2005; Te Kulve, 2006). Since no research on that subject has been carried out regarding Swedish, Polish or Iranian newspapers, it seems to be crucial to gain a longer time perspective. Such an approach is also advised by Gomm (2008) who argues that the choice of a longer time period is especially useful in the study of changes of newspaper representation of a particular issue.

In terms of sources to be used in this research project, it was decided to focus on daily broadsheets (so called 'elite press') in each of the three countries. The main reason for excluding tabloids was that searches using various search engines resulted in only a small number of articles related to nanotechnology published in tabloids. The same phenomenon was observed by Anderson et al. (2005) in their study on media coverage of nanotechnology in British newspapers. Maeseele and Schuttrman (2008), who investigated the press coverage of biotechnology in Northern Belgium, provide some additional justification for excluding tabloids from content analysis of media coverage. The first argument is the assumption that the elite press is more likely to be an arena for discussion of questions around new emerging technologies and that tabloids, having a lower rank in the newspapers' hierarchy, eventually reprint those articles . Maeseele's and Schuttrman (2008) also point out that elite newspaper articles can be easily accessed in a digital format.

In order to achieve consistency among the data-sets from each country, it was decided that the same number of newspapers should be investigated in each country. As could be observed in chapter three Sweden has the lowest number of daily broadsheets in nationwide circulation ('Dagens Nyheter' and 'Svenska Dagbladet'). That would limit the number of Polish and Iranian broadsheets considered for this study to two newspapers per country.

The second criterion was the circulation of a particular newspaper. Similar criteria have been applied in studies on media coverage of nanotechnology conducted by Groboljsek and Mali (2012) or Anderson et al. (Anderson et al., 2005). The circulation numbers for various Swedish, Polish and Iranian newspapers have been provided in chapter three.

Authors of previous media studies accessed the relevant newspaper articles using databases such as Lexis Nexis, Cedon SNI, FPInformat, Factiva, A-tekst or the newspapers own search engines. In order to obtain a coherence of searching methods, the first approach that was considered was the use of one of the mentioned databases. The University of Nottingham, offers access to both Factiva and LexisNexis. However, it was found that LexisNexis does not cover any of the countries studied here and Factiva covers only the Polish and Swedish press (all major broadsheets apart from 'Nasz Dziennik'). A pilot search for nano-articles using keywords 'nano*' and nanotechnology (Polish: 'nanotechnologia'; Swedish: 'nanoteknologi') showed that both Polish and Swedish newspapers' own search engines gave more results than similar searches conducted using Factiva. Considering this situation, it was decided to use the newspapers' own search engines.

As explained above, only two broadsheets per country, with the highest circulation, are used in this study 'Dagens Nyheter' and 'Svenska Dagbladet' in Sweden, and 'Gazeta Wyborcza' and 'Rzeczpospolita' in Poland. During the process of searching for articles it was observed that some of the articles published in 'Gazeta Wyborcza' have been actually published in its local issues, especially in such cities as Łódź, Kraków and Warszawa – key Polish academic and industrial centres. These issues are sold together with the national issue, so both issues constitute one newspaper (it is impossible to buy only a local issue of 'Gazeta Wyborcza'). Therefore, I assumed that it would be inappropriate to omit the articles from the local editions. However, none of the Swedish broadsheets

have their local issues. Therefore, in order to achieve some consistency between the Polish and Swedish samples, two of the largest local broadsheets, distributed in the two main academic and industrial areas (Malmö and Gothenburg ) have been added to the Swedish corpus – 'Sydsvenskan'[14] and 'Göteborgs Posten'. All of the newspapers offer online access to their archives. The basic information about these newspapers can be found in Table 4-1.

Accessing Iranian articles was an activity beset with difficulties, which at the end affected the choice of the newspaper. Since none of the available databases cover the Iranian press, it was necessary to use Iranian newspapers' own search engines. As pointed out in chapter three almost all main Iranian broadsheets offer access to article archives through their web-pages. However, the pilot search for relevant nano-articles showed that the search results did not cover the time period considered in that study. Most of the online archives contain only articles published during the last twelve months.

All these newspapers were contacted by email (in Spring 2010) with a question regarding a possibility of accessing the articles published between January 2004 and December 2009. Most of the newspapers editors answered stating that there was no possibility of access to articles other than those available online. The only exception to this rule was the 'Ettela'at'-newspaper, whose employee informed me that the archives are available in a form of PDF-files stored on CD-ROM. The CD's are sold online for the price of approximately £1 per CD (one CD contains one-month coverage). In August 2010 I made an order for 120 CD's containing issues of 'Ettela'at' (including special 'scientific' issues) published between January 2004 and December 2009. In response to this order I was informed that because the CD's would be shipped to the United Kingdom, the price of one CD would rise to £10 per CD. This meant that the total cost would reach £1200 – an amount that exceeds the acceptable costs of the research project. In September

[14] The official name of the newspaper is 'Sydvenska Dagbladet Snällposten', although in this thesis the shorter name 'Sydsvenskan' will be used

2010, however, I was offered a temporary position as a tour-guide for a group of Polish catholic pilgrims travelling to Iran in October 2010. After obtaining approval from my supervisor and the Director of the International Office at the University of Nottingham (UoN), I accepted the offer and travelled to Iran, where I purchased the materials for the standard price of £1 per CD. After arrival in Nottingham I found that it was impossible to search for relevant keywords ('nano' or 'nanotechnology') through the PDF-files as each PDF file contained just one single page of the printed edition. This was despite the fact that the email from 'Ettela'at' assured that it would be possible to conduct searches. Attempts to search through the files were made using various PDF-viewers, including those designed for Linux-based operating systems. After a consultation with my supervisors, UoN Information Services and the study of relevant Internet forums, it was assumed that the files may need to be converted into searchable format. Attempts to convert the files into searchable PDF/DOC/RTF-files or to JPG/TIFF-formats (in order to later on convert them into searchable text files using OCR software) were made using a wide range of software although without a positive result.

Since the PDF format has been developed by Adobe Systems, I contacted this company asking for a possible solution. I was referred to a users forum on the company's website, where company specialists give advices to customers. I found that the problem was related to the fact that the PDF files did not contain an embedded font subset i.e. these files did not contain the full code of the fonts used. This way of creating PDF-files is used when the issuer wants to minimize the size of the file, since the full information about the font (which allows searching or editing) constitutes a significant part of files size. Adobe experts stated that a possible solution could be the use of Adobe Acrobat X Professional (AAXP), a commercial version of the programme that needed to be purchased. For two reasons, AAXP was not ultimately used for analysis in this project. Firstly, although AAXP allows converting the files into a searchable format, each file

needs to be converted separately. Given that each file contains only one page from the printed edition of 'Ettela'at', converting the files from this time period would have been extremely time-consuming. Secondly, after contacting both the UoN Information Services and relevant person in the School of Sociology and Social Policy, I was informed that the University did not possess the licence for AAXP and could not purchase it either. Given these financial and practical reasons, it was decided to find an alternative method for searching through the files.

A study of the relevant PDF-specific internet forums and the consultations with Ms Katarzyna Javaheri (a researcher in Iranian studies from Warsaw University) and Mr Leszek Żołądek (a software engineer from the Polish company 'Market Utilities') suggested possible problems with the coding of the Persian font. A series of Persian fonts used in the problematic PDF-files were downloaded and installed and attempts were made to edit the fonts used in these files, with the use of font-specific software. This process was unsuccessful, however, and I was advised by Dr Paweł Prociów from the UoN Department of Electrical and Electronic Engineering that a possible solution could be to design a programme that would allow searches using the code samples that were representing relevant words (e.g. نانو 'nano') in the file's code. In order to achieve this, I attended the eight-week long course in Java-programming offered by the UoN Graduate School. Simultaneously, Dr Prociów tried to develop a relevant programme. However, after many trials and tests no proper solution for the problem was found. In this situation the only possible option would have been to read all files on the 120 CD's purchased in Iran, in order to find relevant nano-articles, which would have been an impossibly time-consuming approach.

While trying to find a way of studying the 'Ettela'at' articles I also searched for a second Iranian broadsheet. As mentioned above, none of the Iranian newspapers' search engines allows access to articles published between 2004

and 2009. An attempt to solve this problem was the use of Google Site Syntax Search (GSSS), a tool search tool designed by Google. GSSS allows searching for the relevant phrase at one particular address only. The example below shows an example of search for pages/articles discussing nanotechnology (keyword 'nanotechnology') at the website of 'The Guardian'.

Example: site:guardian.co.uk nanotechnology

Additionally, the Google search engine allows limiting the search result to the pages published in the particular time period. Searches for Iranian nano-articles using GSSS were conducted for all Iranian newspapers mentioned in chapter three. Only in the case of 'Hamshahri' did the search engine find articles published between January 2004 and December 2009.

There are several problems with using Google search engines in the Iranian data collection, however. Firstly, It could be argued that it would be hard to compare the Iranian and the Polish/ Swedish datasets since it is unknown to what extent GSSS is able to find all relevant articles. Considering that the editor of 'Hamshahri' does not aim to provide access for articles older than 24 months (Google can, apparently, access the articles that are still saved on Hamshahri's server), it may be that some of the articles have been deleted. A second issue is the fact that only one Iranian newspaper would be used in this research project, since coverage of no other Iranian newspaper could be studied for the requested time-period. This would affect the representativeness of this study.

The choice of Google as a search engine is justified by previous studies examining search engine accuracy (Thelwall, 2008; Weaver & Bimber, 2008). Further, while the target articles are not accessible through 'Hamshahri's own search engine they are still stored on the newspaper's server. Of course, the question as to whether some of the articles have been omitted by Google remains valid. However, the problem of search engines' accuracy is a general limitation of any research using data stored on Internet regardless of the particular search engine

used, since no search engine gives a complete guarantee for finding all relevant data (Bryman, 2004; Spink, Jansen, Blakely, & Koshman, 2006; Weaver & Bimber, 2008).

A further problem related to the representativeness of the sample is the fact that the Swedish sample consists of four newspapers, the Polish sample of two newspapers, while only one Iranian newspaper could, in the end, be used. However, this objection can be answered on three levels. The first one is the general question of sampling methods and representativeness in qualitative content analysis. Unlike quantitative content analysis the qualitative approach does not aim to meet statistically valid results. Miles and Huberman (1994) argue that the sampling strategy should be based on the conceptual research question rather than representativeness. Considering the above it could be argued that the difference in number of used newspapers (one from Iran; two from Poland; four from Sweden) does not seem to be a significant limitation in the context of qualitative content analysis. Secondly, a similar constraint in the used corpora can be observed in other studies on media coverage of nanotechnology, e.g. in the comprehensive report on media coverage of nanotechnology in Germany and Switzerland (Grobe et al., 2005). The final argument, which is maybe not a strictly methodological one, relates to the fact that Iranian media have never been studied in this context before. The chosen sampling method is currently the only available one that allows studying Iranian press coverage over a longer period of time. Excluding Iran from this project just because of the sample's representativeness (which has been partially answered above), would mean losing a possibility of investigating a relatively new field for media studies, STS and even for Iranian philology. This means safeguarding the integrity and innovativeness of the study should trump representativeness in this case.

The final list of the used newspapers in the study of media debate on nanotechnology in Sweden, Poland and Iran is presented in Table 4-1.

Table 4-1 Newspapers used in the study

| Country | Newspaper | Type | Circulation | Web-address |
|---|---|---|---|---|
| Iran | Hamshahri | National | 460,000 | www.hamshahrionline.ir |
| Poland | Gazeta Wyborcza | National | 300,000 | www.wyborcza.pl |
| | | plus regional issues | | |
| | Rzeczpospolita | National | 117,000 | www.rp.pl |
| Sweden | Dagens Nyheter | National | 345,000 | www.dn.se |
| | Svenska Dagbladet | National | 200,000 | www.svd.se |
| | Sydsvenskan | Regional | 123,000 | www.sydsvenskan.se |
| | Göteborgs Posten | Regional | 245,000 | www.gp.se |

In a discussion on the use of content analysis, Alan Bryman (2004) points out several criteria that should be considered. The first one is authenticity of the text. According to Bryman there is a question whether 'the document is what it purports to be' (Bryman, 2004, p. 197), especially in context of Internet data since 'anyone could set up a website' (p. 390). In this study this criterion is fulfilled since the articles are published on the newspapers' websites/servers.

The second criterion refers to the credibility of the texts, i.e. 'whether there are grounds of thinking that the contents of the document have been or are distorted in some way' (Bryman, 2004, p. 197). Since any content published on the Internet (regardless whether it is a government or private website) is subject to potential changes, every study of articles published on the Internet is subject to this limitation. The articles investigated in this study represent the texts published in newspapers' paper edition. Therefore, these articles should be, at least theoretically, identical with the original printed versions. The accessed articles are stored or made accessible through the official websites of these broadsheets. It could be argued that it minimizes the risk pointed out by Bryman (2004) of them being changed or manipulated in order to suit someone's (e.g. private company) financial or political interests. Each of the studied newspapers

provides information on the date of publishing and eventual dates when any changes have been made to the article.

The third problem is related to the notion of representativeness of the chosen text, especially a text published online. The question of representativeness has been discussed earlier in this chapter. However, it should be stressed that efforts have been made to achieve diversity among the used corpora. Apart from the case of the Iranian corpus, at least two broadsheets have been used in the study of the coverage in Sweden and Poland. The choice of the timeline for research helps avoiding seasonal changes in the debates on nanotechnology. The fact that Polish and Swedish local issues of newspapers are considered in the study strengthens the representativeness of the sample. However, as mentioned in the discussion of Iranian sources, representativeness is not the main criterion in qualitative content analysis. This is also one of the reasons for choosing this particular method, since quantitative content analysis would be unsuitable for a study of such diverse samples.

### 4.1.3 Searches and Data Selection

Search engines available on the newspapers' own websites and GSSS have been used in order to find relevant nano-related articles. All search engines allowed limiting the results to a specific time period. Keywords used in the conducted searches are listed in Table 4-2.

Table 4-2 Keywords used in the searches for relevant nano-articles

| Language | Keywords | Transliteration / Translation |
|---|---|---|
| Swedish | nanoteknologi<br>nano* | Nanotechnology |
| Polish | nanotechnologia<br>nano* | Nanotechnology |
| Iranian | فناوری نانو<br>نانو | 'fanavari-ye nano' nanotechnology<br>nano* |

The importance of proper choice of keywords has been highlighted by various scholars (Bryman, 2004; Gomm, 2008; Spink et al., 2006). The choice of keywords within this project is based on keywords used in previous research on this subject (Kjølberg 2009, Anderson et al. 2005, Wilkinson et al. 2007, Zimmer et al. 2008, Kulve 2006). The use of asterisk * after 'nano' allows to search for any word beginning with 'nano' and followed by any string of characters e.g. 'nanoscience', 'nanotechnique,' nanorobots' etc.

The results of the searches are presented in Table 4-3 along with the number of articles selected for further analysis, i.e. articles where nanotechnology played a prominent role. Articles dealing only partially with nanotechnology or its application, economic news, information about general educational strategy of a government or any institution where nanotechnology does not play an important role, advertisements, articles where 'nano' is used as part of particular product name (e.g. 'Tata Nano'), as well as articles completely irrelevant (e.g. about Fatos Nano, Albanian Prime Minister) were excluded from the sample. Many excluded articles from Polish newspapers were found by the search engines because of the appearance of the verb 'nanosić`' 'to apply'. In some cases I have decided to include in the corpora articles where nanotechnology was not the main subject, but was one of many issues discussed and nanotechnology, the technology or its applications was described in a more detailed way.

Table 4-3 Number of selected articles

| Country | Newspaper | Initial search result | Number of selected articles |
|---|---|---|---|
| Sweden | Dagens Nyheter | 331 | 20 |
| | Svenska Dagbladet | 247 | 31 |
| | Sydsvenskan | 15 | 9 |
| | Göteborgs Posten | 74 | 7 |
| Poland | Gazeta Wyborcza | 791 | 41 |
| | Rzeczpospolita | 836 | 76 |
| Iran | Hamshahri | | 106 |

A total of 66 Swedish, 118 Polish and 109 Iranian articles were selected for further analysis (see chapter five).

### 4.1.4 Coding

According to Weber (1990) the most fundamental decision in the coding process in any content analysis is defining the coding units. Many scholars (Krippendorff, 2004; Weber, 1990) argue that the coding units in quantitative content analysis should be smaller than sampling units, i.e. single words, sentences, paragraphs or whole articles (as in the case of this study). However, in qualitative research the focus is on individual themes rather than on the physical linguistic units (e.g. words), since a theme, which is an expression of an idea, can be expressed by one word, a whole sentence or even a whole paragraph. Zhang and Wildemuth (2009) state that the coder can 'assign a code to a text chunk of any size, as long as that chunk represents a single theme or issue of relevance to the research question' (Zhang & Wildemuth, 2009, p. 310). In this study the coding units are the whole articles (news items) as in most of the earlier studies in this field.

Initially I intended to use computer software (NVivo) for the coding and analysis. However, I decided to conduct the analysis manually, as there are a number of problems when using NVivo for texts written in Swedish, Polish and Persian. Additionally, as stated by Silverman 'CAQDAS does not do the thinking for you' (Silverman, 2005, p. 207). Unlike the quantitative analysis, qualitative analysis can be done only by the researcher and the software is more of an aid than an all-powerful analytical tool.

One of the main differences between qualitative and quantitative content analysis is the possibility of developing new categories during the process of coding. If a new category emerges during coding, a coder needs to re-read all texts that have been coded earlier in order to check whether this category could be assigned to some of them (Mayring, 2000a). However, Miles and Huberman (1994) state that it is also possible to use some initial coding scheme, which

would be modified during the process of analysis. Macnamara argues that using pre-established coding schemes 'increases the systematicity of qualitative analysis' (Macnamara, 2003, p. 17). An advantage of using a pre-established coding scheme developed by other researchers is that it becomes possible to draw comparisons between the results of different studies. This comparative aspect is crucial in the case of this project, as the use of pre-established codes would create a common field for cross-cultural comparisons of Polish, Swedish and Iranian corpora. It will also allow positioning Iran, Poland and Sweden among other countries of the world in terms of the debate on nanotechnology.

The comparative aspect of the project affects also the development of the initial scheme. Based on the analysis of previous studies of media debates about nanotechnology (see chapter two), I was able to locate the elements of the selected texts that would be the subject of my analysis. These elements include:

- Themes - the content of the particular text (i.e. what is the story about)
- Actors (sources) – person/institution that was active, mentioned or cited in the article in the context of nanotechnology (sources). It does not refer to the author of the article, unless the article is an editorial in which author presents openly his/her own views and opinions on that subject.
- Geographical focus – is the article focused on the country itself (Sweden, Poland or Iran) or maybe on other countries
- Focus on benefits/risks
- General tone of the article

Table 4-4 Coding scheme (excluding frames)

| | |
|---|---|
| Themes<br>- Application<br>- Financial<br>- Generic Research<br>- Politics<br>- Policy and Regulation<br>- Safety and Risks<br>- Other | Benefits vs. Risks<br>- Benefits only<br>- Both<br>- Risks only<br>- None |
| Actors (Sources)<br>- Scientists<br>- Interest group<br>- Business<br>- International Organization<br>- Politician<br>- Media<br>- Military<br>- Moral authorities<br>- Public opinion<br>- None | Tone<br>- Positive<br>- Neutral<br>- Negative<br>Country focus<br>• - Country itself (Sweden/Poland/Iran)<br>• -Other countries<br>• - Comparison<br>• - None |

While themes are strictly related to the content of the particular text (i.e. 'what is the story about'), frames are giving information about the way particular items of news are presented (i.e. 'how is the story told'). As argued by Entman (1993), framing allows one to:

> select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation (p. 52).

Frames have been widely studied in the context of nanotechnology (Arias, 2004; Arnaldi, 2008; Donk et al., 2012; Gorss & Lewenstein, 2005) as well as biotechnology (Nisbet & Lewenstein, 2002).To achieve a deeper understanding of the press coverage in the three countries, it was deemed necessary not only to code the more superficial aspects of content, but also the more hidden frames used in presenting the content, that is code for pervasive frames. The coding of frames in the current study was based on the framing typology adopted by Gorss

and Lewenstein (2005) with five additional frames developed during the process of analysis (see Table 4-5). The characteristics of the additional frames will be provided in chapter five.

Table 4-5 Framing typology

| | |
|---|---|
| **Progress** | report of technical development |
| **Economic Prospects** | nanotechnology's effect on the economy. |
| **Ethical** | nanotechnology is either morally necessary or morally repugnant |
| **Unforeseen Risks** | developing nanotechnology will create unforeseen dangers and unintended consequences |
| **Loss of control** | nanotechnology may spiral out of human control. |
| **Public Accountability** | coverage about ethical, legal, and societal implications; influence over research and development |
| **Time** | applications from nanotechnology will be in the distant future. |
| **Confluence** | nanotechnology represents a confluence of technologies including biotechnology,<br>information technology, and cognitive science |
| **New Industrial Revolution*** | articles where nanotechnology and its development are framed as a New Industrial Revolution |
| **Hope*** | hopes related to nanotechnology and its 'infinite' applications |
| **Entertainment*** | articles that focus on entertaining aspects of nanotechnology rather than 'real' science, such as nano-sized images of human cultural artefacts (guitars, abacus, logos, maps) or nature (flowers, crystals, mountains), abstract art created using scanning tunnelling microscopes, for instance. |
| **Nano-enthusiasm*** | extreme form of enthusiasm for this nanotechnology, its applications, nano-research and everything related to 'nano-' |
| **National*** | Articles discussing the progress in nanotechnology in Poland/Sweden/Iran, highlighting in the same time the strong position of the country and its scientists or companies. The element of 'national pride' is the main distinguishing characteristic of this frame. |

*- frames added during the analysis of the corpora

The names of the three frames in Table 4-5 have been changed. In the original versions these were 'Pandora's Box' (here: 'Unforeseen risks'), 'Runaway' (here: 'Loss of control') and 'Long Way Ahead' ('Time'). In other studies, authors used metaphors to name these frames. However, one of the aims of this study is to investigate the existence and use of metaphors in the corpora separately,

including their use as framing devices. Therefore, use of metaphors in a pre-established coding scheme would be inappropriate decision in the context of this study.

While coding such categories as 'geographical focus', 'benefits vs. risks', and 'tone', coders could chose only one answer per article, i.e. a tone of the article could be positive, negative or neutral. However, in the case of themes, frames and actors coders could choose more than one answer, pointing out the main theme/frame/actor observed in the particular article.

One important issue that needs to be discussed in the context of a cross-linguistic study, as is the case of this project, is the question of overcoming the problems related to dealing with three different languages (translations of texts and coding schemes, choice of coders). In the discussion of conducting cross-national research on samples written in different languages, Weber (1990) suggests translating texts into one language in order to conduct the coding of the whole corpora (in one language). The use of this approach may seem to be justified in the case of quantitative studies, where coding is made by specific software, and quantification of specific set categories is the main purpose. However, it does not seem to be applicable in the context of qualitative research, which looks at such elements as frames or metaphors. Apart from practical constraints related to the translation of large corpora, the main argument for not-translating all of the articles into a single language is problem of translatability of texts (Neubert & Shreve, 1993; Ricoy, 2001), where some nuances of the original text (especially culturally specific metaphors for example) are always lost in translation. Therefore, all texts have been analysed in their original languages – Swedish, Polish and Persian.

As the person conducting the analysis, I am a Polish native speaker and have very good knowledge of Swedish and Persian. Only fragments crucial to the analysis will be translated and included in the thesis, along with the original version. This

pattern can be observed in many other cross-linguistic studies (Abed Al-Haq & El-Sharif, 2008; Bielenia-Grajewska, 2009). My personal background (I am Polish and a Swedish citizen), academic background (BA & MA degrees in Iranian languages and Polish studies; publications in the field) and professional experience (I have been working as interpreter) allows me to do all the readings, coding and analysis. Still, at all stages I consulted with other researchers in the area of STS, linguistics and philology. As in previous cross-linguistic studies of media coverage that involved content analysis (Hibino & Nagata, 2006; Kolmer & Semetko, 2009; Stromback & Dimitrova, 2006), the coding scheme has been prepared in one language (English) and was later translated into other languages.

Weber (1990) suggests that in order to achieve a high reliability for the coding procedure, the coding process should be conducted by more than one person. However many previous studies have been coded by only one person. Stephens (2005), in his research on news narratives about nanotechnology, coded 85% of the material himself. A second coder was used in order to determine inter-coder reliability. For the purposes of this project, the reliability of the coding scheme has been checked separately for each corpus (Swedish, Polish or Iranian). A sample of 50 articles has been coded by both author and a native speaker of the particular language. All of the coders hold a higher education degree and are not specialized in the areas related to nanotechnology.

In the studies that apply a qualitative approach to content analysis checking of the inter-coder reliability is not achieved with the help of the statistical tests used in quantitative studies (Krippendorff's *alpha* or Coehn's *kappa*), but rather through discussion within the research theme. Nevertheless, Mayring (Mayring, 2000b) suggests assessing the inter-coder reliability, although with less strict measures than in quantitative studies, a Coehn's kappa of 0.7 deemed to be a satisfactory indicator of inter-coder agreement level. In the case of this research project the application of this form of inter-coder reliability faces a significant

constraint due to the hierarchical structure of some categories under analysis (frame, theme, actor). Another limitation related to the use of Coehn's kappa is the fact that in order to conduct this test on a set of variables, both coders need to use the same categories within variables. In other words, if one coder coded even one article from the sample using a category that other coder has not used at all, it would be impossible to conduct the test. Since this test could not be conducted for all of the variables and because it was not normally used in the most former studies in this research area, inter-coder reliability has not been assessed in this way. Instead, as suggested by Schilling (2006), the coding scheme and eventual problems with categorization of particular articles was a subject of a constant consultation and discussion between the coders and supervisors.

After the coders achieved a satisfactory level of agreement, the rest of the articles were coded by me. Zhang and Wildemuth (2009) argue that 'it is not safe to assume, that if a sample was coded in a consistent and reliable manner, the coding of the whole corpus of text is also consistent. Human coders are subject to fatigue and are more likely to make more mistakes as the coding proceeds' (Zhang & Wildemuth, 2009, p. 312). Weber (1990) observes also that a coder's understanding of categories may change slightly during the process of coding. Additionally, because of the inductive nature of coding in qualitative content analysis, new categories emerged during that process. Therefore, as suggested by some scholars (Bryman, 2004; Mayring, 2000a; Zhang & Wildemuth, 2009) during and after coding of the whole corpora the coding consistency was rechecked by reading articles again and checked for the presence of the new categories. These decisions were discussed with the inter-coders and supervisors.

The results of the coding have been stored in digital-form using SPSS, which allows extracting more quantifiable information about the corpora, the frequency of particular categories, and changes in the occurrence of particular categories across the analysed time. The next step is the critical analysis of the

corpora, studying the interferences and relations between categories, uncovering patterns and analysing them in the broader economic, cultural and socio-political context.

## 4.2 Metaphor Analysis

The next stage of the research focused on analysing three corpora of chosen texts using metaphor analysis in order to achieve in-depth understanding of conceptualizations of nanotechnology in three different cultural and linguistic contexts. As mentioned in the discussion of the theoretical framework of this study, metaphors as social and cultural phenomena may differ among different nations and society. This aspect of metaphor strengthens the rationale of choosing this approach for studying debates on nanotechnology in a cross-cultural context. Metaphor also strengthens the analysis of frames conducted in this thesis, as metaphor is considered to be one of the most important framing devices (Pan & Kosicki, 1993; Weele & Boomen, 2008) .

In his discussion of the study of metaphors as a qualitative method, Schmitt (2005) argues that:

> Qualitative research yields a multitude of heterogeneous pieces of information which contain complex meaningful structures. Metaphors can well be used to reduce this complexity to clearly structured patterns. (...) Qualitative research needs an approach that allows a systematic reflection of the metaphors in which, and through which, we perceive, speak, think, and act (pp. 360-369).

Schmitt also states that metaphor analysis 'attempts to reconstruct models of thought, language and action' (p. 368) and, as Todd and Harrison (2008) suggest, this approach can be applied in studies of any kind of textual data. Many researchers in the area of qualitative studies (Bryman, 2004; Hansen et al., 1998;

Silverman, 2005) suggest combining research methods as a way of triangulation – cross-checking the findings. In the context of metaphor analysis triangulation is also advised as a way to both validate the results and understanding the differences in the conclusions reached through the use of different methods. However, I would argue that in the case of this project, metaphor analysis is rather used as a way of gaining more in-depth understand of the studied corpora, rather than a way of cross-checking the results. As will be discussed later on in this chapter, metaphor analysis will complement the results of qualitative content analysis by focusing on particular areas that were recognized as worthy of in-depth investigation during the process of content analysis.

Metaphor analysis, as discussed in the literature review, has been applied in various studies of textual data, in a wide range of research fields, including STS (Holmgreen, 2008; Liakopoulos, 2002; Nerlich & Hellsten, 2009; Nerlich, 2007; Petersen, 2005). However, as Todd and Harrison observed 'there are no fixed or established ways of conducting a metaphor analysis' (Todd & Harrison 2008, p. 480). Although work by Lakoff and Johnson (2003) became the basis for many later studies of metaphors, these authors, as well as many researchers that used metaphor analysis within this paradigm did not provide any detailed description of the methodology used. Some attempts to describe and systematize it were provided by Steen (2010), Todd and Harrison (2008), Schmitt (2005), as well as in the work edited by Low, Todd, Deignan and Cameron (2010).

This thesis is not, however, supposed to be 'metaphor study'. The analysis of metaphors is an additional element that will help contextualize the results of the content analysis. The use of the approaches suggested by the aforementioned scholars would have significant methodological and theoretical consequences for the design of this study. Although, it would broaden the scope of the study, it would require more resources, especially in terms of time. The 'simplified' approach taken in this study consists of three elements. The first one is my own

understanding and knowledge of language, culture, literature and life in Poland, Sweden and Iran, which is related to my personal and academic background. This informs the second element, i.e. reading text repeatedly in order to find metaphors. The final element is that extracted metaphors were discussed with native speakers and later with my supervisors. This approach to analysing metaphors has been discussed with my supervisors and has gained their approval.

In his work, Rudolf Schmitt (2005) has highlighted the importance of the *researcher's knowledge, experience and patience*. He has also pointed out the necessity for ensuring trustworthiness in any metaphor analysis, a trait which could be divided into two groups. The first one includes criteria related to the subject of the analysis and the way research process is structured ('inter-subjective credibility'). The first question that should be asked is whether metaphor analysis is an appropriate method for studying media debates on nanotechnology. Schmitt (2005) states that metaphor analysis is 'only appropriate when the goal of the research is to discover patterns of interpretation and how they are altered and/or processed discursively' (p. 381). Considering the aims and goals set forward in the Introduction, it can be stated that this criterion is fulfilled in the case of the current project. The notion of 'inter-subjective credibility' refers to such aspects as documentation of the research process, interpretation in groups and use of standardized procedure. Although, there is no standardized procedure for conducting metaphor analysis, this study follows (as far as is possible) the procedure described above. All decisions were also subject to discussions and consultations with my supervisors, native speakers and researchers in the fields of Polish, Swedish and Iranian studies. The latter is crucial because of the cross-cultural character of this study.

# 5 RESULTS

In this chapter I will present the results of the content analysis of the collected nano-related articles published in Swedish, Polish and Iranian newspapers and the study of the metaphors used in this debate. The information provided in this chapter constitutes background for further discussion in chapter six.

I begin by discussing the results of the content analysis of 291 articles published in the Polish, Swedish and Iranian press between 1st January 2004 and 31st December 2009. This will be followed by a presentation of metaphors used in the nano-debates in all three countries.

## 5.1 Sweden

Four Swedish newspapers were included in the process of searching for nano-related articles: Dagens Nyheter, Svenska Dagbladet, Göteborgs Posten, and Sydsvenskan. In total, 66 nano-related articles were published in the four analysed Swedish newspapers between 1st January 2004 and 31st December 2009 (see Figure 5-1).

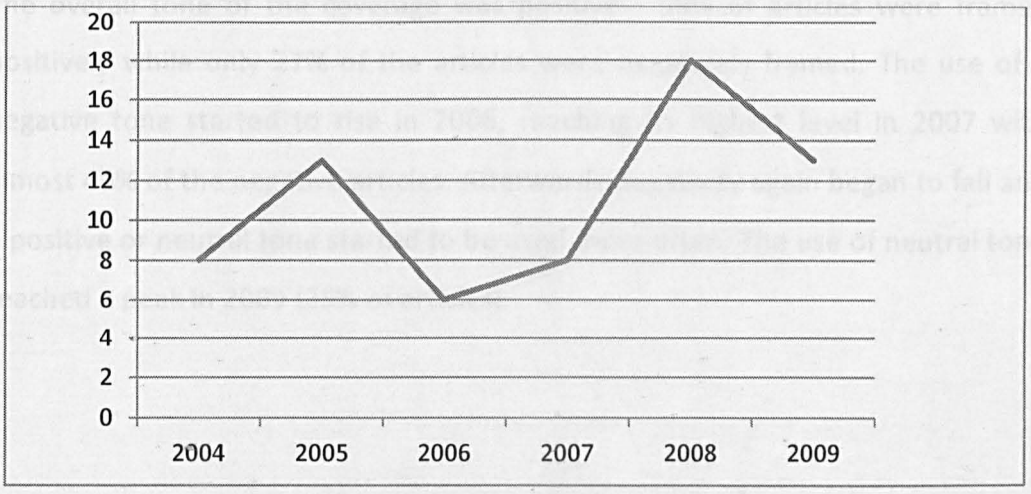


Figure 5-1 Number of published articles in Sweden, 2004-2009

As one can see, there were peaks in the publication of nano-related articles in 2005 and 2008. Information about the number of published articles can be found in Table 5-1.

Table 5-1 Number of Swedish nano-related articles published between 2004 and 2009

| Newspaper | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | Total |
|---|---|---|---|---|---|---|---|
| Dagens Nyheter | 1 | 6 | 2 | 1 | 8 | 2 | 20 |
| Svenska Dagbladet | 5 | 5 | 3 | 5 | 6 | 7 | 31 |
| Göteborgs Posten | 0 | 0 | 1 | 0 | 3 | 2 | 6 |
| Sydsvenskan | 2 | 2 | 0 | 2 | 1 | 2 | 9 |
| Total | 8 | 13 | 6 | 8 | 18 | 13 | 66 |

The majority of the articles were published in two national broadsheets: Dagens Nyheter (47%) and Svenska Dagbladet (30%), while the focus on nanotechnology in the two local newspapers was rather limited. Still, among local newspapers, nanotechnology was more often a subject of articles in Sydsvenskan, which is circulated in the south of Sweden where many nano-companies and nano-research institutions are located (including MAXlab).

### 5.1.1 General tone

The overall tone of the coverage was positive - 59% of articles were framed positively while only 27% of the articles were negatively framed. The use of a negative tone started to rise in 2006, reaching its highest level in 2007 with almost 40% of the negative articles. Afterwards negativity again began to fall and a positive or neutral tone started to be used more often. The use of neutral tone reached a peak in 2009 (25% of articles).

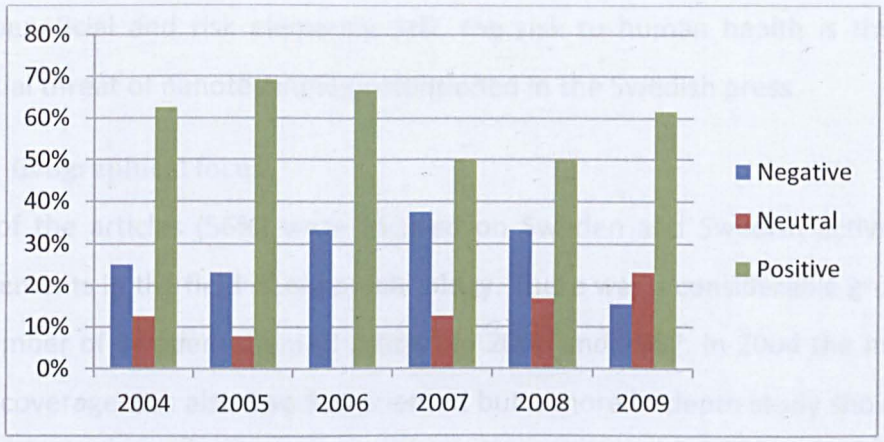


Figure 5-2 General tone of Swedish articles 2004-2009

### 5.1.2 Risks and Benefits

The description of benefits (actual or potential) of nanotechnology has dominated the Swedish debate on this technology. During the first two years (2004-2005) benefits were discussed in more than 70% of articles, in the following years, however, newspapers started to be more interested in the potential risks of nanotechnology. Towards the end of the studied period the number of risk-focused articles began to fall.

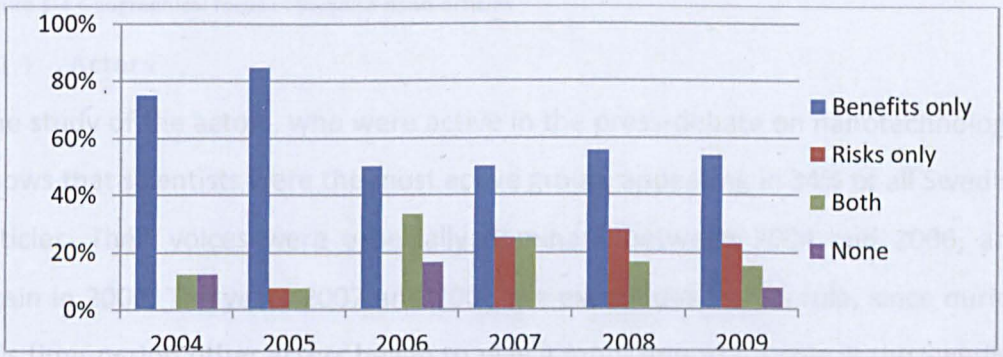


Figure 5-3 Benefits and Risks of nanotechnology in Swedish press

The main benefits of nanotechnology (as presented in the articles) are: new possibilities and higher effectiveness of processes in many areas of human activity (medicine, electronics, mobile phones, computing, preserving historical sites, cosmetics). Further, nanotechnology is often portrayed as an 'environmental-friendly' technology. This latter feature is an interesting example of a tendency to point out the same aspects or applications of nanotechnology as

both beneficial and risk elements. Still, the risk to human health is the main potential threat of nanotechnology mentioned in the Swedish press.

### 5.1.3 Geographical focus

Most of the articles (56%) were focused on Sweden and Swedish activities or achievements in the field of nanotechnology. There was a considerable growth in the number of Sweden-oriented articles in 2006 and 2007. In 2004 the majority of the coverage was also Sweden-oriented but a more in-depth study shows that half of the articles from this category were published in a local newspaper Sydsvenskan and discussed the problems of a local nano-company.

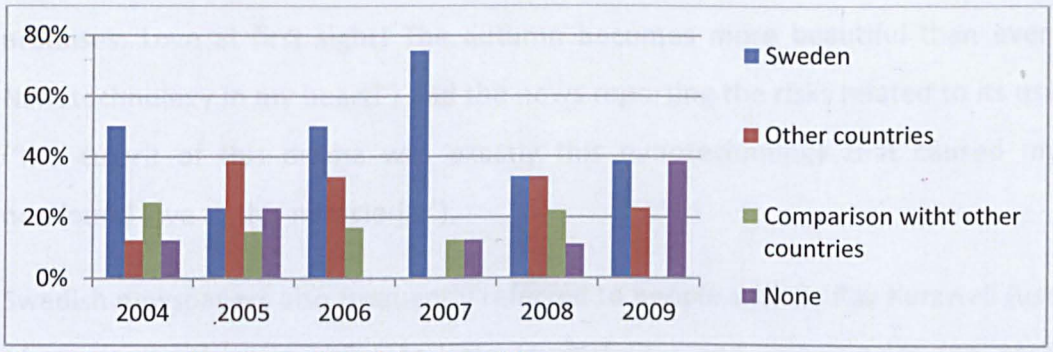


Figure 5-4 Geographical focus of Swedish nano-articles

### 5.1.4 Actors

The study of the actors, who were active in the press-debate on nanotechnology, shows that scientists were the most active group, appearing in 34% of all Swedish articles. Their voices were especially dominant between 2004 and 2006, and again in 2009. The years 2007 and 2008 are exceptions to this rule, since during this time-period other actors began to play a more important role in the Swedish nano-debate, i.e. Business and Institutions' officials, as well as Politicians and International Organisations (in the context of this corpus this refers almost exclusively to EU-institutions, such as the European parliament or the European Commission). NGOs were also active in the debate on nanotechnology, but their presence in the analysed articles was rather limited since they were represented in only four articles. In 2006 and 2009 NGOs active in the debate covered such organisation as the environmental 'Food & Water Watch' and the Swedish

Consumers Organisation, which represent a more critical approach towards nano, as well as aid organisations that perceived nanotechnology as chance to solve health problems in the developing countries (e.g. cleaning water from toxins such as arsenic).

Media representatives occur as actors in the Swedish debate on the benefits and risks of nanotechnology. For example, in an article published in Svenska Dagbladet (19th October 2007) entitled 'Min nanoglädje blev kortvarig' ('My nano-happiness was so short-lived') a journalist describes her own experience and feelings related to the new nano-cream ('(...) the happiness that I felt when I encountered a new, high-tech base powder (...). A small blue box that keeps all promises. Love at first sight! The autumn becomes more beautiful than ever! Nanotechnology in my heart!') and the news reporting the risks related to its use ('the culprit of this drama was exactly this nanotechnology that caused my newfound love to this miracle-jar').

Swedish newspapers also frequently referred to people such as Ray Kurzweil (use of nanotechnology in order to gain immortality) and Eric Drexler (an early promoter of promises and potentials of nanotechnology). Some journalists tried to validate claims made by Kurzweil and Drexler and pointed out that 'Kurzweil is far away from being alone (...) since many gerontologists admit that (...)' (Svenska Dagbladet, 24th April 2005). As will be shown, a similar situation was observed in Poland and Iran. This was a time then when mundane products like face cream containing some type of nanoparticles clashed with almost surreal hopes about nanotechnology making people lives forever.

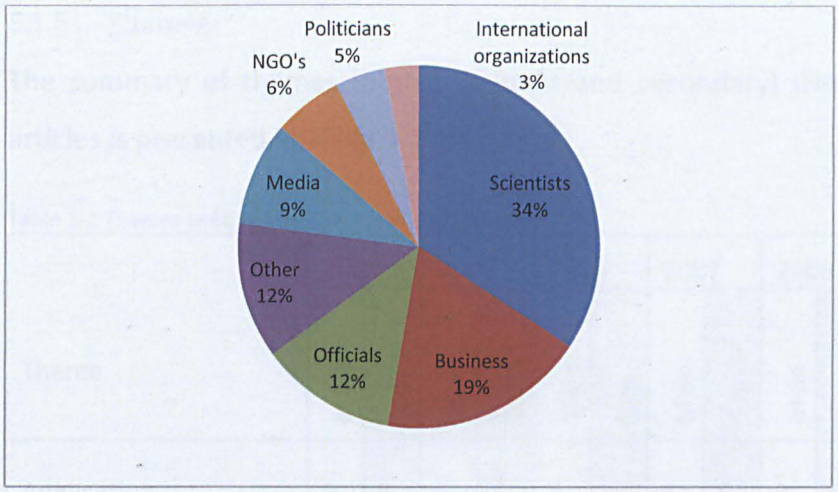


Figure 5-5 Main actors in nano-articles in Sweden

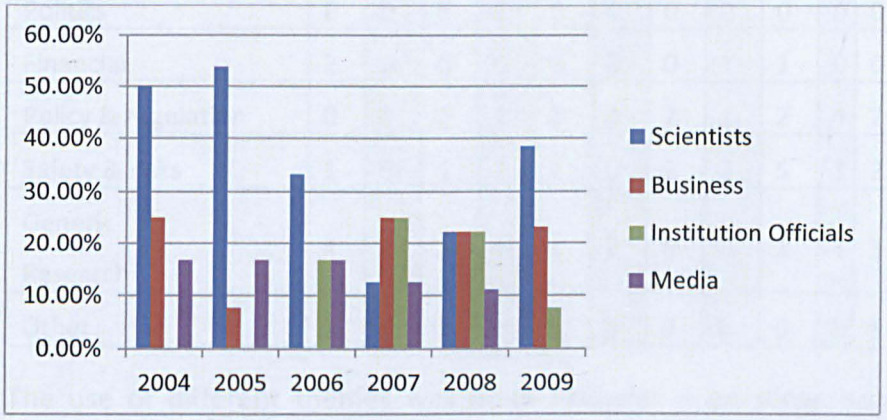


Figure 5-6 Main actors in Swedish nano-debate

### 5.1.5 Themes

The summary of themes (both dominant and secondary) used in the Swedish articles is presented in Table 5-2.

Table 5-2 Themes used in Swedish nano-articles

| Theme | 2004 | | 2005 | | 2006 | | 2007 | | 2008 | | 2009 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Main | Sub- | Main | Sub- | Main | Sub- | Main | Sub- | Main | Sub- | Main | Sub- |
| Application | 0 | 5 | 9 | 12 | 3 | 4 | 4 | 5 | 9 | 13 | 5 | 10 |
| Politics | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Financial | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| Policy & regulation | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 1 | 2 | 4 | 2 | 1 |
| Safety & risks | 1 | 0 | 1 | 1 | 2 | 0 | 2 | 3 | 5 | 1 | 2 | 3 |
| Generic Research | 4 | 0 | 2 | 4 | 1 | 2 | 0 | 0 | 1 | 1 | 3 | 0 |
| Other | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |

The use of different themes was quite irregular – on some occasions (i.e. in particular years) some themes were not used at all. 'Application', 'Safety and Risks', 'Generic research' and 'Policy and regulation' were the most often used themes and therefore their use is presented on Figure 5-7.

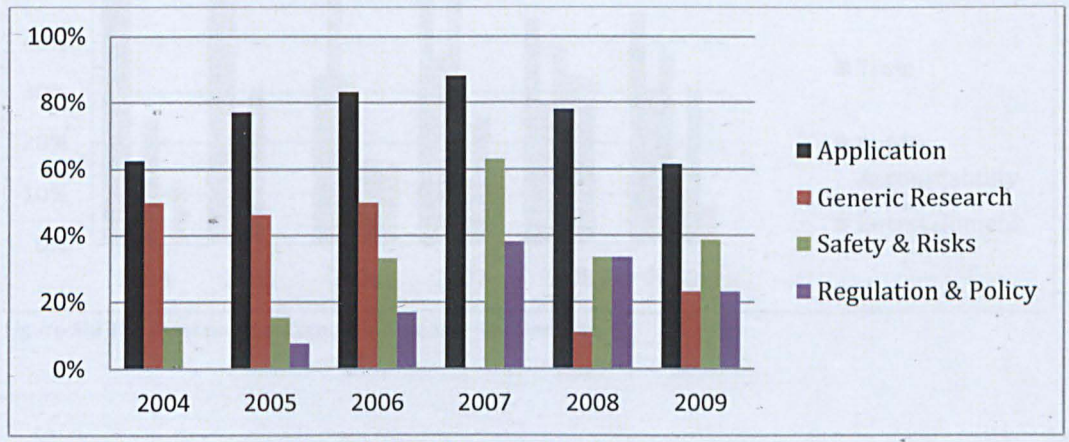


Figure 5-7 The most popular themes in Swedish nano-debate

As can be seen, 'Application' and 'Generic Research' themes were the most popular themes during the first half of the studied period. However, the 'Safety and Risks' theme start to occupy the second place since 2007. In the same year there were no articles discussing issues related to the generic research. While discussing risks and safety, authors usually referred to legal regulations and government policy towards nanotechnology, therefore 'Policy and Regulation' was usually a secondary theme when the main foci were safety issues.

### 5.1.6 Frames

The existing literature on this subject shows that one of the most popular frames used in the media debate about nanotechnology in the European press is 'Progress' (Anderson et al., 2005; Arnaldi, 2008; Gaskell et al., 2005; Groboljsek & Mali, 2012; Kjølberg, 2009; Laing, 2005; Stephens, 2005). The analysis of the Swedish articles shows that the Swedish media tends to follow this pattern - in more than a half of the articles analysed this frame was used as a primary/dominant or secondary frame. Table 5-3 and Figure 5-8 presents frequency of all frames used in Swedish articles.

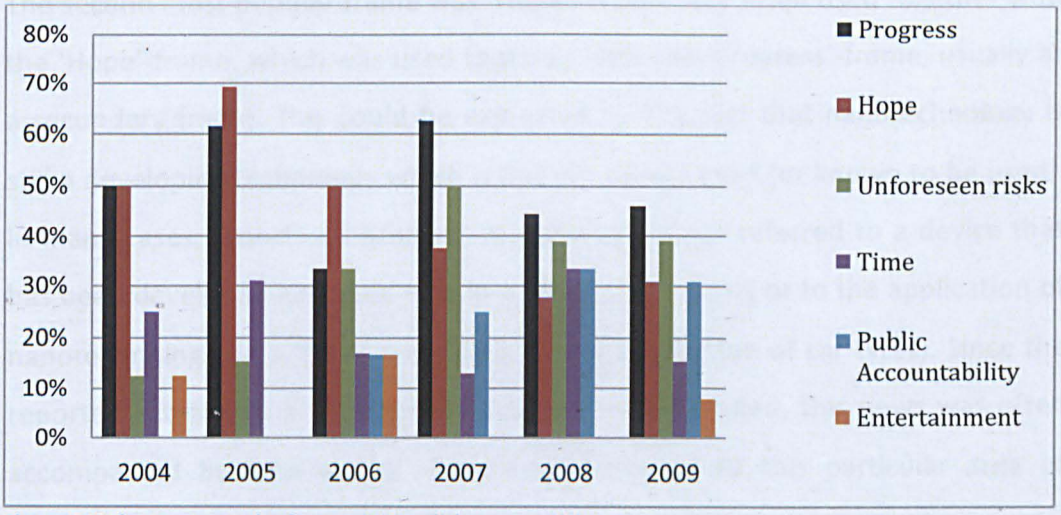


Figure 5-8 The most popular frames in Swedish nano-articles

Table 5-3 Frames used in Swedish nano-articles

| Frame | 2004 | | 2005 | | 2006 | | 2007 | | 2008 | | 2009 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Main | Sub- | Main | Sub- | Main | Sub- | Main | Sub- | Main | Sub- | Main | Sub- |
| Progress | 4 | 0 | 7 | 1 | 1 | 1 | 5 | 0 | 7 | 1 | 5 | 1 |
| Economic Prospects | 2 | 0 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 3 | 0 | 0 |
| Ethical | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unforeseen risks | 0 | 1 | 2 | 0 | 2 | 0 | 3 | 1 | 5 | 2 | 1 | 4 |
| Hope | 0 | 4 | 4 | 5 | 1 | 2 | 0 | 3 | 3 | 2 | 1 | 3 |
| Loss of control | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Public Accountability | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 2 | 4 | 3 | 1 |
| Time | 0 | 2 | 0 | 4 | 1 | 0 | 0 | 1 | 1 | 5 | 1 | 1 |
| Confluence | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| New Revolution | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 1 |
| Entertainment | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| National | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 |
| Enthusiasm | 0 | 1 | 0 | 2 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 2 |

The second most popular frame was 'Hope'. It was very often used together with the 'Hope'-frame, which was used together with the 'Progress'-frame, usually as a secondary frame. This could be explained by the fact that nanotechnology is still a developing technology which is not yet widely used (or known to be used). In many cases, reports on progress in nanotechnology referred to a device that has been developed and used only in a laboratory setting or to the application of nanotechnology on a 'small-scale' (e.g. in the production of car tyres). Since the reported actual use of nanotechnology was rather limited, this news was often accompanied by information about hopes related to this particular area of nanotechnology, suggesting potentially wide use of the nanotechnology in the future in many areas of our life. It could be argued that while the actual findings in the area of nanotechnology are still limited, journalists were trying to gain

readers' interests. Nik Brown stated that 'expectations mobilize the future into the present' (Brown, 2003, p. 3). An example could be this quote from an article published in 'Dagens Nyheter':

> The newly discovered nanoparticles of rust [iron oxides] may also be able to save the life of many, many millions of people (Dagens Nyheter, 12th November 2006).

Nevertheless, the use of both the 'Hope' and 'Progress'-frame changed during this time-period. The reduction in the use of the 'Progress'-frame (since 2007) has been followed by the growing use of other frames, especially 'Unforeseen risks', 'Time' or 'Public Accountability'. The analysis of Figure 5-8 allows us also to draw some conclusions about the tendencies in the way of framing nanotechnology in Sweden between 2004 and 2009. At the beginning of our period of analysis, the articles were mostly focused on progress and hopes related to nanotechnology as well as on economic prospects. The frame of 'New Industrial Revolution' was also used between in 2004 and 2005. The issues related to potential risks and threats of the new technology were not widely discussed – in 2004 either 'Loss of control' or 'Unforeseen risks' were used as dominant frames. The frame of 'Unforeseen risks' started to be more popular (even as a dominant frame) between 2005 and 2007. After 2007 this frame was used less often than before, especially as a dominant frame. Example of the use of these frames includes:

> But nobody knows how all those silver particles are going to affect the environment (Svenska Dagbladet, 1st October 2006).

> However, recent research shows that carbon nanotubes may affect humans in the same way as asbestos. (...) Even an extreme low dose of carbon nanoparticles may cause severe damages in fishes' brain within 48 hours! (Svenska Dagbladet, 6th June 2008).

> Nanoparticles are so small that they can penetrate the cell wall and can have unexpected effects on humans and other organisms (Svenska Dagbladet, 31st October 2007).

During the same time fewer articles were framed through the frame 'Time'. This suggests that during this time authors started to focus more on threats of nanotechnology, although, in contrast to the Hope frame, those threats were not framed as being 'far away from now', i.e. nanotechnology is already a threat. Towards the end of the studied period the use of the 'Unforeseen risks' frame was less popular and the 'Public Accountability'-frame started to be used more frequently, especially as a dominant frame (before 2008 it was not used as a dominant frame at all). It could be argued that after 2007 authors started to realize that the actual uses and threats of nanotechnology were not as urgent as they thought before. Therefore the coverage started to be more balanced in terms of frames or themes used.

As mentioned in Chapter four, five new frames emerged during the analysis. The first one was the 'Entertainment' frame, which captures news where nanotechnology plays only an entertaining role (unlike the 'Progress' frame that is informing about success or progress in this field). The frame can be characterised by the words of the constructor of 'the World's smallest football stadium', who stated that 'the problem is that I do not know what I can actually do with it' (Svenska Dagbladet, 4th July 2006). Still, its use across the Swedish corpora (unlike Polish or Iranian) was rather limited.

Another new frame was labelled 'Nano-enthusiasm', which is characteristic for articles that describe nanotechnology with a 'fantastic form of optimism' that Chris Toumey has called 'childish enthusiasm' (Toumey, 2005, p. 97). The nano-enthusiasm frame differs from the progress frame (new applications, breakthroughs in research etc.) in that it is a form of extreme enthusiasm for this technology, its applications, nano-research and everything related to 'nano-'. This

frame appeared in 12% of articles (N=8). An example of its use in the Swedish press can be this quote from 'Svenska Dagbladet':

> Nanotechnology helps human intelligence [with the use of nanorobots] (Svenska Dagbladet, 18th February 2008).

Another frame, introduced during the study is linked to the country's national success in the area of nanotechnology, e.g.:

> Nano-research in Lund is amongst the most prominent in the world (Sydsvenskan, 9th August 2005).

> Lund's Faculty of Engineering belongs to world's best in the area of manufacturing nano-threads (Svenska Dagbladet, 5th December 2005).

This nation-oriented frame was used in 8% of articles, in one article per year. As it will be seen later on it is the lowest result among all three countries.

## 5.2 Poland

Two Polish newspapers were used for the content analysis: Gazeta Wyborcza and Rzeczpospolita. In total, 118 articles were selected. Figure 5-9 presents the number of published articles between 1st January 2004 and 31st December 2009.

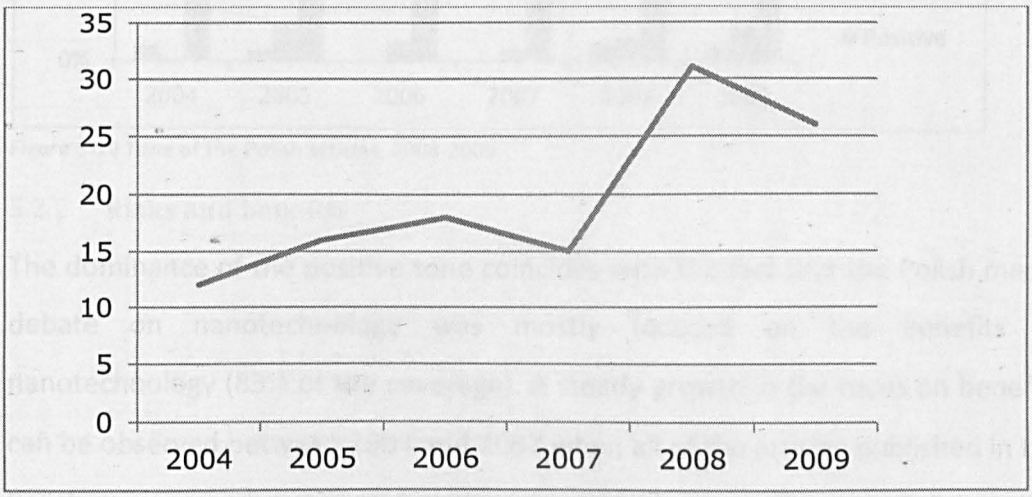


Figure 5-9 Number of published articles in Poland, 2004-2009

Table 5-4 Number of nano-related articles published between 2004 and 2009

| Newspaper | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | Total |
|---|---|---|---|---|---|---|---|
| Gazeta Wyborcza | 6 | 7 | 6 | 5 | 10 | 8 | 42 |
| Rzeczpospolita | 6 | 9 | 12 | 10 | 21 | 18 | 76 |
| Total | 12 | 16 | 18 | 15 | 31 | 26 | 118 |

Gazeta Wyborcza, as the largest broadsheet in the country, distributes local issues together with the national issue. Articles published in the local issues have been included in the analysis. Approximately 17% of the analysed articles were published in the local issues, which corresponds with the 22% for Swedish coverage.

### 5.2.1 General tone

As in the case of Sweden, a positive tone dominated the coverage (81% of all articles). Only a small number of articles had a negative (6%) or neutral tone (13%). In 2006 and 2007 there were no negatively skewed articles at all. Since 2007 the percentage of positively framed articles fallen steadily, while negative and neutral tones were used more often.

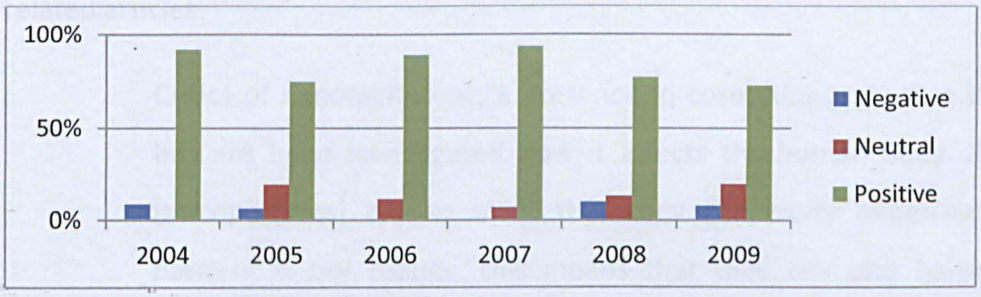


Figure 5-10 Tone of the Polish articles, 2004-2009

### 5.2.2 Risks and benefits

The dominance of the positive tone coincides with the fact that the Polish media debate on nanotechnology was mostly focused on the benefits of nanotechnology (83% of the coverage). A steady growth in the focus on benefits can be observed between 2004 and 2007 when all of the articles published in the Polish press were focused on benefits of nanotechnology. The only Polish article

that was solely focused on risks was published in 2008. All other articles discussed risks alongside benefits. Nevertheless those articles never constituted more than 25% of the yearly coverage.

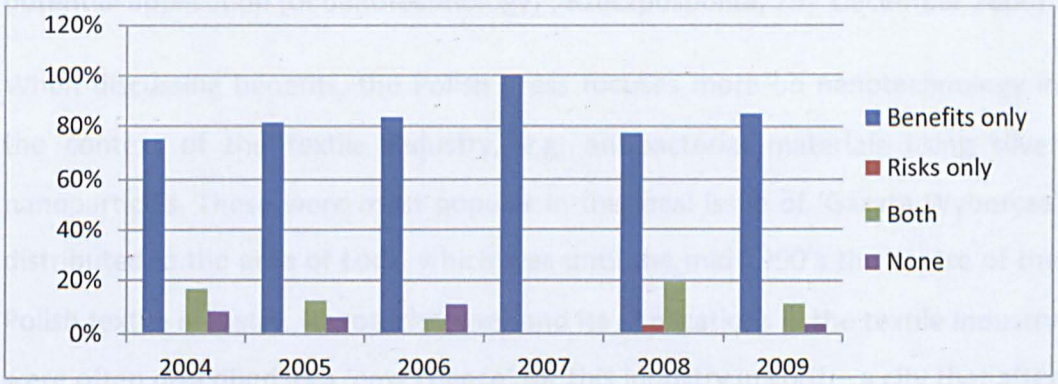


Figure 5-11 Benefits vs. risk in Polish articles, 2004-2009

As in the case of Swedish coverage, the main benefits of nanotechnology mentioned in the articles are: new possibilities and higher effectiveness of processes in many areas of human activity. The industries that are most often mentioned in the context of nanotechnological development are the electronics, medicine, computing and telecommunication industries. Although discussion of risks was limited in Polish press it is possible to point out some example of risk-related articles:

> Critics of nanotechnology's presence in cosmetics warn that it has not been investigated how it affects the human body. If [nanoparticles] are so small that they can easily penetrate barriers in our tissues, this means that they can also harm people by transporting the harmful substances (Gazeta Wyborcza, 12th June 2009).

> (...) The membrane stops bacteria and toxins. However, nanoparticles are able to penetrate it. It is hard to exclude that they will not give any unwanted effects (Rzeczpospolita, 1st June 2008).

The risks of nanotechnology are mostly described as 'unknown' risks both for human health and the entire environment. As in Sweden the applications of nanotechnology are often described as 'potential' ('There are more and more potential application [of nanotechnology]'; Rzeczpospolita, 29th December 2006).

When discussing benefits, the Polish press focuses more on nanotechnology in the context of the textile industry, e.g. antibacterial materials using silver nanoparticles. These were most popular in the local issue of 'Gazeta Wyborcza' distributed in the area of Łódź, which was until the mid 1990's the centre of the Polish textile industry. Nanotechnology and its applications in the textile industry were often described as a 'new chance' for this industry in Łódź – a city that after the fall of communism was severely hit by the problem of unemployment.

### 5.2.3 Geographical focus

The majority of Polish articles were focused on other countries and scientific nano-achievements of foreign scientists and companies. To some extent this can be explained by the fact that in most cases the Polish press was 'forwarding' reports published in foreign scientific journals – 'Nature', 'Science' and 'Proceedings of the National Academy of Sciences' in the US.

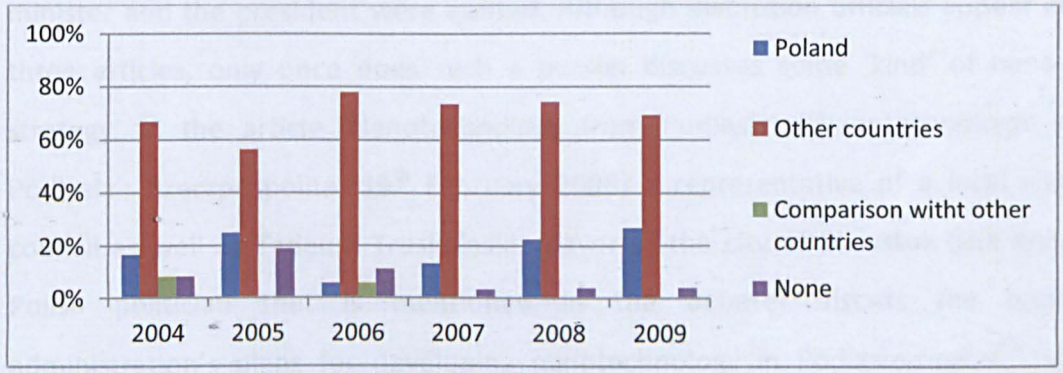


Figure 5-12 Geographical focus of Polish articles

### 5.2.4 Actors

The analysis of the actors active in the media debate on nanotechnology in Poland shows that scientists were the most active group (71% of articles). Both Polish and foreign scientists were quoted or mentioned in the articles, although

the analysed newspapers referred more often to foreign scientists. However, Polish scientists also appeared in articles that were reporting achievements of foreign nano-scientists, where they commented and explained particular achievements or scientific phenomena. The second group active in this debate are representatives of business, although they could be found only in 14% of articles. Business representatives were most often found in the articles that focused on Poland only. Between 2007 and 2009 in particular Polish newspapers published information about Polish companies trying to use nanotechnology and deliver nano-products on the market, signalling heightened expectations around nanotechnology as an economic opportunity.

All other actors appeared in less than 10% of the coverage. Among them the most active were NGOs, Military officials and institution officials. In the first two cases (NGOs and Military), these were foreign actors – representatives of the US Army (in the context of military research) or the Centre for Responsible Nanotechnology. It is worth noticing that, apart for one exception, Polish politicians were not active in this debate. Politicians as actors in the debate occurred only once – in the article published in 'Gazeta Wyborcza' (20th April 2007) reporting on the new Russian nano-strategy where both the Russian prime minister and the president were quoted. Although institution officials appear in three articles, only once does such a person discusses some 'kind' of nano-strategy. In the article 'Nanotechnology from Podlasie' ('Nanotechnologie z Podlasia'; Rzeczpospolita, 19th February 2008) a representative of a local city council as well as Tadeusz Truskolaski, mayor of the city of Bialystok (the only Polish politician that is mentioned in the debate) discuss the local administration's plans for developing nanotechnology in Podlasie-region[15]. In other cases institutional officials discussed some particular applications of

[15] Podlasie is region in the Eastern Poland, characterised (considering the existing statistical data or national surveys) as less developed than the rest of the country and traditionally conservative.

nanotechnology, e.g. in the products of some local company or the use of nanotechnology in the process of preserving some monuments.

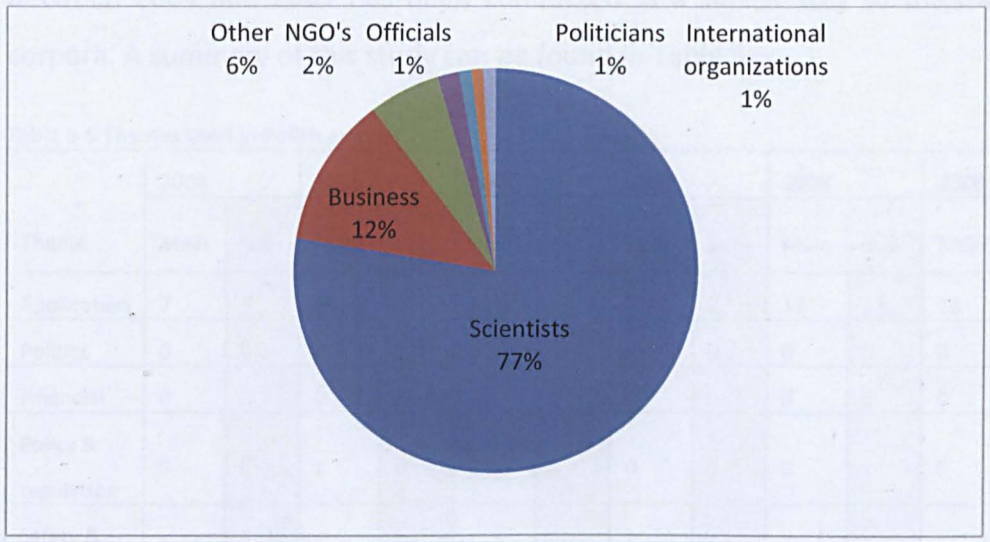


Figure 5-13 Main actors in Polish articles

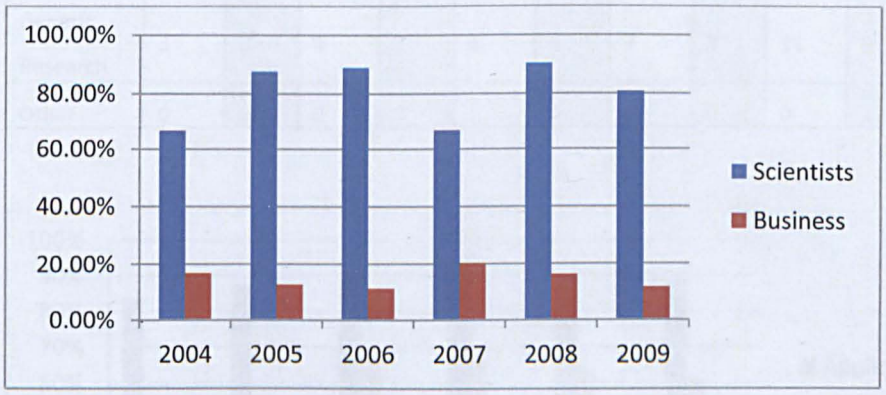


Figure 5-14 Scientists and Business-representatives in Polish articles

The media appeared only once as an active actor in this debate, in the article as an active actor in the debate, i.e. in a short article reporting on a British TV programme about a 'self-cleaning window'. It is also worth mentioning that Polish newspapers very often referred to (or quoted) such people as Ray Kurzweil and Eric Drexler. As in Sweden, journalists to 'validate' or in this case evaluate their views and opinions, e.g. through the use of following statements: 'Eric Drexler – the guru of nanotechnology' (Gazeta Wyborcza, 29th June 2004).

### 5.2.5 Themes

The study of the themes used in the Polish media debate on nanotechnology between 2004 and 2009 has been conducted in a similar way to the Swedish corpora. A summary of this study can be found in Table 5-5.

Table 5-5 Themes used in Polish articles

| Theme | 2004 | | 2005 | | 2006 | | 2007 | | 2008 | | 2009 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Main | Sub- | Main | Sub- | Main | Sub- | Main | Sub- | Main | Sub- | Main | Sub- |
| Application | 7 | 3 | 10 | 4 | 12 | 4 | 7 | 7 | 17 | 11 | 18 | 5 |
| Politics | 0 | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| Financial | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| Policy & regulation | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| Safety & risks | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 2 | 1 | 2 |
| Generic Research | 3 | 2 | 4 | 5 | 4 | 8 | 7 | 3 | 11 | 9 | 7 | 9 |
| Other | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

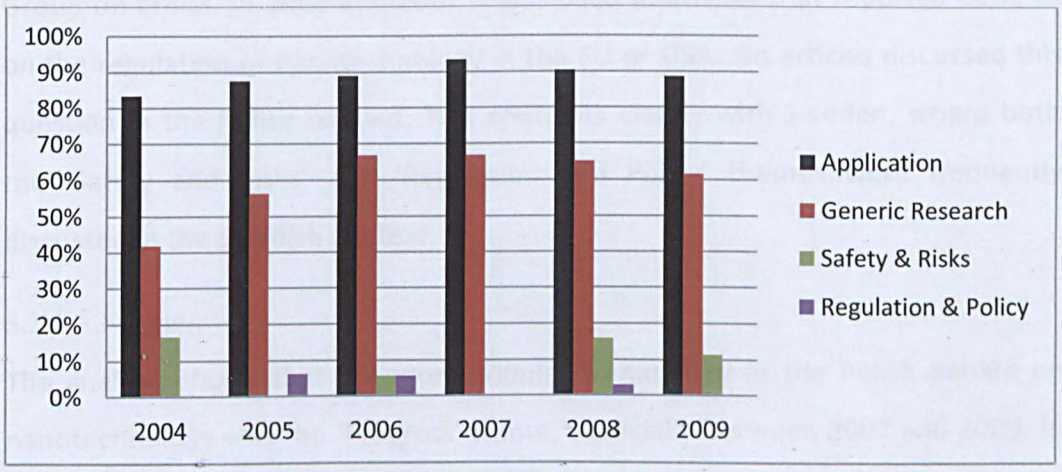


Figure 5-15 The most popular themes in Polish nano-debate

As can be observed in Table 5-5 and in Figure 5-15, the Polish press was mostly focused on applications and generic research in the area of nanotechnology. 'Application' and/or 'Generic research' were themes used in almost every Polish articles published in the studied time period.

The focus on applications remained at approximately the same levels between 2004 and 2009, i.e. each year this theme was used in ca. 87% of articles. The research-theme was not as popular in the beginning of this time period but during the rest of the studied period its used remained at the level above 60% of the articles per year. The 'Risk and Safety' theme was not very popular in Polish coverage. In 2004 it was used in two articles that discussed nano-threats (grey goo or self-replicating nanobots) suggested by Eric Drexler and his revisions of this scenario (Drexler, 1986; Giles, 2004). This theme started to be used again in 2008 when five articles in total discussed safety and risks of nanotechnology. It can be argued that this was caused by the fact that in 2007 and 2008 the questions of the risks of nanotechnology were widely discussed at the EU-level (e.g. EU debate on the regulation of the use of nanoparticles in food products and cosmetics). The use of the Regulation and Policy theme was rather limited in the analysed time period. It can be found only in three articles published between 2005 and 2007. In 2005 it was related to the fact that Polish scholars were appointed as consultants for the European Commission and the European Group on Ethics. In 2006 and 2007 it was used in articles that reported debates on the regulation of nanotechnology in the EU or USA. No articles discussed this question in the Polish context. This contrasts clearly with Sweden, where both the 'Safety and Risks' and 'Regulation and Policy' themes were frequently discussed in the Swedish context.

### 5.2.6 Frames

The analysis shows that the most popular frame used in the Polish debate on nanotechnology was the 'Progress'-frame, especially between 2007 and 2009. In 2007 it was used in more than 90% of articles. The appearance of particular frames is presented in Table 5-6 and Figure 5-16.

Table 5-6 Frames used in Polish nano-articles

| Frame | 2004 | | 2005 | | 2006 | | 2007 | | 2008 | | 2009 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Main | Sub- | Main | Sub- | Main | Sub- | Main | Sub- | Main | Sub- | Main | Sub- |
| Progress | 8 | 1 | 8 | 3 | 12 | 2 | 13 | 1 | 24 | 3 | 21 | 2 |
| Economic Prospects | 0 | 1 | 0 | 2 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 |
| Ethical | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unforeseen risks | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 2 | 2 |
| Hope | 0 | 7 | 4 | 6 | 1 | 5 | 1 | 4 | 0 | 12 | 3 | 12 |
| Loss of control | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Public Accountability | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Time | 0 | 0 | 0 | 3 | 0 | 3 | 0 | 0 | 1 | 7 | 0 | 5 |
| Confluence | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| New Revolution | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 |
| Entertainment | 0 | 3 | 0 | 1 | 2 | 1 | 0 | 1 | 0 | 2 | 0 | 2 |
| National | 0 | 3 | 0 | 5 | 0 | 0 | 0 | 1 | 0 | 6 | 0 | 3 |
| Enthusiasm | 3 | 2 | 3 | 0 | 2 | 3 | 0 | 3 | 3 | 7 | 2 | 6 |

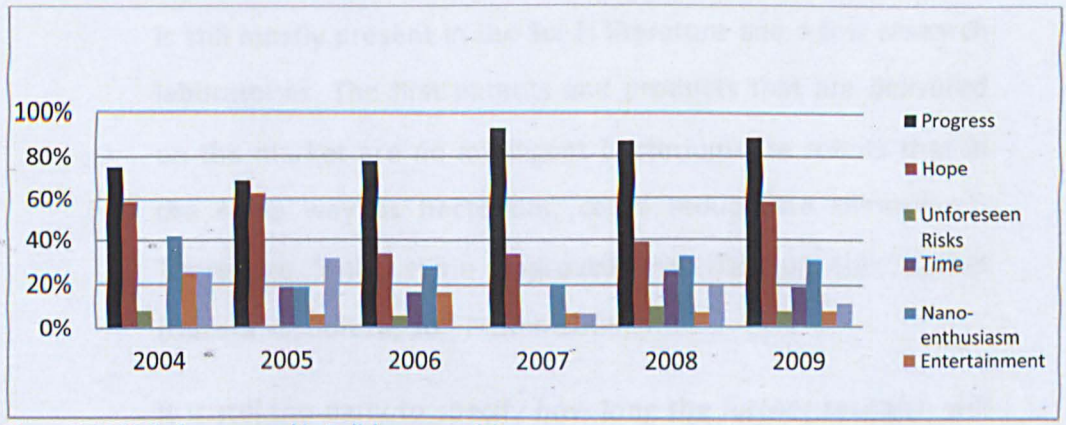


Figure 5-16 Main frames used in Polish nano-articles

The 'Progress'-frame was very often used together with the 'Hope' frame (mostly as a secondary frame). As in the case of the Swedish coverage, these articles simply reported scientific breakthroughs and their possible applications,

which are however not yet available to the wider public. But this automatically raises hopes related to future nanotechnological applications. The 'Hope' frame, as mentioned earlier in this paper, refers to 'the infinite applications' of nanotechnology, which can be seen in the following example, an example that also highlights the merging of facts and what is, as yet, fiction:

> Instead of cutting the patient open we insert into his body a robot that is smaller than the smallest tablet and this robot reaches the diseased organ and performs its task. (...) Such examples [of potential application] can be found in every sphere of our life (Gazeta Wyborcza, 2nd February 2009).

It can be also observed that the 'Economic Prospects'-frame was less popular in Poland, although it can be found in at least one article per year (except 2009) with a peak in 2007 when it was found in 13% of articles. The 'Time' frame was used only in the years 2005-2006 and 2008-2009 and can be characterised by the following quotes from the corpora, where hope is tempered with caution:

> These are still 'preliminary trials'. Nanotechnology, as the engineering on the level of single particles and atoms is called, is still mostly present in the Sci-Fi literature and a few research laboratories. The first patents and products that are delivered on the market are no intelligent bacterium-size robots that in the same way as bacterium, could reduplicate themselves. There are 'only' some improved materials on the market (Gazeta Wyborcza, 30th March 2006).

> It is still too early to specify how long the further research will last for and when will it be possible to produce nanobiodetetctors on an industrial scale. (Gazeta Wyborcza, 11th July 2008).

The 'Unforeseen Risks' frame was not as popular as in the Swedish press and its use was extremely limited across the studied time period. One of the few examples of the use of the 'Unforeseen risk' frame in Polish coverage is presented below:

> However, critics are warning that it still has not been investigated how nanoparticles may affect organisms (Gazeta Wyborcza, 12th September 2009)

The additional frames, introduced during the analysis of the corpora, were relatively popular in Polish press. The first one was labelled 'Nano-enthusiasm', which was appeared each year between 2004 and 2009 in at least 20% of articles per year. The quotes below are examples of the texts where this frame has been used:

> Invisibility is possible! Fantasy becomes reality: the invisibility cloak is no longer just a product of our imagination! (Rzeczpospolita, 20th October 2006).

> If necessary nanorobots will also go to war, transforming into invisible soldiers and spies (Gazeta Wyborcza, 29th April 2004).

> We will have quantum computers by 2020 (...) The data will be stored and processed due to quantum phenomenon that were frightening Albert Einstein. One of them is teleportation – the movement of the items faster than light. Quantum computing will allow a rapid cipher breaking and at the same time it will create ciphers that would be unbreakable by definition. It will allow scientists – physicians or geneticists – to solve the riddles that are so complex that it would take more time than the universe exists to solve them with the use of today's computers (Gazeta Wyborcza, 14th April 2006).

> In less than 20 years we won't need to kill pigs in order to eat a tasty ham. We will produce meat by ourselves. Impossible? Still. We will be taught how to produce meat by nanotechnology – one of the most important sciences of 21st century. Thanks to it our life will change unrecognizably. We will be able to construct the structure of things around us (Gazeta Wyborcza, 23rd February 2005).

In some cases the enthusiasm was emphasised through the use of the exclamation mark, e.g. 'Nanometre is a millionth of a meter!' (Gazeta Wyborcza, 23rd February 2005). In Poland this frame appeared each year between 2004 and 2009– in at least 20% of articles per year. It was often used in articles discussing new applications of nanotechnology or some breakthroughs in this area. It was almost exclusively used in articles where scientists were the main actors (91%).

Another frame introduced during the process of reading the Polish articles was the 'National'-frame. Two examples of the texts representing this frame are presented below:

> (...) scientists presented the device at a conference on Crete. The Polish invention, although still in testing phase, caused great interest (Gazeta Wyborcza, 9th July 2005).

> Nanotechnology is a field that is highly-developed in Poland. In this respect our research institutes are recognized internationally. We can boast of many achievements and research excellence (Rzeczpospolita, 7th September 2006).

This frame was used in more than 15% of the analysed articles. It was most popular in the beginning of the studied time-period and then again in 2008 and 2009. Those articles discussed new investments in nanotechnological research (opening of the new nano-lab at the Jagiellonian University in Cracow), research

successes of Polish scientists (even such that gained interests of foreign institutions such as NASA or NATO) or personal achievements of Polish scientists (e.g. nomination of Prof. K. Marczewski to the European Group on Ethics in 2005).

It has also been observed that the 'Entertainment' frame (the smallest football stadium; smallest car in the world; 'Invisibility cloak' etc.) was more popular in Poland (10%) than in Sweden (4%).

Other frames were used sporadically. The 'Loss of control' frame was used in four articles in total, e.g. in the context of Eric Drexler's theories on the potential risks of nanotechnology. It is worth mentioning that the 'Public Accountability' frame, which was relatively popular in Sweden (33% of articles in 2008) was not used at all in Polish corpora.

## 5.3 Iran

Because of the problems related to accessing Iranian newspaper archives, discussed in detail in chapter four, only one newspaper, 'Hamshahri', has been used in the process of searching for relevant articles.

In total, 109 Iranian articles, published in the newspaper Hamshahri were selected for further analysis and coded. Figure 5-17 and Table 5-7 provide more detailed information on that question.

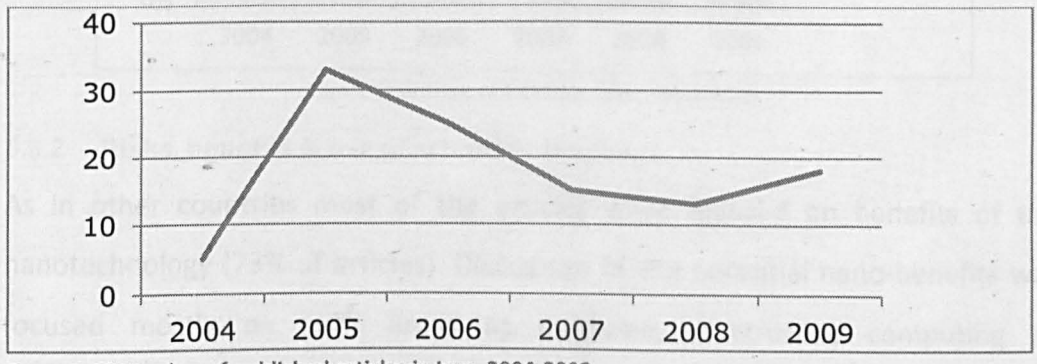


Figure 5-17 Number of published articles in Iran, 2004-2009

Table 5-7 Number of nano-related articles published between 2004 and 2009

| Newspaper | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | Total |
|---|---|---|---|---|---|---|---|
| Hamshahri | 5 | 33 | 25 | 15 | 13 | 18 | 109 |

### 5.3.1 General tone

The study of the general tone of the nano-articles shows that 84% of them are positive with only 2% of articles that have a negative tone. A negative tone was found in two articles published in 2008 and 2009. These articles discussed the problem of nanotoxicity and risk related to the fact that nanoparticles may penetrate human cells.

A neutral tone was used in articles that mentioned some negative aspects/risks of nanotechnology as well as articles that were simply reporting some scientific findings in this area or the current stage of the development of nanotechnology. Although whenever it was related to Iran and Iranian science a positive tone was preferred (77% of articles focused on Iran).

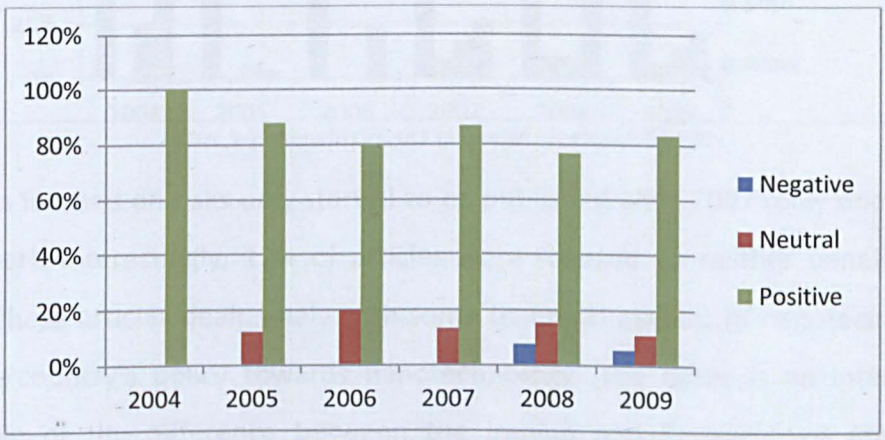


Figure 5-18 Tone of Polish articles, 2004-2009

### 5.3.2 Risks, benefits & use of scientific language

As in other countries most of the articles were focused on benefits of the nanotechnology (73% of articles). Discussion of the potential nano-benefits was focused mostly on such areas as medicine, electronics, computing or telecommunication. Articles focused on issues related to the safety and risks started to appear in the second half of the analysed period, i.e. 2007-2009. Risks

of nanotechnology have been discussed every year but in a very limited number of articles – 1-3 per year. The risks of nanotechnology were usually discussed together with benefits of nanotechnology and usually more space was dedicated towards benefits than risks, e.g.:

> In 2004 another research proved that C60 can cause damages in a fish brain. However, nanotechnology has also many applications in the area of ecology (...). In any case nanotechnology is currently developing very fast and in the future, but not ages, it will be involved in all field of science (Hamshahri, 31st August 2005).

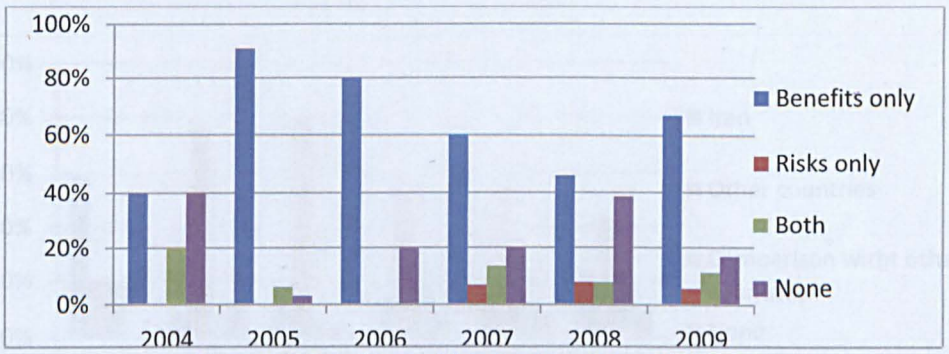


Figure 5-19 Benefits vs. risk in Iranian articles, 2004-2009

Articles focused on risks only started to be published after 2007 (only one paper per year). Interestingly, 17% of articles were focused on neither benefits nor risks. These articles dealt solely with some technical aspects of nanotechnology or the country's policy towards nanotechnology. The latter is an interesting example of the difference between the Iranian and European or American coverage. Iranian articles very often contain detailed descriptions of experiments conducted by researchers. Authors of these articles are often using specific scientific vocabulary that is not necessarily understood by a reader without a scientific background and is usually not used in British, Canadian or American broadsheets. These articles were often (but not always) written in a neutral tone.

### 5.3.3 Geographical focus

As in Poland and Sweden, most articles were focused on other countries, i.e. achievements of foreign scientists or nano-companies. Only 29% of articles discussed nanotechnology in the context of Iran and its own research. More than a half of the coverage (63%) reports on foreign research (e.g. by covering the latest papers published in the international journals such as 'Nature' or 'Science') or on-going discussions around nanotechnology in other countries (e.g. regulatory issues). The political tensions between the Islamic Republic of Iran and the United States (the two countries have no diplomatic relations since 1979) or the United Kingdom is not reflected in the news reporting on nanotechnology. The majority of the articles report the achievements of US or UK scientists.

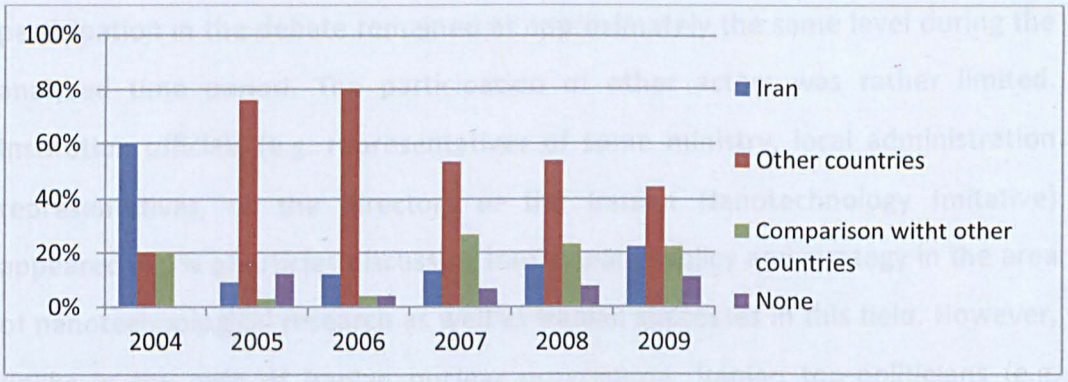


Figure 5-20 Geographical focus of Iranian nano-articles

Since 2006 more and more articles were dedicated to Iranian nanotechnology. However, unlike in Poland and Sweden many articles were focused on comparing Iran with other countries. Those articles usually discussed nanotechnology in the Iranian context but also made comparisons with other countries, especially those in the Middle East. However, Iran's strong position in the area of nanotechnology is frequently stressed in comparison both with developed countries (US, EU-members) as well as Asian and Muslim countries. This did not occur in the Polish or Swedish corpora. Here are some examples of these practices, which can be also linked to the 'National' frame:

> Iran has the first place in nanotechnology in the Muslim World (Hamshahri, 10th December 2007).
>
> In the beginning of our works on nanotechnology, Iran was on 51st place in the world in terms of articles and had the sixth place in among the Muslim countries. Last year we reached the first place among the Muslim countries, excluding Turkey, and 19th place among in the world. We even left behind the Zionistic Regime (Hamshahri, 15th February 2009).

### 5.3.4 Actors

As in other countries (including Poland and Sweden) the most popular actors in the debate on nanotechnology are scientists (73% of the coverage). Their participation in the debate remained at approximately the same level during the analysed time period. The participation of other actors was rather limited. Institution officials (e.g. representatives of some ministry, local administration representatives, or the directors of the Iranian Nanotechnology Imitative) appeared in 6% of articles discussing Iranian nano-policy and strategy in the area of nanotechnological research as well as Iranian successes in this field. However, unlike in the case of Iranian nuclear programme, Iranian top-politicians (e.g. president, speaker of the parliament, or the supreme leader) were not active in this press debate on nanotechnology. Business representatives that were cited or mentioned in the articles were mostly representatives of foreign cosmetic or electronic companies (e.g. IBM).

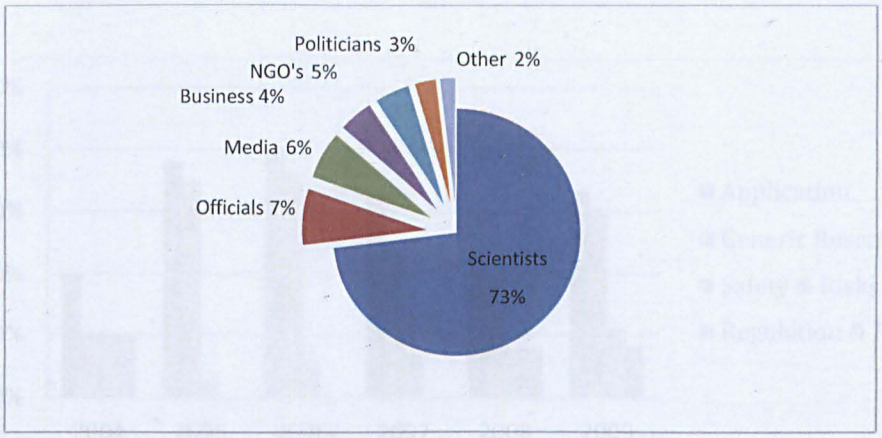


Figure 5-21 Main actors in Iranian nano-debate

### 5.3.5 Themes

Like in Polish and Swedish coverage the most popular themes in the Iranian debates were 'Application' and 'Generic Research' (see Table 5-8 and Figure 5-22).

Table 5-8 Themes used in Iranian articles

| Theme | 2004 | | 2005 | | 2006 | | 2007 | | 2008 | | 2009 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Main | Sub- | Main | Sub- | Main | Sub- | Main | Sub- | Main | Sub- | Main | Sub- |
| Application | 0 | 2 | 15 | 10 | 15 | 5 | 9 | 1 | 6 | 0 | 8 | 4 |
| Politics | 3 | 0 | 1 | 2 | 0 | 0 | 2 | 2 | 3 | 1 | 1 | 4 |
| Financial | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 |
| Policy & regulation | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 1 |
| Safety & risks | 0 | 1 | 0 | 2 | 1 | 2 | 1 | 1 | 2 | 0 | 1 | 3 |
| Generic Research | 1 | 0 | 17 | 6 | 8 | 10 | 2 | 5 | 1 | 4 | 5 | 6 |
| Other | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 1 | 1 | 0 | 1 | 1 |

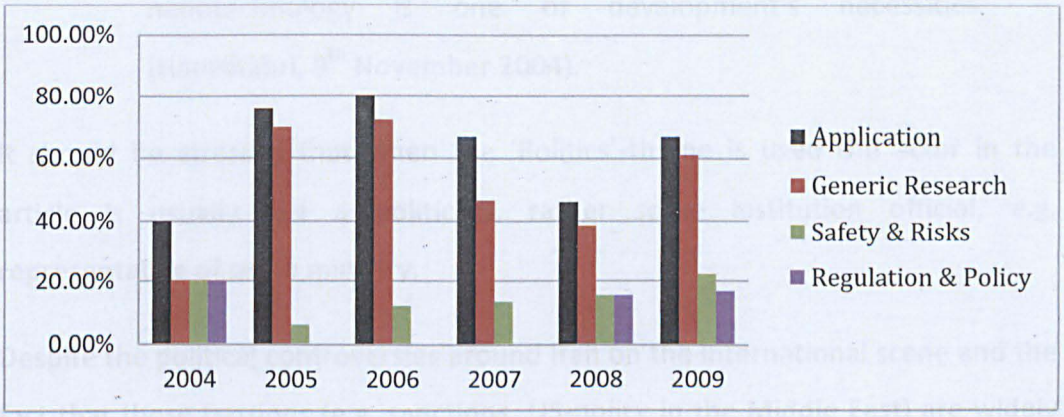


Figure 5-22 The most popular themes in Iranian nano-debate

The second and the third place are occupied by the themes of 'Politics' (17%) and 'Safety and Risks' (13%). The strong position of the Politics theme is something that has not been observed in Poland or Sweden. The Iranian articles where this theme has been coded usually discussed strategies for developing nanotechnology in Iran, nanotechnology's importance for the country's development as well as pointing out the state's support for this emerging technology. Below are two examples:

> Plan of the development of nanotechnology was assigned in the form of one task to one institution. In the field of nanopolicy we have considered two main goals, of which one is enhancement of peoples' life quality and to generate wealth. The second one is to be classified place among 15th best countries in the field of nanotechnology. Therefore, instead of assigning this task to one ministry, it was assigned to one special committee and everything from the scientific development to generation of wealth is its [committee's] responsibility (Hamshahri, 15th February 2009).

> Giving the priority to the plans related to country's nanotechnology is one of development's necessities (Hamshahri, 9th November 2004).

It should be stressed that when the 'Politics'-theme is used the actor in the article is usually not a politician, rather some institution official, e.g. representative of some ministry.

Despite the political controversies around Iran on the international scene and the fact that these tensions (e.g. sanctions, US-policy in the Middle East) are widely discussed in Iranian media, it has not affected the debate on nanotechnology. The only example of situating nanotechnology in a context of international politics is the use of term 'Zionistic regime' in a discussion of Iran's successes in the area of nanoresearch. It is used very often by Iranian media and state propaganda in order to describe Israel.

The use of the 'Safety and Risks' theme remained at the same level across the analysed time period (1-2 articles per year), achieving a small peak in 2009 (four articles). An example of the use of this theme is the following quote:

> However, despite all these compliments, nanotechnology has also many ardent opponents, among whom the most important and active ones are environmental groups. The main point of these opposition groups is the fact that we do not know too much about side-effects of nanotechnology, effects that may sometimes have such influence on environment as a dangerous poison. The second point is that we do not have a proper control over nanotechnology (...) (Hamshahri, 31st August 2005).

The mention of an 'opposition' group may appear as something rather unexpected when considering Iranian political system. However, it needs to be observed that the author of this article is writing about foreign groups and

foreign NGOs. The studied articles do not mention any Iranian NGO or any other group/individual that would question the positive picture of Iranian nanotechnology.

The 'Policy and Regulation' theme was not used until 2008 when it occurred for the first time in two articles. The regulatory questions were usually discussed in the context of other countries, not in the context of Iran and its own legislation.

### 5.3.6 Frames

The study of frames used in the Iranian debates on nanotechnology shows some similarities between Iranian coverage and press debates conducted in other countries. The most popular frames were 'Progress' (78% of) and 'Hope' (59%). Table 5-9 and Figure 5-23 provide more details on that question.

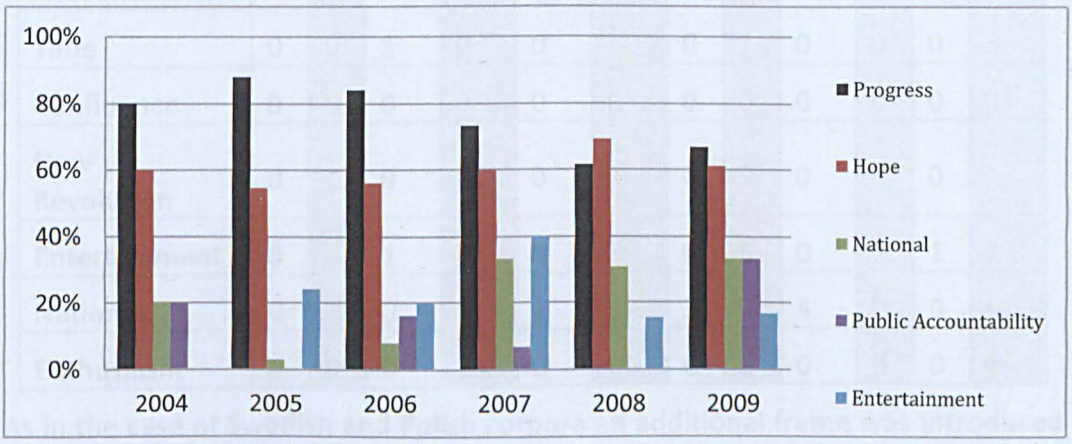


Figure 5-23 Most popular frames in Iranian nano-articles

As in Poland and Sweden the 'Progress' and 'Hope' frames were often used together, with 'Hope' being usually a secondary frame. The use of the 'Hope' frame remained at approximately the same level across the studied time period, i.e. around 60% of articles per year. However, the use of the 'Progress' frame fell gradually after 2006. Instead the 'National' and 'Public Accountability' frames were used more often.

Table 5-9 Frames in Iranian nano-articles

| Frame | 2004 | | 2005 | | 2006 | | 2007 | | 2008 | | 2009 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Main | Sub- | Main | Sub- | Main | Sub- | Main | Sub- | Main | Sub- | Main | Sub- |
| Progress | 4 | 0 | 27 | 2 | 20 | 1 | 7 | 4 | 7 | 1 | 9 | 3 |
| Economic Prospects | 0 | 1 | 0 | 3 | 1 | 0 | 1 | 3 | 0 | 2 | 0 | 1 |
| Ethical | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unforeseen Risks | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Hope | 0 | 3 | 4 | 14 | 0 | 14 | 3 | 6 | 0 | 9 | 5 | 6 |
| Loss of control | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Public Accountability | 1 | 0 | 0 | 0 | 3 | 1 | 0 | 1 | 0 | 0 | 2 | 4 |
| Time | 0 | 0 | 1 | 0 | 0 | 5 | 0 | 1 | 0 | 0 | 0 | 3 |
| Confluence | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| New Revolution | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Entertainment | 0 | 0 | 1 | 7 | 0 | 5 | 0 | 6 | 0 | 2 | 1 | 2 |
| National | 0 | 1 | 0 | 1 | 1 | 1 | 3 | 2 | 4 | 0 | 0 | 6 |
| Enthusiasm | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

As in the case of Swedish and Polish corpora an additional frame was introduced to capture the National-focus of the articles. It was used in 17% of the articles and it often referred to Iran's successes in the field of nanotechnology, with often comparisons to other countries, e.g.:

> Iran occupies the second place in the world in nanotechnology (Hamshahri, 15th July 2005).

> Currently Iran has the first place in nanotechnology among the countries of this region and in this respect Iran counts as a most advanced country among the Muslim countries (Hamshahri, 11th February 2008).
>
> Today, various countries in the world, e.g. Japan, America [USA], China, India, Taiwan, South Korea, Israel, European Union and Russia are HEAVILY competing with each other to occupy the first place in the world in nanotechnology. Even Japan and America called this field the top technological priority of their countries. Of course, Iran's position in that field, in comparison with others field of science, is better and the distance between us and the developed countries in the area of nanotechnology is shorter than the distance in other fields. In terms of publication of nanotechnology articles in ISI journals, in 2004 Iran occupied 42nd place in the world. (Hamshahri, 22nd May 2007).

Although this frame has been used in all three countries, the way it was used in the Iranian press differs slightly from the Swedish or Polish corpora, which will be discussed in more depth in chapter six.

Another frame that became more popular towards the end of the analysed period was the 'Public Accountability' frame, which refers to the coverage that discuss the ethical, legal, and societal implications of nanotechnology including people's influence over research and development. However, in most cases the articles were forwarding news published abroad, reporting the results of research on public perception of science or citing foreign NGOs that were calling for attempts to inform the public about nanotechnology or to increase public's influence over nano-research. Frames used in the Iranian context were slightly different, i.e. it was discussed in terms of potential benefits for the society, rather

than risks that should be controlled. A useful example is the interview with an Iranian researcher, Iman Maradi, published 2nd March 2009. Maradi points out that in Iranian nanoscientists do the research without considering whether it will be useful for country's society or not. The background assumption in that interview is that nanotechnology is good and the only question is how Iranian society may benefit from that.

The 'Entertainment' frame was relatively popular and was found in 22% of the analysed articles. It was most often used between 2005 and 2007 (5-8 articles per year). As in Poland and Sweden these articles highlighted a more entertaining side of nanotechnology including construction of the nano-pencil, nano-guitar or nano-football stadium.

The 'Economic Prospects' frame can be found every year among Hamshahri nano-articles, with the highest value in 2007 (4 articles). An example of this frame is the article published on 15th October 2006 under the title 'The market of nano-products will be worth as much as 2600 billion dollars in 2015'.

Other frames such as 'Time' or 'Unforeseen Risks' were used sporadically and irregularly (1-5 articles across the whole analysed time-period). The 'Loss of control' frame, which had been relatively popular in the Western coverage of nanotechnology, has been also used sporadically in the press. Nevertheless, an obvious example can be found in the article published in 'Hamshahri' on 31st August 2005 where the author states that (referring as in so many other cases at that time implicitly to the grey goo scenario):

> (...) if this technology would become wide spread in the future (in terms of its use), it may run out of the control, bringing threat for humans.

However, in most cases the authors, instead of generally discussing some 'Unforeseen Risks' of nanotechnology, tend to be more focused on specific risks, e.g. nanotoxicity.

## 5.4 Metaphors

As I have mentioned earlier, the discussions of new issues, such as new emerging technologies, are supported by the use of metaphors, since they 'enable people to deal with novel and current events, and to incorporate new experiences into older cultural or cognitive frameworks of thinking and acting' (Gogorosi, 2005, p. 300). In that context, nanotechnology can be definitely categorised as 'novel'. Additionally, as observed by Dorothy Nelkin (1987), journalists often use metaphors in order to familiarize readers with novel scientific or technological issues. Metaphors have been studied by various researchers in the context of biotechnology (Hellsten, 2002; Holmgreen, 2008; Nelkin, 2001; Nerlich et al., 2002; Petersen, 2005; Zwart, 2009). There are also some studies focused on the use of metaphors in nano-debates (Hanson, 2011; Ten Eyck & Hernandez, 2009), although nanotechnology has still not attracted the same level of interest of metaphor-researchers as biotechnology did. Therefore, it seems to be justified that the study of the nano-debates in Sweden, Poland and Iran will be complemented with the analysis of metaphors. This will not only allow me to enhance the picture of the debates obtained in the previous sections, but it may also contribute to the existing literature on metaphors used in the context of nanotechnology, especially in the trans-national context.

The search for metaphors has been conducted through the readings of the collected Swedish, Polish and Iranian articles. Overall, the number of metaphorical expressions found in the media texts was limited. These metaphors have been used only occasionally and therefore it is rather hard to classify metaphors or to reconstruct any metaphorical concepts used in the corpora.

Nevertheless, despite the low numbers, it is possible to point out some main characteristics of the metaphors (including clichés and stock book titles) used in the Swedish, Polish and Iranian media debates on nanotechnology. The following section will discuss the metaphors used to describe nanotechnology in the studied texts: Revolution, Brave New World, Small Worlds, Superhero, Nature, War and fight metaphors.

### 5.4.1 Revolution & Change

A significant part of all metaphors refer to the notion of revolution. This metaphor can be found in the debates on any new technologies (e.g. GM-food), which are supposed to 'revolutionize' and bring radical change not only to the particular area (communication, medicine, electronics, production technologies etc.), but even any other aspects of our life (Gogorosi, 2005; Kaplan, 1990). Due to its widespread use around the world it can be described as 'global metaphor'. It has also been used in the debates about nanotechnology. Robert Sparrow observes that

> This narrative holds that nano-technologies are revolutionary in two senses: firstly, that they represent a radical break from previous human efforts in the area; secondly, that they will change the world (Sparrow, 2007, pp. 58–59).

The most notable examples of the use of revolution metaphor in the context of nanotechnology are Eric Drexler's 'Engines of Creation' (1986) or comparison to the 'New Industrial Revolution' in the official White House press release (2000).

The revolution metaphor is ubiquitous and therefore its use is not limited to Sweden, Poland or Iran. As stated by Sparrow (2007):

> The idea that the development of nanotechnology heralds a technological revolution with widespread social, economic, and

> political implications is perhaps the most common claim made in discussions of nanotechnology (p. 59).

In all three countries journalists have written (at least once) about 'nano-revolution'. On 22nd February 2008, in an article discussing the recent announcements of Ray Kurzweil, 'Gazeta Wyborcza' (Poland) claimed that 'Nanotechnology will revolutionize medicine and will give us immortality'. Swedish journalists limited themselves to the sporadic use of term 'nano-revolution' in the titles or headlines. However, the most prominent use of this metaphor can be observed in Iranian newspaper 'Hamshahri', which, in the very beginning of the studied period, was reporting on 'The rise of the nanotechnological revolution' (Hamshahri, 8th August 2005) and describe nanotechnology as 'the technological revolution of 21st century' (Hamshahri, 3rd March 2005). In the articles published in the following years the references to revolutionary potential of nanotechnology were not as frequent, but still it appeared more often than in Swedish and Polish coverage. It must be stated that these revolutionary-references did not have a political character. Nanotechnology was rather a 'technological' or 'new industrial' revolution, rather than a revolution with a political connotations. Science and technology are very often employed in the official propaganda, which is describing any technological, industrial or economic progress as an 'achievement of the Islamic Revolution' (e.g. railway development). However, in the case of nanotechnology, despite the fact it was pointed out as one of the strategic research areas, no political-references are made. The term 'Islamic Revolution' was never used in any of the studied articles. As mentioned, the revolution-metaphor was used in Iran especially in the beginning of the studied period, i.e. when the Iranian Nanotechnology Initiative was actually starting its activities. One may question whether the decline in the use of this metaphor was related to the slightly declining support for nanotechnology during the presidency of Mohammad

Ahmadinezhad who became president in August 2005 (Ghazinoory & Ghazinouri, 2009).

As has been observed, the revolutionary references were not very popular in Sweden. Instead, Swedish media tended to highlight the 'change potential' of nanotechnology. As observed by 'Svenska Dagbladet' 'nanotubes are going to change the world' or even 'create a new world' (29th December 2009), since 'nanoscience is 'enabling' science' (Sydsvenskan, 6th March 2005). Nanotechnology is also described as 'a great chance' that brings 'promethean hopes' (Rzeczpospolita, 1st June 2008). Still, as observed by Sparrow (2007) this 'world-changing potential' of nanotechnology can be traced back to the revolution metaphor.

### 5.4.2 [Brave] New World

The mentioned reference to the 'new world' that would emerge in the future (or is actually emerging right now) due to the changes brought by the nanotechnological revolution, leads to another metaphor that was widely used across the corpora. It is the metaphor of a 'new world' with often connotations to Aldous Huxley's 1932 novel 'Brave New World', i.e. 'Brave Small World' (Gazeta Wyborcza, 28th June 2004) or 'Brave New Technology' ('Dagens Nyheter, 15th August 2008). As observed by Jones et al. (2001) 'the discourse of the new technologies centers on the 'brave new world' (p. 27). However, I would argue this reference to Huxley's concept is often confusing. The metaphor of the 'Brave New World' is supposed to symbolise the concept of radically changed and re-organised society, where technological advances have significant effect on people's life (both positive and negative). An example of such use can be the article published in 'Dagens Nyheter' discussing the potential use of nanoparticles:

> Consequently the tailored medicines can influence brain function more directly. For better. Or for worse. Maybe for

> making the consciousness controlled more easily (Dagens Nyheter, 15th August 2008).

However, in most cases (especially in Poland) the notion 'Brave New World' was associated with the positive aspects of nanotechnology. It could be argued that journalists are using it as a narrative shortcut without knowing or understanding the underlying concepts of this term.

### 5.4.3 Small Worlds

The notion of 'world' is also used in other metaphor found in the corpora, i.e. the metaphor of 'small worlds'. This is a relatively popular metaphor that had been used since the beginning of microscopy, i.e. the construction of 'associations between what is seen with a microscope and possible views of other worlds' (Hanson, 2011, p. 58). This view of 'other worlds', miniature worlds, can be related to the cultural narratives or fairy tales about miniature worlds and miniature people. Hanson (2011) adds that:

> Unlike microscopic worlds whose vistas are depicted in early drawings of microscopical views, the nanoworld is one that can be virtually entered and constructed (p. 75).

As soon as in January 2004 (so the first month of the studied period) a journalist of 'Gazeta Wyborcza' (Poland) stated, while describing the basics of nanotechnology, that nanotechnology 'is a different world – a nano-world' (Gazeta Wyborcza, 20th January 2004). This 'world of nano' or 'nano-world' is governed by different rules and physics laws than 'our world'. Since materials' properties are different on a nano-scale level, this 'nano-world' is also completely 'new' to us and need to be 'explored'. In a Polish article focused the nano-research conducted at the University of Łódź, the author described this research as a 'Small worlds' laboratory' (Gazeta Wyborcza, 12th December 2008). The above metaphor of the 'new world' was not exploited too much in Swedish press (unlike Polish and Iranian coverage).

### 5.4.4 Nanotechnology as Nature

This metaphor was mostly found in Swedish articles. It is the way of presenting nanotechnology as something natural, an element of nature. This phenomenon, i.e. establishing relationship between nature and nanotechnology has been already observed in the nano-debate in other countries (Wickson, Grieger, & Baun, 2010; Wickson, 2008). In her work Fern Wickson (2008) has observed the existence of the 'nanotechnology as nature' narrative used in the debate about nanotechnology. She argues that:

> This can be understood as a foundational narrative about the relationship between nature and nanotechnology. (...) In simple terms, it is the story that nature is an example of nanotechnology at work. (...) This narrative effectively lays the foundation for the development of nanotechnology as a legitimate field of research because through it, nature is said to prove the feasibility of nanotechnology, representing a kind of proof of concept (Wickson, 2008, p. 313).

Consequently, in the studied articles nanotubes are 'growing' in the 'forests of nano-trees' (Dagens Nyheter, 9th May 2004). Nanoparticles are also 'Life's smallest components' (Sydsvenskan, 29th September 2009). It could be argued that this way of describing nanotechnology, was aiming to present it as something that is not artificial and is a natural part of our world (unlike e.g. gene manipulation or anything else that is actually 'produced'). It appeals to readers who could be potentially sceptical about new products developed in research laboratories, especially in the context of the later debate of nano-toxicity. In that context, Wickson adds that it 'suggests that not only is nanotechnology possible, but that it is natural and therefore familiar and uncontroversial' (Wickson, 2008, p. 314).

Interestingly, this metaphor has not been used at all in Polish and Iranian coverage. This may be related to the fact that the public in these countries could be less interested in environmental issues. An example can be the report of Eurobarometer on Europeans' attitude towards the question of climate change. It shows that while Swedes are showing one of the highest level of awareness of climate issues, Poles are usually less interested in those questions and are less likely to take any actions in that area (European Commission, 2011b).

### 5.4.5 Superhero & Military Metaphors

Furthermore, nanotechnology is assigned almost human attributes. 'His Excellency Nano' – writes a Hamshahri journalist in an article published on 28th August 2008. Especially in Polish and Iranian articles nanotechnology was pictured as a 'superhero' that 'comes to help us' improving our daily life, especially in the area of medicine. The Superhero metaphor has been very often used in the debates of nanotechnology and is rooted modern science-fiction literature (Karaminas, 2004; Milburn, 2005). This metaphor was very often used with metaphors of war. Its use in the US debate about nanotechnology has been also observed by Milburn (2005). Nanoparticles are 'the small enemies of bacteria' who will 'confront viruses' and 'destroy bacteria'. War metaphors have been used in the debate from the very beginning of the studied period. In January 2004 'Gazeta Wyborcza' (Poland) was calling to stand up for 'the nanofight' (Gazeta Wyborcza, 13th January 2004). The popularity of the war metaphors could be related to the fact that these metaphors are very popular in any debates on medicine, since metaphors of war are very often used in the debates about medical issues (Annas, 1995; Arrigo, 1999; Larson, Nerlich, & Wallis, 2005; Nerlich, 2009, 2012b). In the same time most of the potential nano-application discussed in the studied articles, were medical applications.

### 5.4.6 Negative picture of nanotechnology

The negative aspects of nanotechnology are also framed with the frames of fight and destruction. These were found especially in Polish newspapers that were

reporting that 'nanoparticles have sneaked into our life' and 'are attacking us from every side' (Gazeta Wyborcza, 27th January 2009). On the other occasion the same newspaper stated that 'Nanoparticles are not angels and they may cause problems' and therefore should be kept 'under control' (Gazeta Wyborcza, 17th September 2009). Such metaphors have not been found in Swedish or Iranian coverage. In one Iranian article discussing potential nano-risks authors claim that '[i]t is possible that nanotechnology will cause destruction, just like a hurricane' (Hamshahri, 28th September 2005). However, this metaphor has not been developed further and has not been found in any other Iranian article (still, the number of risk-focused articles in 'Hamshahri' was very limited).

Especially in Poland, when discussing negative aspects of nanotechnology, nanoparticles are compared to troublemaking soldiers who are 'attacking', 'damaging' 'sneaking' and need to be 'under control'. The only other way used in that context (i.e. nano-risks) is 'nanotechnology is like asbestos of tomorrow'. This metaphor has been often employed in the debates on nanorisks in other countries (Ten Eyck & Hernandez, 2009). In this study it was found only in two Polish and Swedish articles.

## 5.5 Summary

This chapter presented the results of the qualitative content analysis of Swedish, Polish and Iranian nano-articles published between 2004 and 2009. It considered both the results of qualitative content analysis and metaphor analysis.

The study revealed differences between the nano-coverage of each studied country. Polish and Iranian nano-debates were extremely positive, focused on nano-applications and scientific research. It was dominated by scientists. The discussion of risks, regulations or social aspects of nanotechnology was rather limited. In the same time Swedish coverage was more diverse in terms of frames, themes and actors active in the debates. Potential nano-risks and the need for regulations were highlighted relatively often, especially towards the end of the

studied period. The discussion about nanotechnology attracted a broader spectrum of actors: scientists, business representatives, politicians, NGOs and institution officials. In the context of politicians it is worth mentioning that in Poland politicians were almost absent in this debate. There is also an interesting difference between Sweden and Iran. While Swedish politicians used to discuss risks of nanotechnology and the necessity of regulation, the Iranian politicians were only focused on the success of Iranian nanotechnology and its further development. Additionally, it has been observed that Iranian journalists more frequently used the National-frame, referring to the national pride, Iran's achievements and Iran's strong position in the field of nanotechnology.

The study shows also a low number of metaphors used in the media-debates about nanotechnology in the studied countries. Those found in the corpora are metaphors that have been used in the nano-debates in other countries, i.e. metaphors of revolution, small worlds, brave new world, superhero or war metaphors. The most popular metaphor that has been used in all three countries is the revolution metaphor, which has been widely used across the world in the debates on emerging technologies. The use of other metaphors was differing among the studied countries. The data available in this study is very limited and therefore does not allow drawing any conclusions regarding their use.

The results presented in this chapter constitute a basis for the examination conducted in the discussion, where I will analyse the results using the 'model of mediated issue development' that was presented in chapter two. It will be used in order to highlight specific patterns of the Polish, Swedish and Iranian nano-debates. However, the results of content analysis and metaphor analysis will help with investigating the applicability and generalisability of the model, which have been developed by Nisbet and Huge (2007).

The use of the 'National'-frame, which has been introduced during the analysis of the corpora, will be also discussed in that chapter, aiming to find out differences and country-specific characteristics of their use.

The data gathered and presented in this chapter will be also used in the chapter six where it will help drawing final conclusions regarding the nano-debates in Poland, Sweden and Iran. It will be discussed in the context of the existing literature on that subject and will allow making suggestions regarding the future research.

# 6 Discussion

In this chapter I will discuss the characteristics of the coverage in Swedish, Polish and Iranian newspapers and the use of metaphors in this coverage. I will discuss these results and observations within the general theoretical framework of my thesis, based on the 'model of mediated issue development' by Nisbet and Huge (Nisbet & Huge, 2007). This discussion will look not only at the nano-debates through the lens of the model chosen for this study, but it will also investigate the model itself – its generalisability and applicability in the context of the studied countries. I will explore how it works when applied cross-culturally.

I will then discuss the use of one particular frame, the 'National'-frame, whose importance for the press coverage in all three countries emerged during the process of analysis and may shed new light on the cross-cultural differences between nano-debates in each country.

The socio-political contexts in which the media debates took place in each of the three countries, which is essential for their understanding, were discussed in detail in chapter three and form the background for this chapter, alongside the results discussed in chapter five.

## 6.1 Sweden

In the beginning of the studied period Swedish coverage was more focused on the future benefits of nanotechnology and the main actors in the articles were scientists. During the next stage the media's interest in nanotechnology dropped to only six articles published in 2006 and eight in 2007. At that time newspapers started to report potential risks related to nanotechnology. The change in tenor of the coverage is clearly visible when investigating the subject of the articles. On 18th September 2007, 'Svenska Dagbladet' published an article that reported the results of the EU's scientific committee, which suggested that nano-cosmetics may cause cancer. A day later a similar article was published in 'Dagens Nyheter'. During the next three months, i.e. until the end of 2007, five nano-related articles

were published, two of which discussed the question of the potential cancer risk (referring to the EU's report). Nanotechnology stopped being framed as 'only a future thing'. The 'Time'-frame was used less often, which could suggest that the authors wanted to point out that nano-risks are real and are 'already here'. The geographical focus of articles moved towards Sweden, with authors pointing out which risky nano-products can already be bought there. Nano was getting closer not only in time but also in space. At the same time discussions began about how the use of nano-products was regulated by Swedish law ('Nano-technique's risks are poorly investigated in Sweden'; Svenska Dagbladet, 31st October 2007). Towards the end of the studied period the debate became more balanced in terms of frames, themes or actors.

Swedish coverage of nanotechnology was generally more diverse than the Iranian or Polish press. The media also discussed more often the risks of nanotechnology and the need for regulation in this area (especially between 2007 and 2009). These elements could be related to the social and economic conditions in which the nanotechnology is developing in Sweden. The nanotechnology research and development sector in Sweden is far more advanced than in Poland and Iran. Additionally, Sweden has a long tradition of democracy and enhancing public participation in decision making processes. Swedish researchers also have more research possibilities, in terms of access to research equipment, collaborations or funding compared to Iran or Poland. With the progress of nanotechnology research and development in Sweden, various actors started to be more interested in the potential risks or social aspects of this technology. This is especially important in the context of Sweden, where environmental issues play a significant role for its citizens (European Commission, 2011b). The popularity of the 'Nature' metaphor also shows how important the environmental aspect is for gaining the public's acceptance for a new technology.

It could be argued that nanotechnology is 'more real' and its applications are 'much closer' in Sweden than in the other two countries. This assumption is also based on the observation of changes to the coverage towards the end of the studied period. The debate became more diverse and started to move from more positive positions towards more balanced and even critical approaches to nanotechnology. This may suggest a gradual end to the initial stage of the Swedish nano-debate. This assumption would need to be verified through the study of the coverage in the following years.

However, the diversification of the Swedish debate is also symbolic in the context of Swedish science policy in general, and nano-policy in particular. At both levels there is a huge diversification in terms of governing science and managing research funding. There is no central institution coordinates nanotechnological research (in the same way as NNI in the US). The discussion of the construction of MAXlab in Lund provided examples of problems with financing and coordinating large-scale research projects. As observed by Hallonsten (2011), there are many players (theoretically) active in the particular area but there is no one who could coordinate these activities. The same can be said about the diversification of the Swedish nano-debate. Many different actors can be observed in the coverage but nobody plays a leading role in the debate. Interestingly, representatives of the Swedish government or ministries were not active in these discussions.

## 6.2 Poland

The Polish media debate on nanotechnology has not been as diverse as in Sweden. The coverage was mostly focused on scientific achievements and the possible nano-applications. The coverage was overwhelmingly positive, focused mostly on the future benefits and applications of nanotechnology, framed using 'Progress' and 'Hope' frames, with scientists as the main actors. Additionally the articles were framed using the 'Nano-Enthusiasm' frame (representing extreme enthusiasm for nanotechnology and its applications) and the 'A Pole can' frame

(success of Polish scientists, companies and institution). Until 2007 the debate was mostly focused on scientific progress and was extremely positive. In some articles it was even framed as a 'New Industrial Revolution' (a common phrase in coverage of nanotechnology world-wide). The discussion of risks or regulation of nanotechnology was limited in the Polish context. In 2007, questions of financial benefits and economic prospects had arisen more often than before (and after), with the highest participation of business-representatives in the nano-debate (e.g. Polish textile company that adds silver nanoparticles to its products). After 2007, the press started to discuss the risks of nanotechnology more broadly. Many articles published in 2008 focused on the ongoing European debate on the risks of nanotechnology and the EU's efforts to regulate this area of science. It is worth mentioning that such 'non-positive' aspects of nanotechnology were never discussed in a Polish context and no Polish politician expressed an opinion on these issues.

The Polish coverage can be, to some extent, located in the middle between Swedish and Iranian coverage. As in Iran, it was mostly positive and focused on the benefits of nanotechnology, while the discussion of the social and ethical aspects of nanotechnology or the potential risks and regulation of this science is extremely limited. Still, nanotechnology is framed by the Polish media as a domain of (proud) scientists doing research in their laboratories, with almost no place for any other actors or themes. This has implications for engaging the public in the process of governing nanoscience (as in Iran). Following Kjølberg's (2009) discussion of the debate on nanotechnology in Norway it could be argued that a 'one sided' coverage of nanotechnology 'may make public engagement less likely' (Kjølberg, 2009, p. 71). The same phenomenon has been observed in Slovenia, another former-communist state, where politicians or institution officials were not very active in the Polish nano-debate (Groboljsek & Mali, 2012). This contrasts with Western European countries (e.g. Germany, UK) or the US, where politicians participated actively in the discussion around nanotechnology

and its social, legal and ethical implications, including former US-president Bill Clinton. Politicians or NGOs (as actors/sources) in the Polish nano-coverage occurred mostly in articles discussing nanotechnology in the context of other countries. An additional aspect here is the low level of civil activity among Poles and to some extent the coverage reflects that problem – the only persons involved in the development of nanotechnology were active in the debate (scientists and sometimes industry representatives).

The fact that nanotechnology is frequently discussed in a foreign context indicates that nanoscience, like many other sciences, still lacks both political and financial support from the Polish state; quite unlike Western Europe and the United States. As a consequence, any achievement by a Polish scientist in the field of nanotechnology is highlighted by the press. It includes even such non-scientific news as the appointment of a Polish scientist as an advisor in one of the EU-institutions. Despite the small number of occasions when nanotechnology is discussed in the Polish context, these situations are used by the media to highlight Poland's important position in the scientific world. It can be assumed that this is related to the underdevelopment of Polish science (comparing to Western Europe or the US) and that the frame 'A Pole can' aims to minimize the gap between Polish and Western science.

## 6.3 Iran

Iranian coverage followed, to some extent, the tendencies observed in other countries in terms of the most popular frames, themes, actors, or tone of the articles. In the beginning the debate was more focused on 'Progress', 'Applications' and 'Generic Research'. However, it is important to remember the socio-political context of this coverage. Nanotechnology has been pointed to by the government as a strategic area in terms of research and technological development. Iran is therefore the only country, among the three studied, that has established a central institution that coordinates its nanotechnological

activities. However, in the same way as the government controls all nano-research institutions, it also controls all major papers in Iran and the private ones are still subject to state censorship. It could be argued that this could have affected the coverage, since it would be highly unlikely that the government would accept articles questioning the aims of the Iranian nano-research agenda or highlighting the potential risks of the technology that became the government's priority. The coverage of nanotechnology in Iranian articles was overwhelmingly positive, focusing on scientific research and future applications. Additionally, many articles were focused on research details; reporting the scientific progress using very technical and scientific language. It could be argued that journalists were using such language in order to enhance the credibility of their articles and the new technology.

In 2004 the Iranian programme for nanotechnology development was relatively new which could explain why it was not discussed at all in the studied articles. During the first years of the analysed time-period the tone of the articles was mostly positive and focused on other countries. Actually, the first 'alarming' article about nanotechnology was printed in 2006. Alongside the discussion of nano-risks, the discussion of public influence and nanotechnology's importance for society was developing steadily ('Public Accountability'-frame). However, it is worth pointing out an interesting difference between Iranian coverage and the nano-debate in Poland and Sweden, since this frame was used in Iran in a slightly different context. While the use of the 'Public Accountability' frame in Sweden was related to 'alarming' articles discussing the risks of nanotechnology, in Iran it was often used in articles discussing positive aspects of nanotechnology. In this context, the necessity for public influence/participation was triggered by the possibilities this technology may create for Iranians. The discussion of potential risks was extremely limited and the questions of society's influence over nanotechnology were not related to its potential risks (as in Sweden) but to its benefits (in order to ensure that everyone should get access to the new

technology). Risk were discussed together with the potential benefits and risks were usually presented as a minor problem especially when considering the benefits. Risks were also presented as specific problems, not as 'potential', 'unknown' risks that may come together with the development of nanotechnology. In general, it can be observed that news about risks took on more of an 'informative-character', i.e. they are mentioned as an element of nanotechnology but no in-depth discussion on the negative aspects of this emerging technology was provided.

As mentioned, the debate was dominated by scientists, i.e. actors typical of administrative venues (according to Nisbet and Huge's model). The low number of business representatives active in the debate reflects the lack of private Iranian companies active in the field of nanotechnology. The same observation can be said about the lack of Iranian NGOs or environmentalist groups, whose activity is impossible in the Islamic Republic of Iran. As in the discussion about other issues, critical voices are mostly absent in the Iranian media. Towards the end of the studied period, Iranian politicians started to appear more often in the articles. Still, the study of the online archives of the Iranian Parliament shows that nanotechnology had not been discussed by the parliament between 2004 and 2009[16].

An important element of the Iranian coverage was the use of nanotechnology in state propaganda in order to highlight the country's international position. This was related to a feature that will be discussed in-depth in section 6.6 - the focus on the national successes.

## 6.4 Metaphors

In this study, the content analysis of the corpora was enhanced with the analysis of metaphors used in the studied nano-debates. As mentioned in chapter two,

[16] Searches have been conducted using Majles website http://www.majlis.ir/

metaphors have been studied in the context of emerging technologies before, but studies on their use in the debates on nanotechnology remains rather limited. No research has considered this issue in a cross-national context.

The study shows that a limited number of metaphors have been used in the Swedish, Polish and Iranian press coverage. Therefore it is hard to make any strong conclusions regarding their use. Still, it is possible to point out some major characteristics of metaphors' popularity in particular countries.

First, all of the metaphors observed in the analysed articles have been observed previously in studies focused on nano-debates in other countries (Hanson, 2011; Milburn, 2005; Sparrow, 2007; Ten Eyck & Hernandez, 2009; Wickson, 2008). These were metaphors of revolution, change, brave new world, small worlds, nature, superhero, and war.

The revolution metaphor was mostly used in Iran, although it did not have any political connotations (as might have been expected). Both Iranian and Polish media have described nanotechnology as a 'new world' with its own rules. In both countries nanotechnology was also described as 'superhero' that will help us by enhancing our quality of life and our fight against deadly diseases. At the same time, Swedish journalists often presented nanotechnology as 'natural'. This difference between the studied countries reflects observations made in earlier chapters. The Polish and Iranian coverage was extremely positive, focused on future applications, and scientific achievements, highlighting the hopes related to this emerging technology. In that context, the use of the metaphors already mentioned seems to be justified since it helps to promote the enthusiastic picture of nanoscience. The Swedish coverage has been found to be more balanced, less positive and more risk-aware. The discussion of environmental issues in the context of nanotechnology was more developed than in Poland or Iran. Describing new emerging technology as something 'natural' seems to fit the

debate already conducted in a country where environmental issues play a significant role for its citizens and politicians.

These positive metaphors stand in contrast to the more negative metaphors of nanoparticles, such as sneaking, fighting, attacking or that they may potentially destroy us. Interestingly these were mostly found in Polish articles. In Sweden, where the negative aspects of nanotechnology were discussed more often, the potential risks and threats were described without using any of these metaphors. The only exception was the asbestos-metaphor: one commonly used in the debates on nanotechnology around the world (referring to the danger posed by inhaling or ingesting nanoparticles that may later turn out to be dangerous for health).

In terms of metaphorical expression, the debate was conducted from two different positions. In Poland, the positive picture of nanotechnology as a 'superhero' that will change the world and nanotechnology as 'a new world' is opposed to the negative picture of the evil, attacking and sneaking nanotechnology. The 'new world' is opposed by the old experience of 'asbestos' (i.e. nanotechnology is nothing other than simply the 'asbestos of tomorrow'). This comparison is even more evident in Sweden, where the asbestos metaphor is opposed to the positive view of nanotechnology as a natural element of our world. While the Iranian coverage was actually lacking metaphors related to negative pictures of nanotechnology (which is probably related to the overwhelmingly positive Iranian coverage), it must be stated that in general Iranian coverage still shows many similarities, in terms of metaphors used, to the Polish coverage. Again, this could be related to the fact that both countries are still developing their nano-research potential and that the coverage is in an early stage. The positive tone of the articles coincides here with the more positive metaphors (which refer mainly to potential applications of nanotechnology).

As mentioned earlier in this thesis, the studies of metaphors in media coverage of nanotechnology have been very limited. Therefore this study provides a novel contribution to the literature by investigating this question not only in the context of particular countries, but in a cross-cultural and cross-national context. The cross-cultural context is actually the most important element of this contribution since it provides new insights into the area of metaphor studies. While the studies of conceptual metaphors that are based on examples from English have a relatively long tradition (Lakoff & Johnson, 1980, 2003), the cultural study of metaphors is a relatively new research area.

## 6.5 Model of mediated issue development

The framework for studying the changes to the coverage of nanotechnology across time is based on Nisbet and Huge's 'model of mediated issue development' (Nisbet & Huge, 2007), discussed in more depth in chapter three, together with a discussion of the relevant literature. The model assumes that the media debate on a particular issue (e.g. nanotechnology) goes through specific attention cycles (see also Downs (1972)) that can be assigned to the specific venues of the debate. The model claims that debates in overtly political or policy venues are more likely to be framed dramatically with a high presence of actors such as NGOs. By contrast, debates in administrative venues often employ technical frames, with scientists and industry representatives as the main actors, and generally attracting less media attention (Nisbet & Huge, 2007).

According to Nisbet and Huge, typical administrative venues are various agencies or types of 'independent scientific advisory body' (Nisbet & Huge, 2007, p. 198), while overtly political venues are (in the US context) Congress or the White House. The question is whether this distinction can be applied to studying debates about emerging technologies in countries other than the US. In the case of the nano-debates in the three countries studied, administrative venues may be particular regulatory bodies (e.g. Swedish Chemical Agency or Iranian

Nanotechnology Initiative Council) or scientific bodies (e.g. Polish Academy of Sciences), while overtly political venues would include parliaments and the European Parliament (for Poland and Sweden). Still, it should be remembered that in this case the term 'venue' refers not only to the physical spaces of the discussion but also the whole context of the debate within which specific issues are discussed.

In their study of the US media debate on plant biotechnology, Nisbet and Huge distinguish between dramatic and technical framing, assigning different frames to particular groups.

Frames were divided into two groups based on the description provided by the authors. However, a problem that appears at this stage is the question of 'What is actually the difference between technical and dramatic framing?'. When reading Nisbet and Huge (2007) and analysing their typology it appears that the authors draw a clear distinction: all sceptical coverage, all opposition voices (in their case towards plant biotechnology) are framed dramatically, while all "nano-optimistic" articles were framed in (neutral) technical terms. When discussing examples of changes in the debates around controversial issues (tobacco, nuclear energy, or pesticides) the authors observe that:

> In the case of each issue, its early history was characterized by positive image-making and enthusiasm for creating institutional arrangements that would further market development. Eventually, however, these pro-industry policy monopolies were broken up by opponents who successfully redefined the issue in provocative and negative ways, and who shifted decision making away from administrative arenas to more overtly political contexts (Nisbet & Huge, 2007, p. 200).

The pro-technology coverage is mostly framed technically and the sceptical voices are very often emotionally 'charged'. However, in such cases there is a

question of what to do with the dramatically framed pro-technology articles. The framing typology used in this study that was revised during the analysis of corpora, includes such frames as 'New Industrial Revolution', 'Nano-enthusiasm', 'Hope' or 'Entertainment'. These frames definitely represent a "pro-nano" attitude but at the same time are emotionally 'charged'. All of them can (at least at some point) be found in the nano-debates in Poland, Sweden and Iran. These frames are very often used in articles where the main sources are scientists, business representatives or politicians, i.e. actors that seem to be characteristic of the administrative venues. At the same time not all sceptical voices need to be expressed through dramatic frames, e.g. the Time frame. This frame is not dramatic but it represents some kind of scepticism towards the promises of nanotechnology (or the promises of nanotechnology that would soon bring us the technological breakthrough). Therefore there is a question about whether dramatic framing should necessarily be reserved for sceptical voices in debates about emerging technologies and the debates conducted within overtly political venues. This section aims to explore these questions while investigating the changes to the coverage of nanotechnology between 2004 and 2009 in all countries studied.

First, in order to be consistent with the original model (i.e. the one used by Nisbet and Huge (2007)), this study will follow the frame division suggested by the authors. Following the original study (Nisbet & Huge, 2007), frames has been divided into two groups: technical and dramatic. I will firstly look only at the frames that were considered in Nisbet and Huge's framing typology. Second, because of the considerations mentioned above, I will also look at situations when the additional frames (i.e. frames that have not been originally used by Nisbet and Huge) are also classified as either technical or dramatic. All frames are presented in Table 6-1, with the additional frames marked with *.

Table 6-1 Technical vs. dramatic frames

| Technical frames | Dramatic frames |
|---|---|
| - Progress | - Ethical |
| - Economic Prospects | - Uncertainty |
| - Time* | - Public Accountability |
| | - Runaway |
| | - Nano-enthusiasm* |
| | - New Industrial Revolution* |
| | - Entertainment * |
| | - Hope* |

In their study, Nisbet and Huge (2007) have also discussed actors (active in the debate on plant biotechnology) in relation to the debate's stage. Administrative policy arenas, where the debate is usually framed technically 'typically prioritize access and input from industry and the scientific community, enabling mostly insular decision-making by administrators, scientists and independently constituted scientific advisory boards' (Nisbet & Huge, 2007, pp. 198–199). Unlike framing typology, which does not map onto the model, the category of 'Actor' used in this study is compatible with the one used by Nisbet and Huge. Following their approach, the actors in Swedish, Polish and Iranian nano-debates have been divided into two groups (see Table 6-2)

Table 6-2 Administrative vs. overtly political actors

| Actors characteristic of administrative venues | Actors characteristic of overtly political venues |
|---|---|
| Scientists | NGO |
| Business representatives | Media representatives, |
| Institution officials (administrators) | Politicians |
| International organisation (e.g. EC) | Public opinion |
| Military representatives | Moral authorities |

Media representatives have not been mentioned directly in the Nisbet and Huge study but considering the fact that the debates in overtly political venues were

characterised by the broader diversity of actors involved and attracted more media attention, the decision was made to include this category in that particular group.

Using the model of mediated issue development (in both original and revised form) I will now analyse the temporal changes of the frames, themes, actors and other characteristics of the articles. I will not only look at the nano-debates in particular countries but will also investigate the model itself. One of the main aims of this chapter is to test the generalisability of the model.

### 6.5.1 Sweden

In terms of an issue-attention cycle it can be observed that there is a lack of any major event that could be described as a 'trigger' for a longer and widespread debate on nanotechnology. On a smaller scale, the EU report on nano-cosmetics published in 2007 played such a role, since after its publication the number of nano-articles started to grow. Some of these articles directly discussed the question of nanotoxicity and nano-risks. The searches for speeches, questions or interpellations related to nanotechnology conducted on the Swedish Parliament's website reveal one 'event' per year, the only exception was 2007 when it was discussed twice. It needs to be stated that the newspapers studied never mentioned any of these.

The study of the debate, with the help of the Nisbet and Huge model, i.e. using frames mentioned in Table 6-1 (not marked with *), shows that the proportion of dramatic framing compared to technical framing changed between 2004 and 2009 (see Figure 6-1).

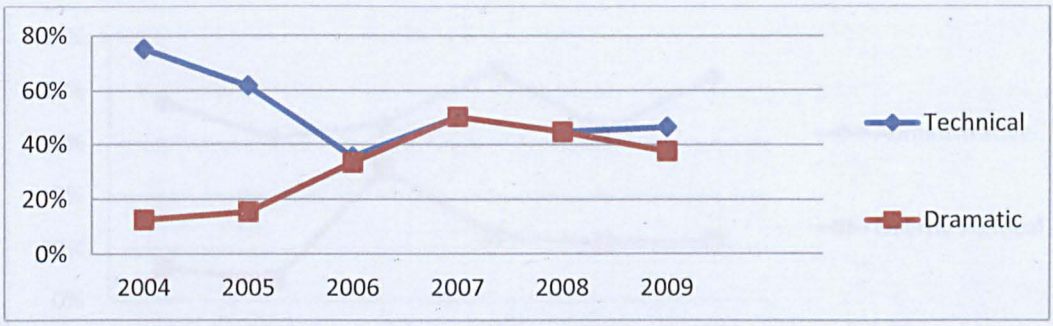


Figure 6-1 More dramatic vs. more technical framing of Swedish nano-articles

Figure 6-1 shows that the use of dramatic frames rose over time, while the use of technical frames fell. Nevertheless, despite a peak in 2007, the more dramatic frames were never used in more than 50% of the articles per year. In 2007 and 2008 the media focused heavily on the risks of nanotechnology, following the European Commission's report (2007) and pronouncements by some Swedish politicians and NGOs. When using the original framing typology of Nisbet and Huge (2007) it can be observed that all of the articles discussing risks where framed dramatically. It is also worth mentioning that towards the end of the studied period the number of dramatic frames used was rising. While 'more dramatic' articles published in 2004 or 2005 were framed with only one such frame, articles published in 2007 and 2008 consisted sometimes of two or three different 'dramatic frames'. Still, the differences between both variables are small (for years 2006-2009) and it is impossible to draw any robust conclusions. In the context of the above observations (focus on risks; anti-nano attitude) it could be argued that what Nisbet and Huge call 'dramatic' frames should actually be described as alarmist. However, this question will be discussed in the latter sections of this chapter.

The study of the activity of particular groups of actors shows that the actors characteristic of administrative venues (scientists and business/industry representatives), dominated the debate across the studied time period (see Figure 6-2).

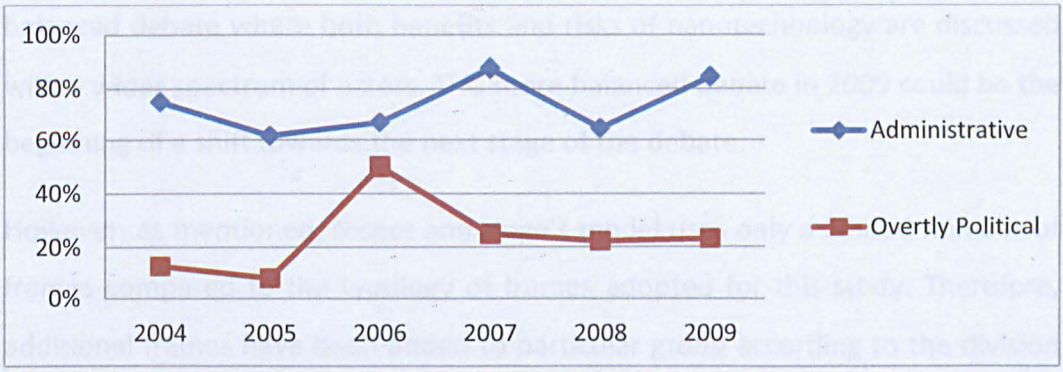


Figure 6-2 Groups in the Swedish nano-debate

It has been observed that scientists and business/industry representatives, who are more characteristic for administrative venues, dominated the debate across the studied time period. The only moment when their participation dropped significantly was in 2008 (8 of 18) when a broader variety of actors became active in the discussions around nanotechnology. This diversity, alongside the increased presence of such actors as NGOs or politicians, is typical of the overtly political venues (e.g. discussions in Swedish Parliament). This coincides with the drop in the use of technical frames and the more frequent use of dramatic frames that characterise the overtly political venues. However, Figure 6-2 does not suggest that actors from this group (NGOs, Public opinion) were more active during this time period. This could be caused by the small total number of Swedish nano-articles.

It could be argued that to some extent the Swedish debate on nanotechnology followed the model described by Nisbet and Huge. The changes of frames used by media and actors active in the debate are following a particular pattern that allows the debates held in administrative and overtly political venues to be distinguished. During the studied time period we can observe a move from an administrative to an overtly political venue (with a peak in 2007/2008). This is reflected in the rising frequency of dramatic frames and the growing diversity of actors active in the nano-debate. The debate evolved from a very positive debate that was focused mainly on future applications of nanotechnology, through a critical discussion of potential risk, safety issues and regulation policy, to a more

balanced debate where both benefits and risks of nanotechnology are discussed with a wider spectrum of actors. This more balanced debate in 2009 could be the beginning of a shift towards the next stage of the debate.

However, as mentioned, Nisbet and Huge's model uses only a limited number of frames compared to the typology of frames adopted for this study. Therefore, additional frames have been added to particular group according to the division presented in Figure 6-1. This new situation, in terms of dramatic and technical framing across the studied time is presented on Figure 6-3.


Figure 6-3 Technical vs. Dramatic frames in Swedish articles - revised

When the additional fames are considered (especially dramatic ones), the picture of the Swedish nano-coverage between 2004 and 2009 looks completely different. Dramatic frames are not only used more often but they also seem to dominate the debate. At the same time the use of technical frames declined over time. This radical change, especially in the case of dramatic framing, is related to the fact that the additional frames (especially the Hope-frame) were used very often alongside the technical frames, in the articles focused on scientific progress or new applications. These articles mostly framed nanotechnology in a positive way. An example is the coverage from 2006, where all of the articles were framed dramatically. However, most of the articles discussed positive aspects of nanotechnology and hopes related to its future applications. Additionally, it can be observed that some of the actors that are typical for the administrative venues (e.g. institution officials) used this dramatic framing.

As in the case of the Swedish nano-debate no event could be identified that could be said to have triggered a widespread debate about nanotechnology. The publication of scientific reports on the toxicity of nanoparticles attracted some interest in 2008 and 2009 but it is impossible to talk about any significant 'shift' in the debate, since the number of articles was relatively small (3-4 per year). Questions of safety and risks (that could potentially cause such a shift) were discussed in two articles in 2004, but only in relation to the then fashionable discussion of grey goo (Crichton, 2002; Drexler, 2004); a fantastic scenario of nanobots, that bears no resemblance to actual risks that nanoparticles may pose. Both articles aimed to 'calm down' the public stating that nanoparticles 'are not going to eat us anymore' (Gazeta Wyborcza 29th June 2004). The question of nano-risks came back in 2008 and 2009 following reports of the potential toxicity of nanoparticles issued by some western scientists and the European Commission. In Polish nanotechnology was only discussed in the context of higher education study programmes. According to researchers from the Industrial Chemistry Research Institute, the existing regulations of nanotechnology (about its use and safety issues) are based directly on the legislation of the European Parliament.

The size of the corpora did not permit any conclusions regarding changes that would follow the issue-attention cycle described by Downs (1972). The level of media attention on nanotechnology did not shift across time. In terms of numbers there was a steady growth – from 12 articles in 2004 to 31 in 2008.

The study of frames (dramatic vs. technical framing; limited number of frames – as in the original model) shows that technical frames dominated the Polish corpora, constituting each year over 75% of the coverage (see Figure 6-4). The percentage of the articles framed with more dramatic frames was very low. However, as in the case of the Swedish nano-debate, if we consider the numbers

we find that 2008 and 2009 were characterised by a higher numbers of articles framed in this way (4 in 2008 and 2009).


Figure 6-4 More dramatic vs. more technical framing of Polish nano-articles

Interestingly, unlike Sweden, the discussion of nano-risks is not always framed in a dramatic way. Only half of the articles that mentioned the risk-question were framed in this way, while the rest were framed technically. Following the model of Nisbet and Huge (Nisbet & Huge, 2007) it could be argued that this is related to the dominance of scientists and business/industry representatives in Polish nano-debate (over 80% each year). These actors are typical (according to the authors) of technically framed debates conducted in an administrative context. The activity of the representatives of the other group (NGOs, Public Opinion, and Media) was minimal (usually one article per year).

Between 2004 and 2009, the Polish nano-debate took place within administrative venues only. Unlike the Swedish debate, it did not change too much across this time period in terms of frames or themes. It should be added that within the Polish parliament, which is an overtly political venue, this issue was not discussed at all during this time[17].

The preceding analysis suggests some vagueness in Nisbet and Huge's 'framing typology' and therefore it is necessary to investigate this question further by

[17] Searches have been conducted using two databases: www.sejm.gov.pl and dziennikustaw.org.pl, using keywords nanotech*, nano* and nanotechnologia.

expanding their definition of 'dramatic' and 'technical' frames. Following the earlier suggestions, five additional frames were added to the original set. Figure 6-5 shows how the use of these 'expanded' groups of frames changed between 2004 and 2009.

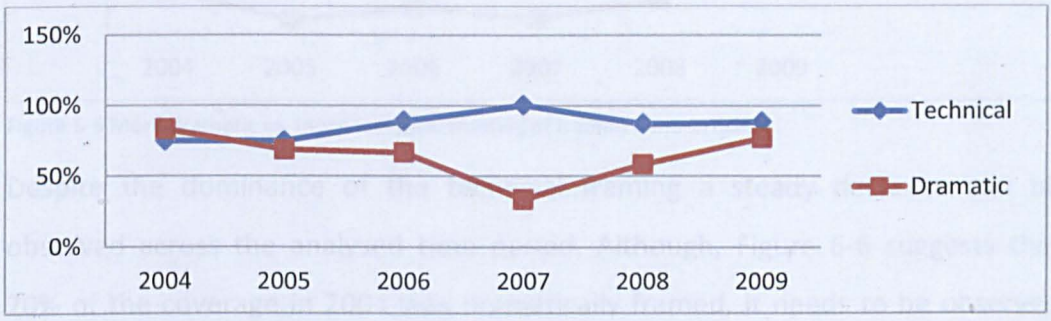


Figure 6-5 Technical vs. Dramatic frames in Poland - revised

Even with the additional frames added, technical frames still dominate the coverage, but in the same time the presence of dramatic frames has risen (as in Sweden). Although actors typical of the administrative venues dominated the debate and most of the articles were focused on the positive aspects of nanotechnology and its applications, a significant portion of the articles were framed dramatically. However, these were not 'alarmist' frames as the definitions in Nisbet and Huge's study might suggest. In the Polish nano-debate most of the dramatic frames were positive, i.e. representing the positive approach towards nanotechnology.

### 6.5.3 Iran

In terms of changes to the coverage, a significant drop in the number of articles can be observed between 2005 and 2008. When following the original framing typology of Nisbet and Huges' (2007) it can be observed that the debate was mostly framed technically (see Figure 6-6).

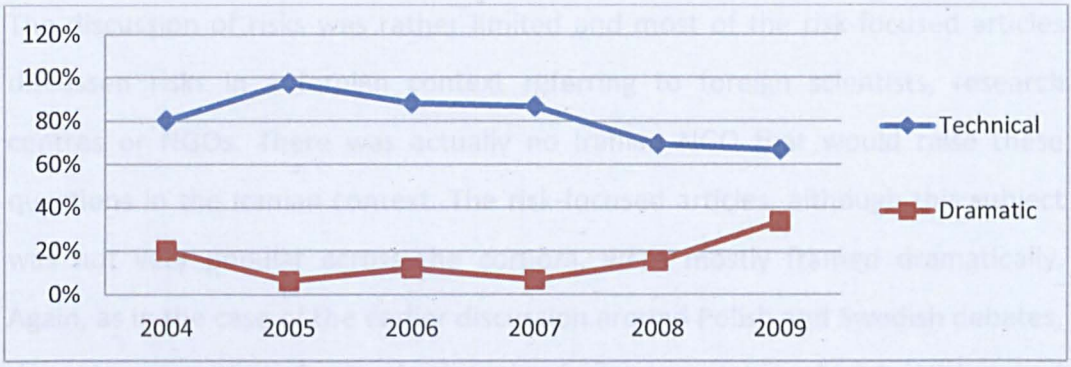


Figure 6-6 More dramatic vs. more technical framing of Iranian nano-articles

Despite the dominance of the technical framing a steady decrease can be observed across the analysed time period. Although, Figure 6-6 suggests that 20% of the coverage in 2004 was dramatically framed, it needs to be observed that this year the total number of articles was very low (n=5) and therefore this 20% in fact represents only one article. The article itself, although it discusses the possible risks of nanotechnology, is mostly focused on the necessity of the development of new regulations and describes nanotechnology as a rapidly developing technology. The number of dramatically framed articles grew since 2006, achieving its peak in 2009. In the same time the use of technical frames began to fall. Similar observations can be made when looking at the group of actors active in the debate (Figure 6-7).

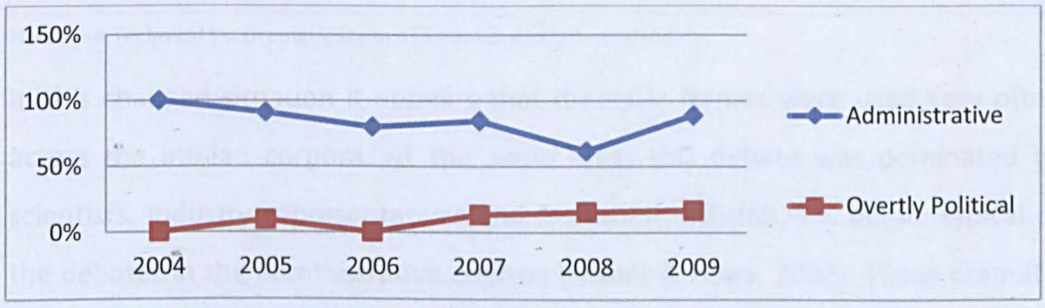


Figure 6-7 Groups of actors in the Iranian nano-debate

The participation of actors that are characteristic of overtly political venues was growing since 2006, while scientists and business/industry officials were less often present in the analysed articles.

The discussion of risks was rather limited and most of the risk-focused articles discussed risks in a foreign context referring to foreign scientists, research centres or NGOs. There was actually no Iranian NGO that would raise these questions in the Iranian context. The risk-focused articles, although this subject was not very popular across the corpora, were mostly framed dramatically. Again, as in the case of the earlier discussion around Polish and Swedish debates, there is a question about whether the frame concept applied in Nisbet and Huge's study (2007) is too vague.

To help answer this question I will enhance the definitions of dramatic and technical framing, using the additional frames used in this study ('New Industrial Revolution', 'Entertainment', 'Hope', and 'Time'). The result can be observed in Figure 6-8.

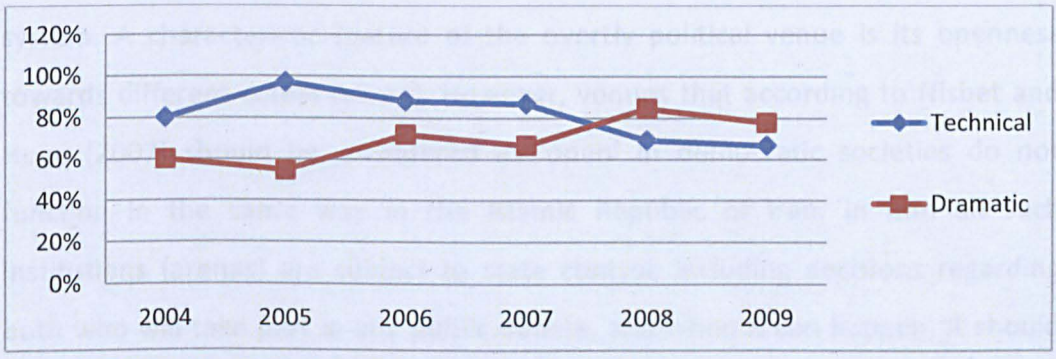


Figure 6-8 Technical vs. Dramatic frames in Iranian articles - revised

In this changed situation it appears that dramatic frames were used very often across the Iranian corpora. At the same time, this debate was dominated by scientists, industry representatives and institution officials, i.e. actors typical of the debates in the administrative context (Nisbet & Huge, 2007). These dramatic frames were used in articles discussing nanotechnology in a positive way, which is again evidence that supporters of technology are not necessarily only limiting their choice of frames to technical ones. In the Iranian context it is also important to remember that nanotechnology plays a significant role in the government's scientific policy. Between 2004 and 2009 the government made numerous efforts

to promote knowledge about nanotechnology. This could explain the popularity of the Entertainment frame. However, the most significant part of the dramatically framed articles was focused on hopes related to the possibilities that nanoscience may have for Iran and Iranian society. This example shows the difficulty of assigning a particular kind of framing to a specific approach towards nanotechnology or debate-arena (venue). As could be observed in the case of Swedish or Polish coverage, while the use of more alarmist frames ('Runaway' or 'Unforeseen risks') can be characterised in such a way, the use of any kind of dramatic frame (i.e. emotionally charged) cannot be explained easily in this way.

Nevertheless, both versions of the model (the original and the enhanced one) show a particular trend towards the end of the studied period. One may suggest that the debate was moving towards the overtly political venue. However, at this point we need to discuss this question in the context of the Iranian political system. A characteristic feature of the overtly political venue is its openness towards different actors (views). However, venues that according to Nisbet and Huge (2007) should be considered as 'open' in democratic societies do not function in the same way in the Islamic Republic of Iran. In Iran all such institutions (arenas) are subject to state control, including decisions regarding both who will take part in any public debate, and when it can happen. It should be remembered that nanotechnology is considered to be one of the strategic areas of Iranian research and in large parts the state owned/controlled institutions are responsible for research, funding and any industrial implementations of nanotechnology. It is unlikely therefore that in such situations the state owned media would raise critical or doubtful voices on the issue. Eventually, criticism of nanotechnology could be made in the context of Western countries. This example shows that the 'model of mediated issue development' is not fully applicable to a country such as Iran. It is impossible to judge to what extent the 'open' venues are actually open, since the debate within this venue is controlled by the administration and to some extent by the

same actors that Nisbet and Huge would describe as characteristic for 'administrative venues', too.

### 6.5.4 General comments on the model

The above discussion leads to the question of the methodological limitations of the model developed by Nisbet and Huge (2007). First, it should be stated that the question of the framing of debates on emerging technologies (not only nanotechnology) is a complicated issue. The particular approach towards nanotechnology cannot be assigned simply to one specific group of actors or to the specific way of framing (dramatic or technical). On the other hand the particular way of framing is not characteristic of the particular venues of the debates. One could argue that instead of distinguishing between dramatic and technical frames, the authors should distinguish between technical and 'alarmist' framing, which is more likely to fit their model.

Another question is related to the model's applicability to studying the coverage in these particular countries. First, the fact that no changes to the venues of the debates have been observed could be related to the short period of time that was studied (2004-2009). Previous studies that used this model (Nisbet & Huge, 2007; Nisbet & Scheufele, 2009) covered longer periods of time – 20-30 years, and the changes to the debates were usually observed every 4-7 years. However, since this project is focused on nanotechnology, not biotechnology - as is the case in the other studies just cited - taking a longer time period would not affect this situation. Nanotechnology is a much younger technology and the initial searches for articles showed that the nano-coverage before 2004 was extremely limited, much lower than in the studied period. Therefore it could be argued that the lack of significant changes to the coverage between 2004 and 2009 may be related to the fact that this debate is in its initial stages. As mentioned earlier, nanotechnology has actually not attracted significant media attention. It did not have its 'Monsanto-debate' or gained status as a 'celebrity issue'. This could

affect both the number of articles and the shape of the debate, resulting in the dominating presence of scientists and industry representatives, especially in the use of particular frames and the focus on scientific progress and future applications. The low number of metaphors used in the coverage may also suggest that debate in all three countries is still in its initial stages.

Second, there is a question as to what extent Nisbet and Huge's model can be applied in countries other than the United States. Although the authors argue that the model could be used for studies of media coverage in other countries, their description of the model is situated in the context of US media, US organisations (e.g. environmentalists), US policymaking processes and the US political system in general. As pointed out before it differs significantly from the Swedish, Polish or Iranian context. The parliaments in the studied countries did not focus too much on the question of nanotechnology, although (according to the model) these places should be characterised by a broad discussion of such issues. In terms of official institutions involved in policymaking processes, it needs to be observed that Sweden and Poland are members of the European Union and most of the regulation in the area of nanotechnology has been introduced at the EU level. Therefore, many of these issues were not discussed at the national level (by relevant industry or environmentalists), since the decision-making process took place in Brussels or Strasbourg. This is not comparable with the situation in the US. In the case of Iran, the main difference is the political system of the Islamic Republic of Iran. As in many other countries with limited democracy, the process of policymaking is very often unclear for observers and the participation of external actors is limited. An additional element is censorship of press coverage and the fact that all of the largest newspapers are controlled by the state. This has definite consequences for the tone and framing of the coverage of nanotechnology, especially since it is considered a strategic research area by the Iranian government.

NGOs also play a significant role in Nisbet and Huge's model. These actors (especially nano-sceptics) are supposed to affect the coverage through the use of dramatic framing in order to gain the media's or politician's interest, and in this way influence relevant legislation or decisions. However, Iran lacks such independent organisations (due to the political system) and their activity in Poland is limited. In the case of Poland, this is due to the fact that social issues such as the environment are of less interest to its citizens than to the citizens of Western or Northern Europe. Additionally, as discussed before in this thesis, the level of participation in public life is relatively low in Poland. Still, all of the above reservations could be related to the fact that the debate on nanotechnology is its initial stages and has yet to attract public interest.

The main goal of using Nisbet and Huge's model was to investigate the changes (and their context) to the debate across the time period studied. However, the analysis of the corpora using this model helped to point out the methodological limitations of this approach. In future studies, the above observation may contribute to the further development of the approaches used in the debates on emerging technologies. These suggestions will be discussed further towards the end of this chapter.

## 6.6 The use of the National-frame

During the analysis of the corpora I encountered a group of articles that were framed in a very specific way. These articles were nation-oriented articles, focused on a specific country's successes in nanotechnology, i.e. the 'national pride'. The frame has been used in each of the countries studied. In Iran it constituted 17% of the coverage, 15% in Poland and 8% in Sweden. More detailed information about the frame's use across time can be observed in Figure 6-9.

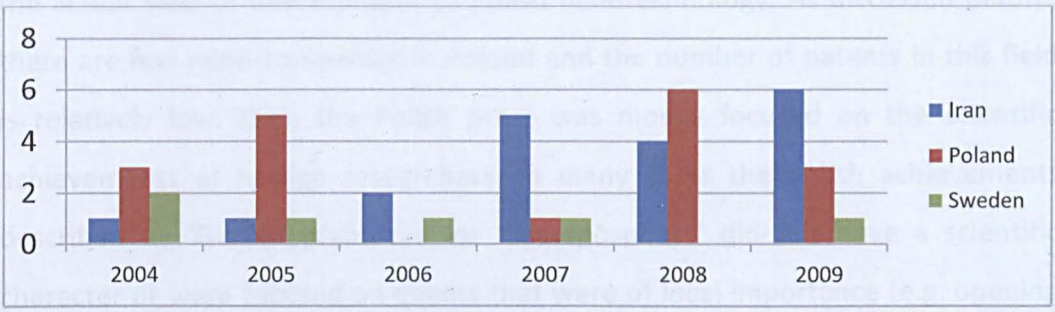

Figure 6-9 The use of the 'National'-frame in Poland, Sweden and Iran

The frame was especially popular in Poland and Iran, while in Sweden its use was minimal (6 articles in total). The Swedish articles were mostly focused on the success of Swedish researchers (e.g. from Lund University) or local companies. The Swedish articles framed with the 'National'-frame usually highlighted Swedish superiority in some very specific areas (e.g. 'Lund's Faculty of Engineering is amongst the best in the world in the field of manufacturing nano-threads'; Svenska Dagbladet, 5th December 2005). Considering the above mentioned focus on Sweden's 'leading position', the frame was called 'Best in test', which refers to a popular Swedish saying 'Bäst i test'.

The 'National'-frame was used more often in Polish debate, with two clear peaks in 2004 and 2008. While reading the examples provided in chapter five it can be observed that the main element that distinguishes the use of this frame in the Polish context was its focus on scientists' own inventions and creativity, which led to successes despite hard financial situations and the lack of modern equipment. Therefore it could be called the 'A Pole can'-frame. This is a reference to a popular Polish expression 'Polak potrafi' ('A Pole can do it'): a situation where others (foreigners; foreign countries etc.) are unable to do something or are struggling to achieve some goal, but Poles are able to do it – very often in some new and innovative way or despite technological and economic problems. This phrase was very often used in official propaganda during communist rule, especially in the context of the country's technological achievements (e.g. construction of new and modern steel mills) (Bralczyk, 2006). The frequent use of this frame, the pride from the Polish nano-achievements, stands in contrast to

the actual level of development of Polish nanotechnology. As discussed before, there are few nano-companies in Poland and the number of patents in this field is relatively low. Even the Polish press was mostly focused on the scientific achievements of foreign researchers. In many cases the Polish achievements described by 'Gazeta Wyborcza' or 'Rzeczpospolita' did not have a scientific character or were focused on events that were of local importance (e.g. opening of the nano-laboratory at university).

Among these three countries Iranian journalists most often framed their nano-articles with the help of the 'National' frame. It is the only country where it was used every year, although in 2004 and 2005 it was used in only one article per year. The considerable rise in its use can be observed after 2006. It was related to the above-mentioned successes of Iranian nanotechnology – construction of the first Iranian STM and the strong international position in terms of the number of nano-papers published in scientific journals. What distinguishes the frame's use among the other countries studied is the strong emphasis on comparisons with other countries. The Iranian press highlights the strong position of Iran among such developed countries as US, Japan or EU. However, in most cases journalists tended to compare Iran with other Muslim countries or all of the Central Asian and Middle Eastern countries, including Israel (described as 'the Zionistic Regime'). Nanotechnology also becomes a field for competition with other Middle Eastern countries and becomes a symbol for Iran's ambitions of being a regional superpower. This could be rooted in Iranian politics and culture for many decades: even during the former regime, the idea of becoming a local superpower (equal with Western countries) was a dominating element of government policy. In this way nanotechnology is used as an element of the government's propaganda of national success, which can be observed in many other areas, e.g. railway development. As in the case of other technologies, Iran is highlighting its own independence in nano-research. This independence (not only in nanotechnology) is Iran's answer to the economic sanctions and

international isolation. The achievements of Iranian nanotechnology are used as evidence that this strategy works.

This rhetoric contrasts with the actual development of nanotechnology, i.e. the number of patents, nano-companies or significant research achievements. When discussing the comparison with other countries, especially Western ones, it is worth mentioning that the political tensions between the Islamic Republic of Iran and the United States (both countries have not had any diplomatic relations since 1979) or the United Kingdom are not reflected in the news reporting on nanotechnology. Actually, the majority of articles that discussed nanotechnology in a foreign context do report the achievements of US or UK scientists, referring to the papers published in international journals such as 'Nature' or 'Science'.

Its use shows how a technology can be used as a symbol of national success and national pride. Of course there are differences in its use across the countries studied. In Sweden it was used to highlight the country's achievements in the area of nano-research, especially in a local context. In Poland it was more focused on how scientists' own inventions and creativity distinguish them in the world, despite hard financial situations and the lack of modern equipment, while in Iran it was used for comparisons with other countries. Interestingly the 'National' frame was less popular in Sweden: the country that has the most developed nano-research among these three countries. It could be argued that nanotechnology is perceived in countries like Poland or Iran as an area where these countries may successfully compete with the most developed countries. Nanotechnology is not only a possible way for Iran to be considered on equal terms with the US, Western Europe or Japan (i.e. the leaders in terms of scientific

and technological development) but it is also a chance for 'pushing forward' the country's development[18].

Although former studies in this area did not observe these aspects of the debates on nanotechnology, it cannot be said that the above findings challenge or contradict the previous works. The former studies have been mostly conducted in the context of highly developed countries – UK (Anderson et al., 2005; Wilkinson, Allan, Anderson, & Petersen, 2007), US (Arias, 2004; Gorss & Lewenstein, 2005) or Germany (Grobe et al., 2005; Zimmer, Hertel, et al., 2008). This study has shown that the National frame is more likely to be used in countries that are less-developed or developing. Second, most of the studies were focused on one country only, with a few exceptions that compared English-speaking countries (Friedman & Egolf, 2005; Laing, 2005; Stephens, 2005). Finally, many studies were focused on very specific aspects of the nanotechnology debate or used a predefined framing typology. All of these three elements explain (to some extent) why the 'National'-frame has not been observed before. In this way the findings regarding the presence of the 'National' frame, especially in a cross-national context, contribute to the literature by pointing out a phenomenon that has not been discussed before.

## 6.7 Summary

The aim of this chapter was to discuss the results of the analysis of Swedish, Polish and Iranian newspapers, applying the model of mediated issue development. It also aimed to discuss the applicability of this model to national press coverage of emerging technologies, other than in the US. Additionally I

[18] A representative of consulting company that I met at the EuroNanoForum in Budapest (June 2011), argued that these countries are hoping that nanotechnology could become 'their Nokia', referring to the success of the Finish company that became symbol of Finland's technological and research achievement

have discussed the use of the 'National'-frame introduced here and located it in the context of Nisbet and Huge's (2007) framework.

When looking at the changes to the nano-debates in the countries studied through the original model of mediated issue development, clear cross-national differences can be observed. Polish and Iranian nano-debates between 2004 and 2009 took place within administrative venues only. These debates were dominated by scientists and business/industry representatives and the articles were mostly focused on new achievements, scientific progress and future nano-applications. The dramatic framing was not very popular, although articles framed in such a way started to appear more often towards the end of the time period studied. In Swedish press-coverage there was a clear change in the debate (from an administrative venue towards overtly political one), which occurred in the second half of the studied period. Sweden is also the only country where a clear shift in the press' interest in nanotechnology can be observed. The differences between these countries reflect specific cultural and socio-political differences. As mentioned in chapter five, the level of Polish or Iranian citizens' activity with regard to the environment or to emerging technologies (e.g. NGOs) is lower than it is in Sweden. In Iran this is related mostly to the political system, which does not encourage citizens' own initiatives, especially if such activity would question any element of government policy; and nanotechnology is one of the governments' priorities. Although Poland is currently a democracy, people's approach to engaging in any projects or NGOs is still affected by the experiences of the previous system. Groboljsek and Mali (2012) have made similar observations in the case of Slovenia, the former Yugoslavian republic. The Eurobarometer reports also pointed out that this is a significant difference between Western European countries and Central/Eastern European Countries (European Commission, 2006, 2011b). Therefore the debates in Poland and Iran have typically been dominated by administrative actors, i.e. scientists, business/industry representatives or institution officials. However, in the case of

Poland, institution officials were less active in the nano-debate. Again, this can be related to the Polish socio-political context outlined in chapter three. Although during communist rule government and officials expressed interest in science and technology development (partially due to central planning, the same way as in Iran), the new governments did not pay too much attention to this area. It was assumed that this area should be governed by the researchers and scientists themselves. The coverage reflects this approach. On the other hand Sweden is a country with a high level of citizens' activity and interest in various environmental issues. This difference between Sweden and Poland has been reflected through the differences in metaphors used to picture the positive view of nanotechnology. As pointed out in chapter five Sweden was the only country where nanotechnology was described as 'natural'.

In terms of the model of mediated issue development, this study has pointed out the range of its potential limitations. These are related to the vagueness of the framing typology in the original model and its applicability to studies of coverage in countries other than the US. It was found that the use of dramatic frames can be used in order to promote nanotechnology. This can be related to the widespread use of the revolution metaphor. As observed by Stahl 'The revolution metaphor is taken up and intensified by commercial interest, which emphasise the significance of changes of consumer products' (Stahl, 2011, p. 141). Therefore, dramatic framing cannot be limited to the nano-skeptical approach. It could be argued that what Nisbet and Huge describe as 'dramatic' should rather be called 'alarmist' framing, which would be more suitable for their choice of frames.

An additional aspect discussed in this chapter in the context of Nisbet and Huge's model was the use of the 'National' frame, whose importance became increasingly apparent during the analysis of the three corpora of newspaper articles from countries which have different views about nationhood and national

identity. The comparison between Sweden, Poland and Iran shows that this frame is not used everywhere in the same way or with the same frequency. It was shown that its use depends, to some extent, on the socio-political context in which it is used. It is more popular in Iran, where the government (as the main funding body and owner of most research institutions) is using achievements in nanotechnology to highlight the country's international position. At the same time, this frame was less popular in Sweden: the country that has the most nano-achievements among these three countries. In Poland and Iran it was used for comparison with other countries, but the use of the frame stood in contrast to the lack of actual scientific achievements on a global scale. Although, there are differences in the use of that frame in Poland and Iran, in both countries nanotechnology was described as a nations' chance to catch up with the developed countries.

This element of 'national pride' should also be considered when developing framing typologies for studies on media in countries like Poland and Iran, where it was found to appear relatively often. As such, this frame could be classified as a dramatic one, since it is emotionally charged. However, it would be more characteristic of administrative venues and pro-nano voices. This is another example of the problem of the generalisability of Nisbet and Huge's model and the limitations of their proposed framing typology.

# 7 Conclusions

Media studies of nanotechnology research and development have proliferated over the last fifteen years. We know much more know about how newspapers in Western countries (especially English-speaking ones) have reported on developments in nanotechnology research from the second half of the 1990s onwards, with a peak in reporting around 2004. To study such press reporting, various methods have been used, such as content analysis and frame analysis. Media scholars have also developed a variety of models, some of which extend existing ones, to explore changes in public debate including perceptions and opinions, how knowledge of nanotechnology is shaped, diffused and disseminated by the media, and how facts and fictions are mixed in this context. The novelty of this thesis and its contribution to this growing field of social sciences can not only be found in its analysis of three different countries (never studied before) but also in the methods used and investigation of the applicability and generalisability of a model that has been used previously to study the coverage of emerging technologies.

The main aim of this project was to move the research-focus from the developed Western countries (especially English-speaking ones) towards Sweden, Poland and Iran. These countries represent different perspectives on nanotechnology debates in terms of different cultures, languages, economies, religion or socio-political systems. As pointed out in chapters one and three, these three countries are at different stages of development in terms of economy, technological development, scientific research (including nanotechnology) and political systems. Therefore, I have conducted a content analysis of a sample of over 300 articles published in seven daily Swedish, Polish and Iranian newspapers between January 2004 and December 2009. The analysis was conducted in the context of particular country's economic, scientific and socio-political backgrounds (see chapter three).

As explained in the introduction, this thesis set out to answer the following research questions:

- What are the main characteristics of the press coverage of nanotechnology in a particular country? What aspects (areas) of nanotechnology are most often covered by the media?

- How were the nano-debates framed in the Swedish, Polish and Iranian press? How did the use of particular frames change over the time?

- How have metaphors been used in the press coverage of nanotechnology in each of the three countries and are there similarities and differences?

- What are the similarities and differences across nano-debates in the studied countries? And are these differences mainly due to political and economic context or are there other, more unexpected features of coverage that can be found?

To summarise, my overall aim in this thesis was to find the key characteristics of the coverage of nanotechnology in the three countries, especially differences in the way press coverage was framed and, most importantly, how it changed (or not) over time. To achieve these objectives I have used the model of mediated issue development as proposed by Nisbet and Huge. I have also tried to determine whether the same model can be applied to studying press coverage and debates of nanotechnology in non-Western countries (especially countries other than the United States). Finally, I examined the use of metaphors in these debates, as indicators of cultural differences and/or a developing global language about nanotechnology.

The research and analysis produced original and sometimes surprising findings that challenge some aspects of the established knowledge about the relationship

between nanotechnology, its reporting in the media and its potential to shape public perceptions. These key findings are summarized below:

- In terms of framing, themes, metaphors, actors and tone the press coverage in all three countries followed general patterns observed in other countries (positive tone, focus on generic research and applications). This was surprising because, despite their different cultural and political contexts, not only did all three types of press coverage exhibit similar patterns between them (especially Poland and Iran), but that all three patterns are in accord with global patterns.

- Coverage of nanotechnology was mostly positive and focused on scientific research and applications; only in Sweden (towards the end of the studied time period) did it start to be more diverse and focused on negative aspects of nanotechnology – this shows how a particular socio-cultural background may affect the debate, since it was only in Sweden that eventual reports on potential nano-risks caused some broader concerns.

- As can be expected, press coverage debating nanotechnologies in Poland and Iran is still in its early stages and will require further monitoring in the future to detect any changes in coverage as the nanotechnology sector becomes more established.

- There has been no trigger for a more widespread, in-depth or heated discussion of nanotechnology in any of the countries studied, this overlaps with other countries' debates studied in the literature. It could be said that despite some initial stories around largely fictional grey goo scenarios, nanotechnology has not yet produced its own 'Dolly the sheep' or 'Frankenfood'. Nanotechnology has simply not become a 'celebrity issue'.

- The press coverage of nanotechnology reflects the socio-political context of the country in which nanotechnology is being discussed- from a democratic

modern economy with highly developed scientific research (Sweden), through to a country in economic and political transition (Poland), to an un-democratic developing country with a strong element of central planning and extremely limited participation of independent actors in public debate (Iran). This constitutes a major contribution of this work to the social science literature in this area as media coverage of nanotechnology has not previously been studied as 'a mirror' of a particular country's socio-economic and political characteristics, especially in such a comparative cross-national and cross-cultural context.

- In terms of methodological development, this thesis demonstrates that the model of mediated issue development that was successfully used in the US context cannot be applied in an unmodified form to studies located in other countries. A one-size-fits-all approach in the case ignores the particular and, more importantly, diverse political, economic, social and cultural conditions of the selected countries (even when located in the same continent as Poland and Sweden) and therefore weakens the generalisability of the results obtained using the original model. The findings of this study challenge claims made in former studies that suggest that the model can be unproblematically applied in the context of other countries.

- In contrast to observations made by other researchers, this thesis reveals that the use of particular dramatic/technical frames cannot be assigned to a specific approach to nanotechnology, to a particular venue of the debate (administrative vs. overtly political) or to specific actors.

- Nanotechnology can be used as symbol of the national pride and success in countries with less developed economies or scientific facilities. This is a novel discovery that has not been found in any other studies in this area, partially because most studies have focused on Western countries with developed infrastructures. This finding contributes not only to the literature on media

studies of emerging technologies, but also to the aligned fields of cultural studies and political science.

The above list covers the main findings of this thesis and their number and novelty demonstrates the depth of this study's contribution to existing academic knowledge.

As with any focused study aiming to contribute original knowledge to an established field, this research has at times encountered specific problems that have resulted in some limitations. The main one is that only one Iranian newspaper could be considered in this study. Nonetheless, gaining access to this newspaper's archive presented its own challenges in that it required the development of a sophisticated and novel searching strategy that has not been used before in similar studies. This allowed me to provide a glimpse into the Iranian press-debate on science and technology that has been rarely (if at all) studied by Western researchers. Another limitation, due to practical reasons, was the inability to investigate in more depth the relationship between press-coverage and peoples' attitudes towards nanotechnology. The exploration of this question lies beyond the scope of this research project, and thus should be a consideration for future research projects in this field as thus far scholars have almost exclusively discussed this question in the context of Western countries. A further suggestion for future research would involve the study of temporal changes in newspaper coverage over extended periods of time e.g. 15-20 years. Because of nanotechnology's relative novelty in the countries studied in this thesis, such research will only become possible in the next 5-10 years. Of course, drawing on the lessons learnt in this thesis, the frameworks and typologies of these potential projects should consider the specific socio-political contexts of non-Western countries.

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# APPENDIX 1

Table 3 Former studies on media coverage of nanotechnology

| Author(s) | Year of Publ. | Countries covered | Timeline | Analysed sources | Sample |
|---|---|---|---|---|---|
| Boholm, M. | 2013 | Sweden* | 1988-2010 | 'Swedish national and major regional newspapers' | 2564 |
| Boholm, M.<br>Boholm, Å. | 2012 | Sweden* | | | |
| Donk, A.<br>Metag, J.<br>Kohring, M.<br>Marcinkowski, F. | 2012 | Germany | 2000-2008 | Daily newspapers: 6<br>Weeklies: 3 | 1807 |
| Groboljsek, B.<br>Mali, F. | 2012 | Slovenia | 2004-2009 | Daily newspapers: 3 | 73 |
| Fitzgerald, S.<br>Rubin, B. | 2010 | US | 1998-2005 | Daily newspapers: 4<br>Magazine: 4 | 576 |
| Allan, S.<br>Anderson, A.<br>Petersen, A. | 2010 | UK | 2003-2004 | Daily newspapers: 10<br>Sunday newspapers: 8 | 344 |
| Dudo, A.<br>Choi, D.<br>Scheufele, D. | 2010 | US (nano-food only) | 1980-2009 | Daily newspapers: 21 | 250 |
| Veltri, G. | 2010 | Spain | 1997-2010 | Daily newspapers: 3 | 646 |
| Kjærgaard, R. S. | 2008 | Denmark | 1996-2006 | Danish national newspapers | 250 |
| Weaver, D.<br>Lively, E.<br>Bimber, B. | 2009 | US | 1999-2008 | 10 largest newspaper | 137 |
| Kjølberg, K. L. | 2009 | Norway | 2000-2007 | National newspapers: 7<br>Regional newspapers:9<br>Totally: 16 (all main daily newspapers) | 224 |
| Deveraux, Z.<br>Mogoutov, A.<br>Theoret, C.G.<br>Allard, C. | 2009 | Canada | 2000-2008 | Web pages and blogs<br>*"Canadian newspaper outlets"*<br>No detailed numbers given | not given |
| Zimmer, R.<br>Hertel, R.<br>Böl, G.-F. | 2008 | Germany | 2000-2007 | Daily newspapers: 5<br>Weeklies: 2<br>Newsmagazines: 2 | 1969 |
| Fogelberg, H. | 2008 | Sweden | 1990 - 2007 | Daily newspapers: 3<br>Industry/Business Journal: 2 | 405 |

| | | | | | |
|---|---|---|---|---|---|
| Arnaldi, S. | 2007 | Italy | 2002-2006 | Daily newspapers: 4 | 71 |
| Fitzgerald, S. | 2007 | US | 1998-2005 | Popular Press: 3<br>Trade Journals: 2<br>General Science Journals: 2 | 576 |
| Wilkinson, C.<br>Allan, S.<br>Anderson, A.<br>Petersen, A. | 2007 | UK | 2003-2006 | Daily newspapers : 9<br>Sunday newspapers: 8 | 636 |
| Faber, B. | 2006 | US,<br>Canada (?) | 1986 - 1999 | no information given | 203 |
| Kulve, H.T. | 2006 | Netherlands | 1992-2005 | National daily newspapers: 5<br>Regional daily newspaper: 1<br>Economical Journal: 1 | 237 |
| Petersen, A.<br>Anderson, A.<br>Allan, S.<br>Wilkinson, C. | 2006 | UK | 2003-2004 | Daily newspapers : 10<br>Sunday newspapers: 8<br>Totally: 17 | 344 |
| Anderson, A.<br>Allan, S.<br>Petersen, A.<br>Wilkinson, C. | 2005 | | | | |
| Laing, A. | 2005 | Canada,<br>US | 2004-2004 | Daily newspapers<br>Canada: 15<br>USA: 12 | 381 |
| Stephens, L.F. | 2005 | US and "other" English – speaking countries, | 1988 - 2004 | major US newspapers: 76%<br>non-US newspapers: 24%<br>precise number not given;<br>search for "news' using LexisNexis and South Carolina news databases | 350 |
| Faber, B.<br>MacKinnon, J.<br>Petroccione, M. | 2005 | US,<br>Canada | 1986-2000 | US: 19 daily newspapers<br>Canada: 3 daily newspapers<br>Totally: 22 | 303 |
| Friedman, S.M.<br>Egolf, B.P. | 2005 | UK,<br>US | 2002-2004 | UK: 7 daily newspapers<br>US: 6 daily | 121<br>- 71 US<br>- 50 |

| | | | | | |
|---|---|---|---|---|---|
| | | | | newspapers & 2 wire sources<br>Totally: 15 | UK |
| Gorss, J.<br>Lewenstein, B.V. | 2005 | US | 1986-2004 | 3 „elite" media outlet<br>1 general media outlet<br>Totally: 4 | 620 |
| Grobe, A.<br>Eberhard, C.<br>Hutterli, M. | 2005 | Germany<br>Switzerland | 2001-2005 | German daily newspapers: 3<br>Swiss daily newspapers: 1<br>Totally: 4 | 407 |
| Gaskell, G.<br>Ten Eyck, T.<br>Jackson, J.<br>Veltri, G. | 2005 | US,<br>UK | 1990 –-2003 | US: 1,<br>UK: 1,<br>Totally:2 | 176<br>110 US<br>66 UK |
| Arias, I. A. | 2004 | US | 1986-2003 | 4 daily newspapers | 245 |

*-paper published after submission of this thesis

# APPENDIX 2

List of the press-articles used for the analysis in this study.

Table 4 Swedish nano-articles, 2004-2009

| Date | Title | Newspaper |
|---|---|---|
| 2004-02-07 | Den stora staten faller | Svenska Dagbladet |
| 2004-04-28 | Hlaverad omsättning för Obducat | Sydsvenskan |
| 2004-05-19 | Liten julgran ger effektiva solceller | Dagens Nyheter |
| 2004-05-30 | Nanotrådarna i Lund ska förändra världen | Svenska Dagbladet |
| 2004-07-31 | Svenskar först med nanotrådsklyvning | Svenska Dagbladet |
| 2004-08-12 | Obducat ger sig efter hård kritik | Sydsvenskan |
| 2004-10-31 | Gränsen mellan människa och robot på väg att suddas | Svenska Dagbladet |
| 2004-11-17 | Rörlighetsmani har ersattvår framtidstro | Svenska Dagbladet |
| 2005-02-06 | Vita lysdioder vann pris som årets miljöinnovation | Svenska Dagbladet |
| 2005-02-11 | Katastrofenscyniska räknelära | Svenska Dagbladet |
| 2005-02-24 | Tandkräm lagar tänder utan borr | Dagens Nyheter |
| 2005-03-06 | Lagarbete förde forskare till toppen | Sydsvenskan |
| 2005-03-13 | Mer liv till åren inte mer år till livet | Svenska Dagbladet |
| 2005-04-11 | Superbatteri godis för elbilen | Svenska Dagbladet |
| 2005-04-24 | Nu spelar vi skjortan över döden | Dagens Nyheter |
| 2005-06-27 | Lera i nya brandsäkra plagg | Sydsvenskan |
| 2005-09-18 | Snabbtest avslöjar cancer | Dagens Nyheter |
| 2005-10-23 | Ryggmuskel blev nytt pannben | Dagens Nyheter |
| 2005-12-03 | Resurssnålare Mazda 3 | Göteborgs Posten |
| 2005-12-06 | Teknologi upphöjd till religion | Svenska Dagbladet |
| 2005-12-17 | Fuskare frodas i hetaste labben | Dagens Nyheter |
| 2006-03-10 | Universum lockar med nanoteknik | Svenska Dagbladet |
| 2006-07-04 | Världens minsta fotbollsplan | Svenska Dagbladet |
| 2006-08-26 | Platinjakt för renare luft | Dagens Nyheter |
| 2006-10-01 | Nanopartiklar kan bli nästa miljögift | Svenska Dagbladet |
| 2006-11-12 | Nanoteknik renar arsenik | Dagens Nyheter |
| 2006-11-17 | Gästkrönika 18/11: Genteknik är inget konstigt | Göteborgs Posten |
| 2007-01-30 | Nanoteknik ska lyfta Obducat | Sydsvenskan |
| 2007-09-18 | Kosmetika kan framkalla cancer | Svenska Dagbladet |
| 2007-09-19 | Kosmetika kan framkalla cancer | Dagens Nyheter |
| 2007-10-07 | Forskare vill koppla protesen till hjärnan | Svenska Dagbladet |
| 2007-10-18 | Min nanoglädje blev kortvarig | Svenska Dagbladet |
| 2007-10-31 | Nanoteknikens risker dåligt utredda | Svenska Dagbladet |
| 2007-10-31 | Ny metod räddar kyrkokonst | Svenska Dagbladet |
| 2007-11-08 | Ddet nya ljuset från Lund | Sydsvenskan |

| | | |
|---|---|---|
| 2008-02-18 | Nanorobotar hjälper människans intelligens | Svenska Dagbladet |
| 2008-03-22 | Nanoteknikens framfart oroar forskare | Sydsvenskan |
| 2008-03-28 | Majs i däck ska minska utsläpen | Dagens Nyheter |
| 2008-05-28 | Miljögifter i solkrämer | Dagens Nyheter |
| 2008-05-29 | Oro efter larm om farlig solkräm | Göteborgs Posten |
| 2008-06-01 | Bomber biter inte på ettor och nollor | Svenska Dagbladet |
| 2008-06-04 | Låt kläderna ladda dina pryllar | Dagens Nyheter |
| 2008-06-06 | Ta nanoteknikens hälsorisker på allvar | Svenska Dagbladet |
| 2008-06-18 | Godis med azofärg varningstextas | Göteborgs Posten |
| 2008-08-15 | Du sköna nya teknik | Dagens Nyheter |
| 2008-09-26 | Kolla in Nokias stretchmobil på Youtube | Dagens Nyheter |
| 2008-10-02 | Framtidens mobiler | Svenska Dagbladet |
| 2008-10-24 | Dålig kunskap om småpartiklar i mat | Svenska Dagbladet |
| 2008-10-26 | Nanostyrning i politiken | Dagens Nyheter |
| 2008-11-28 | Implantat kan hjälpa hörselskadade | Dagens Nyheter |
| 2008-12-03 | Mazda 3 avväckt på Bolognamässan | Dagens Nyheter |
| 2008-12-05 | Snacka på så laddar du mobilen | Dagens Nyheter |
| 2008-12-19 | Så hinner tomten med | Göteborgs Posten |
| 2009-01-16 | Miljövänligare Bridgestone däck | Göteborgs Posten |
| 2009-02-13 | Mikroskop ser insidan av virus | Svenska Dagbladet |
| 2009-02-25 | MIT rankar 10 heta tekniktrender | Dagens Nyheter |
| 2009-03-05 | Barntatueringar gav Vincent blåsor | Svenska Dagbladet |
| 2009-03-09 | Silverkläder 09 | Göteborgs Posten |
| 2009-03-24 | Nya EU-regler för säkrare kosmetika | Svenska Dagbladet |
| 2009-04-04 | Nanoprodukter ska granska hårdare | Svenska Dagbladet |
| 2009-04-11 | Näsa för nano | Sydsvenskan |
| 2009-08-12 | Patentläsning skapade ett nanoföretag | Svenska Dagbladet |
| 2009-09-28 | Miljöforskare: Gör med dubbdecken som i Oslo | Dagens Nyheter |
| 2009-09-29 | Livets minsta beståndsdelar | Sydsvenskan |
| 2009-11-16 | Kontaktlinsen blir mörk i solen | Dagens Nyheter |
| 2009-12-29 | Nanotekniken kan skappa en ny värld | Svenska Dagbladet |

Table 5 Polish nano-articles, 2003-2006

| Date | Title | Newspaper |
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| 2004-01-13 | Do nanoboju! | Gazeta Wyborcza |
| 2004-01-20 | Dziwny nanoświat | Gazeta Wyborcza |
| 2004-01-20 | Uniwersytet Jagielloński ma nowe Laboratorium Syntezy i Diagnostyki Nanostruktur | Gazeta Wyborcza |
| 2004-02-13 | Pożyteczne okno klejone | Rzeczpospolita |
| 2004-04-21 | Zmiana dotknie wszystkich | Rzeczpospolita |
| 2004-05-07 | Samo-chodzik | Rzeczpospolita |
| 2004-06-09 | Okienko umyj sié | Gazeta Wyborcza |
| 2004-06-29 | Już nas nie pożrą | Gazeta Wyborcza |
| 2004-06-29 | Nie pożrą nas roboty | Gazeta Wyborcza |
| 2004-09-21 | Antena światła widzialnego | Rzeczpospolita |
| 2004-09-29 | Lek zdalnie sterowany | Rzeczpospolita |
| 2004-12-16 | Wynalazek łodzkich naukowców | Gazeta Wyborcza |
| 2005-02-23 | Świat nano(wo) | Gazeta Wyborcza |
| 2005-03-15 | Świat współczesnej alchemii | Rzeczpospolita |
| 2005-03-24 | Pamięć mechanicznej stonogi | Rzeczpospolita |
| 2005-03-31 | Ostatnie piętro: orbita | Rzeczpospolita |
| 2005-05-10 | Nanoekrany - następcy CRT i LCD | Gazeta Wyborcza |
| 2005-05-30 | O nanotechnologiach | Gazeta Wyborcza |
| 2005-05-30 | O nanotechnologii na politechnice | Gazeta Wyborcza |
| 2005-07-09 | Mikrowykrywacz | Gazeta Wyborcza |
| 2005-07-09 | Naukowcy z UAM zbudowali wykrywacz pojedynczych żywych komórek | Gazeta Wyborcza |
| 2005-07-21 | Druciki w tętnicach | Rzeczpospolita |
| 2005-07-29 | Inteligentny pocisk antyrakowy | Rzeczpospolita |
| 2005-10-22 | Z plastikiem na słońce | Gazeta Wyborcza |
| 2005-10-25 | Auto z atomów węgla | Rzeczpospolita |
| 2005-10-29 | Człowiek ponad technologią | Gazeta Wyborcza |
| 2005-11-03 | Antyrakowa bomba | Rzeczpospolita |
| 2006-02-03 | Posrebrzane DNA | Rzeczpospolita |
| 2006-03-15 | Chomik odzyskuje wzrok | Gazeta Wyborcza |
| 2006-03-17 | Jak chomik odzyskał wzrok | Rzeczpospolita |
| 2006-03-30 | I co mi zrobisz, nanomaszyno? | Gazeta Wyborcza |
| 2006-04-14 | Będziemy składać atom po atomie... | Gazeta Wyborcza |
| 2006-04-20 | Szansa dla zabytków | Rzeczpospolita |
| 2006-04-26 | Chiński przełom w nanotechnologii | Gazeta Wyborcza |
| 2006-05-26 | Nie do zobaczenia | Gazeta Wyborcza |
| 2006-05-30 | Sfilmować milionową część milimetra | Gazeta Wyborcza |
| 2006-08-31 | Nanotechnologiczne kamizelki | Rzeczpospolita |
| 2006-09-07 | Nanotechnologiczna szansa stoi przed stolicą | Rzeczpospolita |

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| 2006-09-26 | Koniec problemu brudnych kół | Rzeczpospolita |
| 2006-10-11 | Opatrunek w płynie | Rzeczpospolita |
| 2006-10-20 | Niewidzialność jest możliwa | Rzeczpospolita |
| 2006-11-16 | Czasowstrzymywacze | Rzeczpospolita |
| 2006-11-29 | Jak podwoić wydajność baterii | Rzeczpospolita |
| 2006-12-01 | Oddychająca guma ochroni organizm przed chemikaliami | Rzeczpospolita |
| 2006-12-29 | Złoty środek na raka | Rzeczpospolita |
| 2007-01-18 | Nanotechnologia dla mózgu | Rzeczpospolita |
| 2007-02-08 | Bielizna high-tech | Rzeczpospolita |
| 2007-03-01 | Siatka grubości atomu węgla | Rzeczpospolita |
| 2007-04-20 | Rosja stawia na nanotechnologię | Gazeta Wyborcza |
| 2007-04-21 | Mikrokosmos | Gazeta Wyborcza |
| 2007-05-19 | Klejące cząsteczki połączą dowolne materiały | Rzeczpospolita |
| 2007-07-21 | Magnetyczny płyn jak kameleon | Rzeczpospolita |
| 2007-08-14 | Papierowa bateria | Rzeczpospolita |
| 2007-08-16 | zabójcze srebro | Rzeczpospolita |
| 2007-08-29 | Nanorurki węglowe zniszczą bakterie | Rzeczpospolita |
| 2007-10-06 | Srebrne rajstopki | Gazeta Wyborcza |
| 2007-10-10 | Nanotechnologia twardego dysku | Rzeczpospolita |
| 2007-10-19 | Nanoradyjko z nanorurek | Gazeta Wyborcza |
| 2007-10-24 | Węglowe rurki splecionew supernić | Rzeczpospolita |
| 2007-11-10 | Srebrny pył zwalczy grzyba pod Rynkiem | Gazeta Wyborcza |
| 2008-01-02 | Wynalazek z Gdańska: Mali wrogowie bakterii | Gazeta Wyborcza |
| 2008-01-03 | Gdańscy naukowcy pracują m.in.. Nad antybakteryjnymi zabawkami | Gazeta Wyborcza |
| 2008-01-18 | Czerń prawie idealna | Gazeta Wyborcza |
| 2008-02-13 | Elektryczna koszula przemieni oddech w prąd | Rzeczpospolita |
| 2008-02-14 | Tkanina z mikrowłókien sama doładuje ci komórkę | Gazeta Wyborcza |
| 2008-02-19 | Nanotechnologie z Podlasia | Rzeczpospolita |
| 2008-02-20 | Wieczne życie dla każdego | Gazeta Wyborcza |
| 2008-03-05 | Magnesy zwalczą raka | Rzeczpospolita |
| 2008-03-12 | Chemiczny komputer steruje robotami | Rzeczpospolita |
| 2008-03-29 | Mikroprocesory: co po krzemie | Rzeczpospolita |
| 2008-04-02 | Laser wykryje nowotwory | Rzeczpospolita |
| 2008-04-22 | Dziesięcionanometrowy tranzystor grafenowy | Gazeta Wyborcza |
| 2008-05-14 | Twarzą twarz z kremem | Rzeczpospolita |
| 2008-05-27 | Nanorurki jak azbest | Rzeczpospolita |
| 2008-06-01 | Diabelska piłka z atomów węgla | Rzeczpospolita |
| 2008-06-07 | Bibuła do wysysania ropy | Rzeczpospolita |
| 2008-06-21 | Kolorowe jutro diagnostyki | Rzeczpospolita |

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| 2008-07-01 | Pleśń zagłodzi nowotwór | Rzeczpospolita |
| 2008-07-11 | Puławy. Zabójcze bakterie już się nie ukryją | Gazeta Wyborcza |
| 2008-07-13 | Żołnierz z aluminium | Gazeta Wyborcza |
| 2008-07-23 | Łódź centrum tkanin high-tech | Gazeta Wyborcza |
| 2008-07-25 | Zważą atomy | Rzeczpospolita |
| 2008-08-09 | Guma, która przewodzi prąd | Rzeczpospolita |
| 2008-08-12 | Czego oczy nie zobaczą | Rzeczpospolita |
| 2008-08-26 | Zaglądanie do środka głowy | Rzeczpospolita |
| 2008-08-27 | Złoto najlepsze | Rzeczpospolita |
| 2008-08-30 | Minimagnes na raka | Rzeczpospolita |
| 2008-09-04 | Gadżety nie tylko dla Bonda | Gazeta Wyborcza |
| 2008-11-06 | Czy nanokosmetyki mogą być groźne | Rzeczpospolita |
| 2008-11-27 | Podróż w kosmos po nanorurkach | Rzeczpospolita |
| 2008-12-12 | Laboratorium małych światów | Gazeta Wyborcza |
| 2009-01-06 | Japoński specjalsita od kropek na politechnice | Gazeta Wyborcza |
| 2009-01-21 | Mikrorobot we krwii | Rzeczpospolita |
| 2009-01-23 | Lenistwo na drugie ma kreatywność | Rzeczpospolita |
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| 2009-01-30 | Tytan, chemia i implanty | Rzeczpospolita |
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| 2009-02-20 | Prof. Jaroniec dokotrem honoris causa UMK | Gazeta Wyborcza |
| 2009-03-06 | Widok molekuł od wnętrza | Rzeczpospolita |
| 2009-03-12 | Zabić raka w białych rękawiczkach | Rzeczpospolita |
| 2009-03-17 | Nanocząstki pod kontrolą | Gazeta Wyborcza |
| 2009-03-26 | Złote kule rozerwą komórki nowotworu | Rzeczpospolita |
| 2009-03-27 | Prąd spod serca | Rzeczpospolita |
| 2009-04-01 | Lecznicze nanocząsteczki | Rzeczpospolita |
| 2009-04-07 | Komórki zreperują kości | Rzeczpospolita |
| 2009-05-04 | Mistrz szuka uczniów | Gazeta Wyborcza |
| 2009-06-12 | Nanokosmos na twarzy | Gazeta Wyborcza |
| 2009-06-13 | Inżynier podgląda atomy | Rzeczpospolita |
| 2009-06-30 | Czary Mary I dokument znikl | Rzeczpospolita |
| 2009-07-09 | Nanoplaster | Rzeczpospolita |
| 2009-09-29 | Więcej komputera w telewizorze | Rzeczpospolita |
| 2009-10-03 | Te cząsteczki docierają głębiej | Gazeta Wyborcza |
| 2009-10-29 | Biotechnologiczna perełka | Rzeczpospolita |
| 2009-11-07 | Po linie na orbitę Ziemi | Rzeczpospolita |
| 2009-11-17 | Supergąbka | Rzeczpospolita |
| 2009-11-27 | Miniaturowe półprzewodniki przyszłości | Rzeczpospolita |
| 2009-12-31 | Życie wieczne na wyciągnięcie ręki | Rzeczpospolita |

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| 22/12/2004 | علم خواص عجيب مواد | Hamshahri |
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| 20/01/2005 | درس‌های کنکور دکتری شیمی در حد سنجش ترم اولی‌ها است! | Hamshahri |
| 03/02/2005 | علي اصغر محمدي | Hamshahri |
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| 03/03/2005 | نانو، فناوري نوظهور قرن ۲۱ | Hamshahri |
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| 20/06/2005 | نقش دندريومرها در داروسازي | Hamshahri |
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| 02/07/2005 | روشي جديد براي استنتار | Hamshahri |
| 02/07/2005 | ساخت سشوار بر پايه فناوري نانو | Hamshahri |
| 15/07/2005 | دستگاه شمارش الكترون هاي منفرد | Hamshahri |
| 01/08/2005 | ناسا سفينه هاي خود را كوچك تر مي كند | Hamshahri |
| 08/08/2005 | ريزمدار هاي جديد | Hamshahri |
| 23/08/2005 | ساخت نخستين سوييچ الكترونيك نانو كربني | Hamshahri |
| 26/08/2005 | كوچكترين روبات دنيا | Hamshahri |
| 31/08/2005 | دنيايي به وسعت نانو | Hamshahri |
| 03/09/2005 | توليد سخت ترين ماده جهان با استفاده از فناوري نانو | Hamshahri |
| 14/09/2005 | مكانيزم جديد رشد نانو ذرات | Hamshahri |
| 28/09/2005 | ريز ترين دستاورد بشر | Hamshahri |
| 29/09/2005 | وعده هاي فناوري نانو به واقعيت مي رسد | Hamshahri |
| 29/09/2005 | رهاسازي DNA درون هسته سلول | Hamshahri |
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| 29/10/2005 | پودر لباسشويي نانومتري | Hamshahri |
| 29/10/2005 | ساخت مولكول PNA براي طرح هاي نانو | Hamshahri |
| 30/10/2005 | جوهر رسانا | Hamshahri |
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| 10/11/2005 | كد ژنتيكي چگونه به پروتئين تبديل مي شود؟ | Hamshahri |
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| Hamshahri | دانش فني نانولوله هاي تك جداره وارد صنعت مي شود | 04/01/2006 |
| Hamshahri | ساخت رايانه هاي كوانتومي | 28/01/2006 |
| Hamshahri | نفوذ به دنياي سلول هاي زنده نانومقياس | 25/02/2006 |
| Hamshahri | يكصدمين شماره «فناوري نانو» | 28/02/2006 |
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| Hamshahri | كاربرد نانولوله ها در درمان بيماران سرطاني | 14/03/2006 |
| Hamshahri | سنتز ذخائر آلي هيدروژن | 28/03/2006 |
| Hamshahri | ساخت ترانزيستور با استفاده از نانولوله هاي كربني | 04/04/2006 |
| Hamshahri | سرطان ، بمباران مي شود | 04/04/2006 |
| Hamshahri | ساخت اولين نانوموتور خورشيدي | 04/04/2006 |
| Hamshahri | آهن رباهاي نانومقياس نويدبخش تراشه هاي كوچكتر | 10/04/2006 |
| Hamshahri | ابداع نانو ليزرهاي جديد با تنها چند نقطه كوانتومي | 08/05/2006 |
| Hamshahri | ايران رتبه دوم جهاني در جست و جوي فناوري نانو | 15/07/2006 |
| Hamshahri | ذخيره اطلاعات روي نانوذرات | 27/07/2006 |
| Hamshahri | نانو سيم ها در مغز | 31/08/2006 |
| Hamshahri | مقاومت باكتري ها در برابر تابش هاي راديواكتيو | 07/09/2006 |
| Hamshahri | كاربرد نانوتكنولوژي در تنيس | 19/10/2006 |
| Hamshahri | بازار 2600 ميليارد دلاري نانوتكنولوژي در سال 2015 | 19/10/2006 |
| Hamshahri | تقديرازطرح هاي برگزيده زيست فناوري | 08/11/2006 |
| Hamshahri | رهايش طولاني مدت داروها در بدن | 15/11/2006 |
| Hamshahri | اتصال ارگانيسم هاي زنده به رايانه | 30/11/2006 |
| Hamshahri | مشاهده مرگ سلولی با نقاط کوانتومی | 04/12/2006 |
| Hamshahri | افزایش طرفداران استفاده از فناوری نانو | 09/12/2006 |
| Hamshahri | همایش نانو فناوری و کاربرد آن در صنایع پتروشیمی | 17/12/2006 |
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| Hamshahri | ترکیب نانوذرات با آرسنیک برای ساخت داروی ضدسرطان | **30/12/2006** |
| Hamshahri | استفاده از بال جیرجیرک در نانوساختارها | 28/01/2007 |
| Hamshahri | تسخير مرز تازه نانومتري در عالم تراشه ها | 06/02/2007 |
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| Hamshahri | پرنده کوچك جاسوس | 07/12/2007 |
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| Hamshahri | نانو تکنولوژی در خدمت بیابان‌زدایی | 15/06/2009 |
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