

**Culture in Framing Nanotechnology:  
The effect of cultural dimensions on media frames of  
nanotechnology in South Korea, Germany, Austria, and Japan  
between 2001 and 2015**

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# 1. INTRODUCTION

Historically, technology is a key driver changing society. Human beings achieved the Protestant Reformation with printing technology and developed the steam engine during the industrial revolution. Furthermore, society is currently experiencing the digital revolution through telecommunication technology. As such, the social paradigm has changed along with the development of technologies.

From the beginning of the 21<sup>st</sup> century, technology accelerated social change. The internet fundamentally changed the way human beings communicated and biotechnology provided the most diversified food supplies historically. Moreover, artificial intelligence (AI) and robotics rapidly improved economic productivity and new therapy for previously incurable diseases has developed using stem cells. However, telecommunication technology has infringed on privacy and gene modification technology has exposed human beings to unprecedented potential risks. Although technology's impact is debated, it is undisputed that technology has impacted no era more than the current era. Therefore, it is very critical to identify the process by which modern society recognizes and accepts technology.

Intrinsically, technology is a specialized field with high-level complexity. Furthermore, it is also a political issue triggering unending disputes on its potential benefits and risks. Accordingly, the public needs an interpreter to help the public understand technology's complexities and to provide a public sphere for the political discussion necessary to help the public accept it. Media plays a role as this interpreter in modern society. Fundamentally, the public gets its information on technology through media. Media filters scientific discoveries for the audience so they can easily understand and suggests the standards for how to judge technologies. Thus social acceptance of technology changes with how media presents it.

Regarding the social acceptance of technologies, the media frame has applied to science communication. It has been extensively supported that the way media frames technology in science communication reconstructs it and it is linked to its social acceptance. Therefore, this study investigated how the frames the media gives nanotechnology helps identify role media plays related to nanotechnology's social acceptance.

Nanotechnology generates nanomaterial with a new molecular structure because it controls its characteristics on the nanometer level. It modifies or even creates all human being made artificial materials because it can control the basic properties of specific material. Such characteristics present significant benefits to society at large. For example, nanotechnology has treated a variety of incurable diseases and has innovatively extended human beings' life expectancy. Nanotechnology also improves manufacturing competitiveness and creates new products. However, nanotechnology has risks as well as potential benefits. Nanomaterials are extremely tiny and can accumulate in a body without biologically decomposing. Furthermore, they cause varied toxicities and induce new environmental pollution. In Society, it is possible that nanotechnology aggravates inequality and infringes on human rights.

Due to this duality, nanotechnology has emerged as a socially important issue. Like nuclear power and genetically modified organisms in the past, nanotechnology also triggers conflicting discourse related to its social acceptance. However, the public doesn't sufficiently understand it due to its high-level specialty and complexity. Accordingly, its representation in the media certainly drives public opinion and social acceptance.

With respect to the media representation of nanotechnology, this study established three main goals: 1) identification of the media frame of nanotechnology; 2) identification of the cultural effects on the media frame of nanotechnology; 3) verification of a new approach to determine the media frame.

First of all, this study analyzed how the nanotechnology's media frame emerged. Science communication focuses on the process by which the public accepts nanotechnology. According to information-processing cognitive models, the public does not use all available information to decide on scientific issues such as nanotechnology that require significant cognitive effort for an in-depth understanding. Rather, the public relies on heuristic or cognitive shortcuts to form an opinion about a topic that they know little or nothing about. More specifically, as the public has little or no direct experience with nanotechnology, news coverage provides a key heuristic to the public (Nisbet & Lewenstein, 2002; Popkin, 1994).

In particular, the public judges nanotechnology based on its media frame. In accordance with the Heuristic/Framing model, public attitudes and opinions on nanotechnology are influenced by the media and how media represents it (Scheufele & Lewenstein, 2005). The media functions as the key heuristics for the public and has become the most important tool to understanding nanotechnology's social acceptance.

In the 2000s, many researchers investigated the media frame of nanotechnology. Their studies pointed out that media described mainly the scientific findings and economic benefits of nanotechnology and emphasized its positive aspects. Even though diverse countries implement nanotechnology globally through a variety of initiatives and policies, existing studies focused only on news coverage in Europe and North America. And those studies were merely restricted to one country or regions speaking the same language. Moreover, a few studies were conducted since 2010 when various countries' regulations drew attention to the discussion of nanotechnology's potential risks. Consequently, this study identified media frames of nanotechnology and compared differences by country and time period.

Second, this study examined cultural effects on media frame of nanotechnology. Key to the media frame is how the news reconstructs issues. Then, the media frame studies were

divided into elements affecting having effect the news representation process and how approach this representation effects the audience's perception. For this, this study focused on elements affecting the process of the news representation, i.e., frame building.

A variety of factors influence frame building. While previous studies focused on the microlevel effect of factors like with journalists and media organization on frame building, there are almost no studies on macrolevel factors including philosophy, culture, or moral values. In particular, although some researchers recognized culture as a key factor affecting media framing, no empirical study has examined it.

Cultural effects on the media frame were not studied sufficiently because it was difficult to measure the relationship between them. While culture directly effects the media frame on the macrolevel, it also has an indirect effect on media organizations and journalists. Accordingly, it is necessary to establish a theoretical concept to empirically identify the cultural factors that have a composite and duplicated effect on frame building.

Thus, this study focused on the salience of the media frame through cultural resonance. A specific factor present in the media frame and its sequential linear order is implemented as the media frame salience varies by each the factor's characteristics. Accordingly, to identify the factors having a composite effect on the media frame, for example culture, it is necessary to investigate the process by which the media frame is salient depending on cultural resonance as well as the presence of the media frame itself. However, existing studies focused on identifying the presence of frames by analyzing and comparing frame contents country by country. These approaches, however, can't empirically identify the scope of the cultural effect on the media frame and ignore the salience of media frame cultural resonance causes.

Cultural resonance occurs when the frame coincides with a specific value in culture. The

frame containing the cultural value appears more frequently in news coverage. In addition, since culture has persistent characteristics, it is reflected through resonance with the frame over the long term rather than a change of frame influenced by a microlevel factor. Thus, the stronger the resonance between culture and the media frame is, the more significant the salience of the media frame is.

To empirically investigate cultural effects on media frames, this study analyzed the salience of media frame influenced by cultural resonance. Thus, this study adopted Hofstede's cultural dimension model (Hofstede, 1980, 1991, 2001; Hofstede, Hofstede, & Minkov, 2010). The model provides the scale to quantitatively measure cultural effects. The model comprising a value-based set is remarkably efficient at measuring the cultural resonance created between cultural values and media frames. Consequently, this study expanded the theoretical scope of framing studies by empirically verifying that culture had an effect on the media frame of nanotechnology.

Lastly, this study examined a new approach to eliminate the methodological limits of media frame, largely discussing two aspects. The methodological issues on media frame were discussed largely in two aspects. One limit is reliability and validity because of unclear standards on extracting the media frame. Existing studies generally identified the frames by in-depth analyses of news articles and established a coding book consisting of frames. Then, coders using the coding book conducted an empirical content analysis to classify a media frame. However, many studies failed to suggest clear standards for determining the media frame because researchers defined such standards randomly. Furthermore, since researchers' recognition varies by the issues' complexity, the media frame categories and quantities identified in news articles also varied.

The other limit is that emerging frames are not easily identified. The unique frame of a

researcher, i.e., the coder frame, is identified depending on the researcher's recognition of the issue in the content analysis. When the media frame is determined on a specific issue, it is difficult to identify other media frames because of the researcher's schema. Moreover, researchers have the tendency to stereotype articles into the frame category which they identify.

Consequently, this study adopted a new approach using frame elements to identify the frame and maximizing the independence from researchers' influence. It facilitates identifying new frames based on the combination of frame elements. Matthes and Kohring (2008), who suggested this approach, explained that some elements of frame definitions are grouped systematically in a specific way, and are formed by a pattern identified in the text. According to their assumptions, "a frame consists of several frame elements, and each frame element consists of several content analytical variables" and "every frame is characterized by a specific pattern of variable" that "signify [that] single frame elements are grouped together by hierarchical cluster analysis" (Matthes & Kohring, 2008, p.264).

This approach posits that frames, as patterns of frame elements combinations, are not coded directly with a single variable but with combined frame elements. Therefore, a frame with several content analytical variables can achieve higher reliability and validity than a frame with single variable because frames are not subjectively determined but empirically suggested by an inductive clustering. And this approach has also another advantage in that frame coding is conducted against a coder's schema or bias because a coder does not code frame but codes variables (Matthes & Kohring, 2008).

This approach improves in-depth understanding on existing measurements by defining the frame elements. It also eliminates the methodological ambiguity of existing studies to identify media frames by determining such frames empirically, not subjectively. However, the

approach is not standardized because it has only been applied to very few studies. Thus, this study applied it to examine the complicated nanotechnology issue. In addition, this study examined the methodological efficiency of the new approach by analyzing news coverage in various countries over long time period.

## 2. MEDIA FRAME AND CULTURE

### 2.1. Saliency of Media Frame

#### 2.1.1. Media frame

The researchers who investigate news with a constructive perspective have considered news production as a social reconstruction and posited that news did not reflect reality as it was but represented it based on frames built through experience depending on the media environment (Gitlin, 1980; Tuchman, 1978). Thus, journalists and media institutions selected amorphous events and assigned a certain feature. Through this approach, news is the social reconstruction of reality by which events are selected, emphasized, and excluded.

Lippman (1922), who viewed news as the manipulation of symbols, pointed out that the society we meet through media is not the objective reality which we can directly see but is comprised of the images produced in our head. Boorstin (1961), using the concepts of "pseudo-environment" and "pseudo-event," explained that reality depicted through media was like an intentional counterfeit. Berger and Luckmann (1966) distinguished objective and subjective reality by explaining that reality was socially constructed, and also explained the knowledge-sociology had to analyze the process by which reality occurred. Adoni and Mane (1984) also described three kinds of reality: objective reality, which we experience as reality; symbolic reality, which is constructed in the form of symbolic expression on objective reality such as media content; subjective reality, which an individual constructs as a result of taking in objective and symbolic reality.

Frame means that which the media uses to construct reality. Frame allows media to assign meaning to a specific event or issue in a certain way in the process of constructing

reality. Tuchman adopted the concept of frame related to the media constructing social reality by defining news as the window into the world and insisting that people recognize the world through that window. Accordingly, frame is useful to analyze a specific discourse the news constructs. Frame study doesn't recognize news coverage as objective stimulation unlike traditional contents analysis, but as the construction of a symbolic device structured to interact with each agent (e.g. journalist, audience, and source). Thus, it suggests the possibility of unifying the whole process of news production and consumption (Pan & Kosicki, 1993). Moreover, as Entman (1993) pointed out, content analysis, by classifying and integrating text into negative and positive terms and drawing conclusions based on the dominant meaning, didn't examine the salience of text elements, and didn't catch the relationship between the most salient message frame and the audience schema. But to the contrary, frame can be a useful method to analyze news construction and content that actually influences the audience.

The above concept of frame that media studies have adopted was originally proposed by Goffman (1974). Goffman analyzed human behavior using theatrical metaphor. He thought that frame was a principle of systemization dominating human beings' subjective interference of social events, and the structure invisibly dominating human beings' daily life. His ideas significantly influenced sociologists who had focused on the approach by which the media strengthened a society's dominant ideology.

Meanwhile, Gitlin focused on how reality was constructed, by looking at the process by which the media frame produces news on events on the ideological aspects. He indicated that the media frame is a continuing pattern related to representation, interpretation, suggestion, selection, emphasis, and exclusion of reality, and media itself and journalists should conventionally use such frame devices for manipulating discourse.

In addition to a sociological insight, the psychology field also used the frame concept in focusing on the effect of news article style on the audience's interpretation. Iyengar (1991) defined framing as the subtle change in expressing or suggesting several judgments and selections, and framing effects as the change in decision making such a subtle change causes. The research on to the change in discourse and public opinion produced by media indicated that media discourse was socially and culturally constructed (Iyengar & Simon, 1993). Gamson and Modigliani (1989) explained media discourse as a series of symbolic devices, which assigned meaning to issues using a concept "package" such as frame. They viewed certain devices including metaphor, example, catchphrase, description, and visual images as applying to the media discourse.

Furthermore, Entman indicated that framing was accompanied by selection and salience. Framing selects some aspects of reality and highlights them, making them salient in communication texts. The audience thus pays greater attention to and remembers specific information through the above approach. Entman defined that the event describing the frame above related to the reconstruction of social reality was a specific issue, and performs the function of interpreting the causes and results of that issue, making ethical assessment and proposing a way to solve it.

As discussed above, researchers have defined media frames using different concepts and terms. However, they have generally agreed that media frame is the characteristics of news messages influencing the audience's understanding using a specific method and is a way to manipulate a story by combining a variety of message factors on the story's substantive aspects.

### 2.1.2. Frame Building

Scheufele (1999) studied two frame types. One frame was a "between-level" type defining media frame on the macrolevel and the audience frame on the microlevel. The other was a "within-level" type that conceptualized the media and audience frames as dependent and independent variables, respectively (Figure 2.1.).

This study focused on the media frame as a dependent variable and dealt with factors affecting frame building. Most existing frame studies merely focused on identifying the frame by content analysis. So, it was meaningful to identify the frame building process.

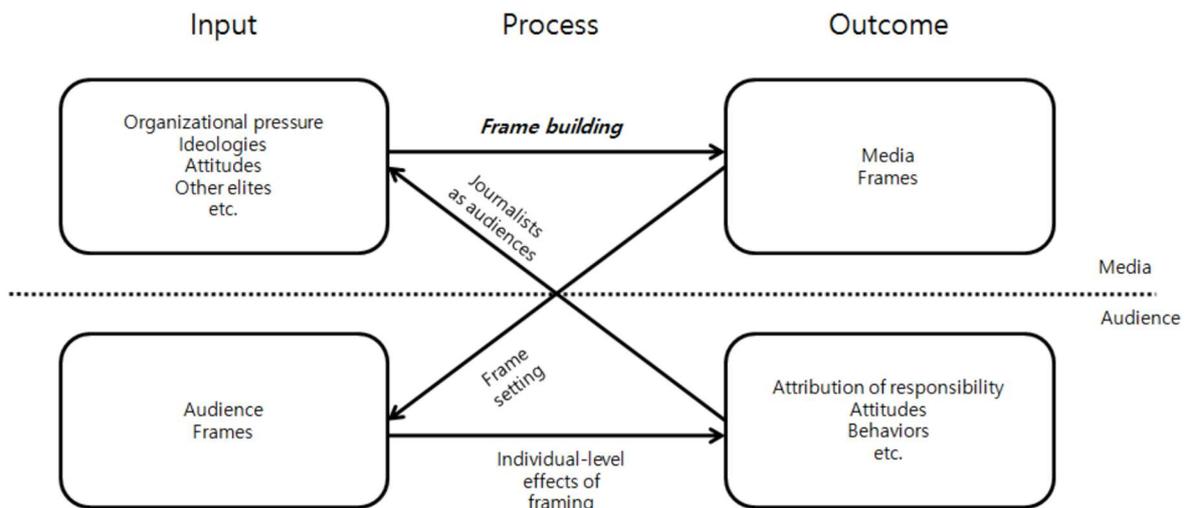


Figure 2.1. Frame building in the frame process model<sup>1</sup>

Frame building used media frame as a dependent variable and was defined as the process related to the factors affecting the creation and change of the media frame applied by journalists. Frame building adopting Cobb and Elder's (1972) Agenda-Setting Model focused on how the individual journalist's features or the media system's organizational or structural factors had an effect on news coverage framing. In this respect, frame building is similar to

<sup>1</sup> Scheufele (1999)

agenda building. However, agenda building is related to an issue itself, but frame building focuses on different levels or aspects of the same issue. In other words, frame building means the macromechanism related to the message's construction rather than media effects.

Actors including interest groups, policy makers, and journalists are interested in the media agenda, and frame affects both a specific issue's news coverage quantity and characteristic. Scheufele classified the factor types having an effect on the frame building by combining the existing studies on the factors affecting news content. He found varied factors affecting news coverage construction including news practices, gatekeepers, ownership structure, ideology, and culture.

Many other studies also identified the factors affecting news coverage, and in particular, some studies systematically classified the factors on the microlevel and macrolevel (Alger, 1989; Bennett, 1993; Gans, 1979; Graber, 1989; Schudson, 1989; Shoemaker & Reese, 1996). Gans found a correlation between various kinds of factors intervening in news production. He identified the detailed factors affecting the reporting process in news coverage including types of news values, the journalist's individual values, and the correlation between the journalist's individual belief and media organization. Shoemaker and Reese also systemized and classified the news production process into individual aspects, including journalists, media routines, and internal and extramedia organization levels, and ideology level. They also created a model on the effect of those levels on message.

Based on the above classification, Scheufele classified three factors having effects on frame building: journalist level, media organization level, and extramedia level. The factors related to the journalist level affecting frame building process means the internal factors and professional norms of journalists, including personalities, background, experience, political tendency, value, belief, and roles (Gans, 1979; Shoemaker & Reese, 1996). Gans suggested

ethnocentrism, altruistic democracy, responsible capitalism, small town pastoralism, individualism, moderatism, and social order as individual values and beliefs which American journalists had that could influence news coverage. The individual's belief, value, and political ideology of journalists could be factors influencing how he/she deals with issues. The progressive or conservative political attitude of journalists formed the political beliefs and values of journalists on a variety of political issues in the US, which could have effects on frame building (McLeod & Detenber, 1999).

A number of studies identified the factors on the media organizational level having effect on news (Blumler & Kavanagh, 1999; Scheufele, 1999; Shoemaker & Reese, 1996). Shoemaker and Reese suggested production routines at the media organization level, and political, economic, and social value and properties of an organization as the factors affecting news. Their suggestions were in line with the Scheufele's factors on the media level. They specified gate-keeping, source, news value, and news construction approach as the production routines affecting news. Scheufele, however, included media norms including objectivity and news value in examining the journalist level. Meanwhile, the Scheufele's factors relating to the media organization level include economic profit, political tendency, social property, and structure of an organization.

Next, researchers found competition among media organizations, pressure from advertising clients, administrative regulations or governmental intervention, politicians, a variety of interest groups, sources, cultural norms, and the ethical values of a society as external factors affecting news coverage (Alger, 1989; Shoemaker & Reese, 1996; Tuchman, 1978). In particular, political pressure can affect the selection and collection of news relating reporting on political issues or governmental-related events. In this case, the media frame can

vary depending on the relationship between political pressure and a media organization's political tendency (Alger, 1989).

The effect according to different news providers, in other words, source, is also an important factor affecting news (Bennett, 1990; Manning, 2001; Shoemaker & Reese, 1996; Tuchman, 1978). Bennett insisted that pressure from external sources including politicians and political groups, were standard in the conventional news production process, and thus news became individualized, polarized, and segmented. He identified the influence from the media organization itself, the influence from colleagues, and news source influence among the reasons causing the above events. Shoemaker and Reese pointed out that a news source could activate or inhibit information expansion consistent with its own interest and a news source's journalist selection could manipulate news content. Shoemaker and Reese definitely emphasized the effect of news source on news coverage because journalists could not include what they don't know in their news article.

Ethical values, cultural norms, and political and economic values affect the news content (Hartley, 1982; Shoemaker & Reese, 1996; Tuchman, 1978). Consistent with Tuchman, since news emphasizes that its function is to maintain status quo rather than to pursue innovation or change, it is framed to justify existing institutional practice and type. Shoemaker and Reese explained ideological influence by postulating that ideology wasn't directly assigned to news, but constructed by institutional, vocational and cultural practices configuring media. Moreover, they indicated that media emphasized ideology on the macrolevel including ethical values and cultural norms because of its pressure on social roles. Gamson and Modigliani (1989) described that cultural resonance and sponsorship as well as employment regulations and journalists' practices contribute to the formation of media discourse. In addition, other researchers discussed the effect of political culture and social norms on news (Henry, 1981;

Rachlin, 1998), and emphasized the roles of ideology, political tendency, and national interest on international media frames (Akhavan-Majid & Ramaprasad, 2000; Chang, Wang, & Chen, 1998; Pan, Lee, Chan, & So, 1999; Yang, 2003).

While a number of researchers have examined the exogenous and endogenous factors affecting news coverage, there is no evidence secured by a systematic and empirical approach investigating how a variety of factors affect the structural characteristics of news with respect to their framing aspects.

### 2.1.3. Presence and Saliency

As discussed above, frame building is the process that creates a media frame influenced by exogenous and endogenous factors. Accordingly, the presence of a media frame resulting from frame building shows frame building's influence.

According to Entman, frame is a result as a process of selection and saliency, and to frame is “to select some aspects of a perceived reality and make them more salient” (Entman, 1993, p.52). This means that it is necessary to identify how the selection and saliency of factors having effect on media frame differentiate.

The media frame thus is classified by the factors affecting frame building (*presence*) or by what kinds of characteristics of the factors affecting frame building help the frame be revealed more saliently (*saliency*). Stated differently, the question is what factors does the media select in frame building and then, which perspectives of the media-selected factor are more salient with media frame.

The conceptual classification above was discussed in frame setting; i.e., the process to identify the media frame's effect on the audience frame. Like the relationship between frame building and agenda building, frame setting is fundamentally based on the same process as

agenda setting. However, while agenda setting focuses on an issue's salience, frame setting relates to the issue property's salience (McComb, Llamas, Lopez-Escobar, & Rey, 1997). In frame setting, the audience frame becomes salient through the influence of the media frame. In other words, the correlation between two variables is positive because the change of the media frame as the independent variable affects on the salience of the audience frame, as the dependent variable.

The factors theoretically having effects on the media frame relate to its presence, and then the presence varies depending on the characteristic of factor. Since it is the process by which media input selects a specific factor and its characteristics that are salient, both concepts have a sequential linear order relationship. However, both concepts must be examined independently because they have different effects on frame building. For frame presence, factors having effects on frame building or their characteristic are included in the media frame. Meanwhile, frame salience is the characteristics of factors affecting frame building that resonate in a specific direction related to the media frame.

Such concept is more meaningful for macrolevel factors like culture. Macrolevel factors generally affect media frame building. They also influence media frame building indirectly through the microlevel factors including journalists or media organizations. Since macrolevel complexity can't be properly reflected only by verifying the presence of the media frame, this study will investigate the difference of effects according to factors' characteristics on the macrolevel.

Certain studies on political communication examined the process related to frame building on two levels (Hänggli, 2012; Tresch, 2009). Those studies investigated, among the factors having effect on frame building, the difference in media frame depending on the power of political actors. Hänggli distinguished frame presence and the frame salience in her

study on how strategic political actors shape news coverage. She insisted the power of the media input factor influenced the media frame. She found that media was substantially interested in more powerful media input in general. Hänggli named it the "power bias hypothesis". The power bias hypothesis means that the frame of a powerful actor is more applicable to news articles than that of a weak actor. This occurs because news media "tend[s] to index the range of voices and viewpoints in both news and editorials according to the range of views expressed in mainstream government debate about a given topic" (Bennett, 1990, p.106).

Similarly, Tresch (2009) classified the presence and the prominence (referred to as salience in this study) of media. In accordance with her study on why news media covered some parliamentarians more frequently than others, senators participating in the discussion on proposed legislative bills had the opportunity to be covered even though their activities were not regularly covered in news articles. In particular, the senators' party leaders drew among more attention from the media and were mentioned as very prominent politicians. This meant that the media frame's presence and salience have different effect on frame building.

This conceptual distinction between the presence and salience of the media frame in frame building may contribute to frame studies significantly since they have not yet been distinguished.

## 2.2. Cultural Resonance

### 2.2.1. Culture in News Coverage

In general, culture "consists of pattern, explicit and implicit, of and for behavior acquired and transmitted by symbols, constituting the distinctive achievement of human

groups, including their embodiments in artifacts; the essential core of culture consists of traditional (i.e., historically derived and selected) ideas and especially their attached values; culture systems may, on the one hand, be considered as productions of action, on the other as conditioning elements of further action" (Kroeber & Kluckhohn, 1952, p.181).

In regard to the social system and interactions between actors, culture is "relatively enduring personality characteristics and patterns that are model among the adult members of the society" (Inkeles & Levinson, 1969, p.17). And it is the "complex whole which includes knowledge, beliefs, art, morals, law, customs, and any other capabilities and habits acquired by man as member of society" (De Mooji & Keegar, 1991, p.74), and "collective programming of the mind which distinguishes the members of one group or category of people from another" (Hofstede, 1991, p.260). Moreover, culture is "the shared beliefs and understandings, mediated by and constituted by symbols and language, of a group or society" (Zald, 1996, p.262), and "the integrated system of learned patterns of behaviors, ideas, and products characteristics of a society" (Hiebert, 1976, p.25). Consequently, culture is a society's value system and contains shared values among members in the society.

News coverage studies discussed culture under two perspectives. One was journalists' news selection and culture as news value (Galtung & Ruge, 1973). For example, other countries' international news was covered more frequently in countries having a similar cultural background. News coverage on the countries accounting for a higher immigration ratio had more opportunity to be covered (Burrowes, 1974; Hester, 1971). Moreover, the journalists in a conflict-oriented culture thought that conflict issues had greater news value (Peterson, 1981). The findings indicated that culture affected journalists' news selection.

Another study type examined the cultural narrative contained in news coverage. Hoggart (1976) explained that the most important filter on how news is constructed is the cultural air

we breathe, our society's entire ideological atmosphere of our society, which tells us which things can be said and which others had best not be said, and explained that cultural air is determined by the context where its system was generated. Pearce (1981) found in analyzing the news coverage in England related to homosexuality, that news dealt with homosexuality only on its the conventional and ethical aspects because homosexuality was considered unethical in England at that time. Similarly the study on news coverage of racial conflict in England found that the "British cultural tradition contains elements derogatory to foreigners, particularly blacks. The media operate within the culture and are obliged to use cultural symbols" (Hartmann & Husband, 1973, p.274). Gans, who examined the relationship between American cultural narrative and journalism, explained that the cultural values of ethnocentrism, altruistic democracy, responsible capitalism, small-town pastoralism, individualism, and moderatism are the core of American news coverage.

### 2.2.2. Culture and Media frame

As discussed in chapter 2.1.1., the frame is the structural representation of social reality. Therefore, a systematic deduction and description is needed on the relationship between the frame and its social and cultural context. In particular, since culture is the key factor comprising meaning, understanding, and knowledge of the external world, the repertoire of the frame shared in culture plays an important role in news production. Goffman (1981) suggested that "frames are a central part of a culture and are institutionalized in various ways" (p.63). Entman also stated that "the culture is the stock of commonly invoked frames" and "culture might be defined as the empirically demonstrable set of common frames exhibited in the discourse and thinking of the most people in a social grouping" (p.53). Gamson and his colleagues explained that the frame was constructed by a framing device, potentially rational

devices, and the culture presenting the extensive meaning package (Gamson & Lasch, 1983; Gamson & Modigliani, 1989).

Although media studies have conceptually recognized that culture affects the frame, the relationship between culture and frame is still obscure. When media constructs social reality through a frame, it is difficult to identify how culture intervenes in the process, and the cultural effect on the frame can't be identified.

The existing studies on the relationship between media frame and culture up to now focused mainly on comparing countries on a single issue (Akhavan-Majid & Ramaprasad, 1998; Brossard, Shanahan, & McComas, 2004; De Vreese, Peter, & Semetko, 2001; Dimitrova & Strömbäck, 2012; Yu & Kim, 2002). For example, De Vreese, Peter, and Semetko pointed out that the media frames for the economic consequences on the introduction of the Euro varied between England, Denmark, and the Netherlands because of the cultural differences of journalists in those countries. In other words, emphasis on the economic consequences of introducing the Euro translated the economic implications of the relevant issue. However, in the culture of journalists in England, journalists themselves were very cautious in translating a specific issue (Köcher, 1986). This explained the insufficient economic consequence frame in the news in England.

Dimitrova and Strömbäck (2012) explained that cultural differences in both countries caused the difference in the media frame of TV news coverage in the US and Sweden. They insisted that the commercialization level of the TV market in both countries influenced such cultural differences. That is, they emphasized the importance of commercialization as a factor in the media frame. The above study results showed the effect of culture on frame building, but were limited in that they didn't classify the factors on the microlevel (including journalist-media organization) and the cultural factors on the macrolevel.

The studies factors on the macrolevel also didn't also define the effect of culture. In accordance with the comparison of the news coverage on the September 11 attack in diverse countries (Yu & Kim, 2001), both Korea and the US covered the attack with an aspect of "good and evil" based on US government perspective. The frames justifying the US attack on Afghanistan were dominant. On the contrary, China described the September 11 attack with a neutral perspective and showed more frames emphasizing the sacrifice of Afghans due to the US attack. This suggested that ideology had a more significant effect on media frame than cultural values (see, Korea and China) depending on the issues. On this aspect, the factors on the macrolevel need to be controlled to identify the cultural effect on media frames.

Except for comparing news coverage, the influence of culture on media frames was not investigated because of an insufficient discussion on how to adopt the cultural factors.

As discussed above, culture can be defined by various meanings and a variety of cultural types have been used as variables in the studies to measure the influence of culture. Communication studies also apply the cultural factor in various ways as a variable. Indeed, risk communication studies frequently adopted two kinds of societal controls and incorporation within bounded social groups, and were constrained by externally imposed rules as the variables (Douglas, 1992). Advertising and PR studies mainly used a variety of cultural dimensions as the variable (Hofstede, Hofstede, & Minkov, 2010; House, Hanges, Javidan, Dorfman, & Gupta, 2004; Schwartz, 1999). In addition, semiotics and international communication studies frequently used the difference of contextual meaning among cultures as variable (Hall, 1976).

Most cultural variables have a methodological limit in empirically assessing the cultural effects, except for cultural dimensions. In accordance with Scheufele's (1999) model, culture has a direct effect on the media frame as the cultural input and simultaneously as an indirect

impact through other media input. Furthermore, the media frame is a cultural result and is represented by the media frame at the same time. It is difficult to empirically identify the causality on the frame due to such overlapping and complicated cultural characteristics.

### 2.2.3. Media Frame with Cultural Resonance

Media content contains culture in frame building. However, since the cultural effect on the media frame is complicated and overlapping due to its characteristics, it can't be examined by claiming that culture is only contained in the presence of the media frame. To identify the cultural effect on media frames, it is necessary to pay attention to the frame salience having a differential effect on a specific frame, as well as a frame presence. To this end, this study focused on the resonance between the media frame and culture to empirically measure the relationship between them.

Resonance is a physical concept meaning the amplification occurring when natural frequencies of two objects respond to each other. All objects generally have unique vibrations. When an external force with the same vibration is applied to the unique vibration of an object, even a small force can deliver a broad amplitude of vibration or energy.

In communication studies the outstanding case is the resonance effect presented by cultivation theory (Gerbner, Gross, Morgan, & Signorielli, 1980; Morgan, Leggett, & Shanahan, 1999; Shanahan & Morgan, 1997; Signorielli & Morgan, 1990; Woo & Doninick, 2003). When the audience is in an environment providing them more opportunity to directly experience thinking that TV contents are similar to their situations or to confirm their pre-existing information, a synergy effect is made and the cultural cultivation effect of TV will be more powerful. It's a kind of resonance effect.

Benford and Snow (2000) applied resonance to a framing study for the first time. They pointed out that resonance is “relevant to the issue of the effectiveness or mobilizing potency of proffered framings,” and considered “why some framings seem to be effective or resonant while others do not.” Since then, several researchers mentioned the resonance of frame in a conceptual approach (Buijs, Arts, Elands, & Lengkeek, 2011; Entman, 1993; Ferree, 2003; Gamson, 1992; Gamson & Modigliani, 1989). In particular, they focused on cultural resonance. These studies described that when the frame is effectively constructed, it resonates with what is applied as a social value, and the roles of culture, the core element in the social value system, will be emphasized.

Cultural resonance occurs when "a certain frame is congruent with specific items within a culture or subculture" (Buijs, Arts, Elands, & Lengkeek, 2011, p.330) and increases “the appeal of a frame by making it appear natural and familiar" (Gamson, 1992, p.135). Therefore, cultural resonance is “an interaction of a certain package of ideas with the variable structure of an institutionally anchored discourse” (Ferree, 2003, p.310)

Gamson and Modigliani (1989) explained the intrinsic advantage because a specific frame resonates with the main cultural theme in a specific country. The frame with a key cultural theme is more frequently found in the media content. Since the cultural theme of a specific country continuously exists, Gamson and Modigliani postulated that culture resonates with frame building as the process, rather than the description of the change of frame.

Snow and Benford (1988) also stated that specific frames "resonate with cultural narrations, that is, with the stories, myths, and folk tales that are part and parcel of one's cultural heritage" (p.201).

However, there are various opinions on the cultural resonance of frame. In particular, there is the dispute on when culture resonates in the frame process. Some studies insisted that cultural resonance was a kind of frame building and thus, the results of cultural resonance had an effect on the salience of frame. It was also pointed out that cultural resonance contributed to frame setting as well as frame building (Gamson & Modigliani, 1989; Snow & Benford, 1988). Meanwhile, Entman thought that culture had a greater effect on frame setting. In other words, he described that words and images constructing a frame accelerated the audience's support or rejection of a relevant issue. Such an ability to accelerate the audience's position on an issue could be measured by cultural resonance. The frames resonating the culture make themselves noticeable, understandable, memorable, and emotionally charged. However, both views on cultural resonance agree that the stronger the resonance between frame and culture is, the stronger the corresponding effect is.

To measure the cultural resonance related to frame, Benford and Snow (2000) suggested three dimensions of frame salience to identify the resonance: centrality, commensurability, and narrative fidelity. Centrality concerns how essential the values related to frame are. The researchers assumed that the more the values related to frame were centralized in the social system around a specific issue, the more salient the frame was likely to be. Commensurability describes the correspondence of daily experience to events or issues where framing occurs. By specifying the correspondence of the societal value system, cultural narratives, myths, major assumptions, and inherent ideologies as narrative fidelity, Benford and Snow (2000) assumed that the higher narrative fidelity of a specific frame might induce a greater frame salience.

Cultural resonance was until now discussed in the media frame mainly by qualitative analysis on narrative fidelity until now. For example, Entman (2004) pointed out Bush

administration framed the September 11 by repeating the words "evil" and "war", and that those words resonated culturally on a very broad scale in the media frame and the American media. Gamson and Modigliani (1989) explained that the "progress frame" benefited from resonance with the main cultural theme of technical advancement. Accordingly, they concluded there was no disagreement in American society on emphasizing a technical approach to solving a problem.

Qualitative analysis is meaningful in that it showed the resonance between the media frame and culture. However, its limit is that general cultural factors were not applied to the media frame. For resonance of a specific culture to a media frame, the relationship between them cannot be accurately identified based on seeing that frame as the result of culture and culture as the representation of frame at the same time. Accordingly, it is necessary to empirically examine the salience of the media frame resonating with general cultural factors.

### **3. CULTURAL DIMENSIONS**

#### 3.1. Models of Cultural Dimensions

##### 3.1.1. Value and Cultural Dimensions

The common definition of culture is that culture is based on shared values. Generally, value is the “relationships among abstract categories that are characterized strong affective components and imply a preference for a certain type of action” (Straub, Loch, Evaristo, Karahanna, & Strite, 2002, p.14) and the “enduring belief that a specific mode of conduct or end-state of existence is personally or socially preferable to an opposite or converse mode of conduct or end-state of existence” (Rokeach, 1973, p.5).

Early cultural studies suggested that value was the core of culture. Parson and Shils (1951) suggested value orientation as the key factor that constitutes culture, and Kroeber (1952) insisted that culture embodies values, which may be formulated or felt by the society. Kluckhohn (1951) explained that “the essential core of culture consists of traditional ideals and especially their attached values” (p.86).

Homeostasis ensures that cultural studies mainly use shared values. People acquire a value in the early stages of life, mainly from family or peer groups, and from schools in later stages. Such social institutions teach the standards of what is right and proper for members in a society and norms on what is appropriate in various situations. Once learned, a value is integrated into the individual's value system according to the relative priority of each value. Then, the cultural value hardly changes and becomes significantly stable (Schwartz, 1999; Straub, Loch, Evaristo, Karahanna, & Strite, 2002; Williams, 1970).

In the Onion Model of Culture presented by Hofstede (1980), culture is classified into

symbol, hero, ritual, and value. While the symbolic level of culture can diversely change, the value comprising the society changes very slowly as being the core of the culture and the most stable level in this model. Under this perspective, comparative studies on culture generally identified and described culture as the values shared in a group (Geertz, 1973; Murdock, 1965; Triandis, 1972).

Values influence the national culture. The national value system hardly changes as the characteristic of a country, much like that country's geographical location or climate. It is needless to say that a national boundary doesn't coincide with the boundaries of the group having the shared cultural values. However, strong integration pressure does act, due to diverse factors in a country, including a single main language, common education, military, or national symbols or events having emotional appeal. Through such pressure, a country has internal homogeneity, and people in that country share cultural values (Hofstede, 1980).

Cultural dimension was used to categorize the comparison of a country and a group on the basis of values. Cultural dimension is a system that conceptualizes cultural diversity by relevancy, and classifies and defines the cultural factors affecting people in a specific group (Kim, 2004). Cultural dimension can be categorized into various types depending on the standards used. A number of researchers developed an individual cultural dimension that could be applied to their own fields. For example, Hall (1976) classified cultural dimension by communication, time, and space, Gray (1988) by an accounting system, Inglehart (1997) by attitude and belief, and Bond et al. (2004) by social belief.

However, most studies adopted a model based on values functioning as the core of culture. Kluckhohn and Strodtbeck (1961), Hofstede (1980), Schwartz (1994), Trompenaars and Hampden-Turner (1997), and the GLOBE Project by House, Hanges, Javidan, Dorman, and Gupta (2004) suggested a value-based cultural dimension model for comparing countries.

The studies determined that the value-based cultural dimension model could be generally applied as the main approach to explain differentiated characteristics or homogeneous phenomenon among countries.

### 3.1.2. A Variety of Models

Kluckhohn and Strodtbeck (1961) clearly classified and presented cultural dimension for the first time. Their basic concept started from the assumption that people confronted the general questions in five dimensions. The researchers proposed that value orientation answers those questions and insisted that a specific society preferred a solution reflecting the cultural values of that society according to five general questions (Table 3.1.). In other words, the preferred value orientation varies for diverse cultures for solving general questions human beings face.

Table 3.1. Kluckhohn and Strodtbeck’s cultural dimensions

Cultural Dimension	Value Orientation		
relationship with nature	mastery	harmony	subjugation
human nature	good	neutral	evil
relationship with people	individualistic	collateral	lineal
human activities	being	becoming	doing
relationship with time	past	present	future

The five general questions are presented below. The first asks what the relationship is between humanity and its natural environment. Its value orientation is classified into a value of viewing nature as the object of control or domination, a value by which human beings and nature co-exist to maintain balance and harmony between them, and a value by which human beings submit to nature because they can’t overcome it. The second question asks what the

human nature is. Its value orientation is that human beings are classified into naturally being good, bad, or a mixture of good and bad depending on the culture. The third question asks how individuals should relate with one another. Its value orientation is classified into collectivism emphasizing a group more than any other social object, individualism emphasizing the roles and importance of individuals, and authoritarianism submitting individuals to their superiors in a strict hierarchical system. The fourth question asks what humans' prime behavioral motivation is. Its value orientation is classified into "being" in which human beings, events, or thoughts are naturally generated and exist and so trying to escape from them and emphasizing the present is the way to be most faithful to the desires of this moment (Adler & Jelinek, 1986), "doing" emphasizing activity and action as the representative value symbolizing American culture, and "becoming" emphasizing the activity to develop all aspects required for the self and emphasizing development and growth. The final question asks what aspect of time we should primarily focus on. Its value orientation is classified into the "past" with the strong belief of the importance of past events, the "present" seeking life's pleasure at this moment, and the "future" expecting a better future than the present with the emphasis on the days to come (Kluckhohn & Strodtbeck, 1961).

Schwartz (1992, 1994, 1999) classified the cultural dimensions into individual and national levels. First, he identified two cultural dimensions on individual level; "openness to change versus conservation" and "self-enhancement versus self-transcendence." And then, he eventually classified seven cultural dimensions on a national level through studying 38 countries from 1988 to 1992 on the basis of the cultural dimension on the individual level (Table 3.2.). Three cultural dimensions corresponding to "openness to change versus conservation" were included at the individual level. "Conservatism" is the cultural value pursuing the maintenance of the status quo, etiquette, and protection of traditional order

comprising social values of close and harmonious relationships among people. "Intellectual autonomy" and "affective autonomy" are the values standing against conservatism. "Intellectual autonomy" means the independent freedom value promoting individual interest and desire. And "affective autonomy" is the value promoting pleasure and delight. According to Schwartz (1992, 1994, 1999), Israel, Malaysia, and Bulgaria are included in conservative cultures whereas France, Switzerland, and Germany are included in the autonomous culture.

Table 3.2. Schwartz's cultural dimensions

Individual level	National level
conservation	conservatism
openness to change	intellectual autonomy
	affective autonomy
self-enhancement	hierarchy
	mastery
self-transcendence	egalitarian commitment
	harmony

Four other cultural dimensions correspond to "self-enhancement versus self-transcendence." Of them, the cultural dimensions on the national level included in "self-enhancement" include "hierarchy" and "mastery." "Hierarchy" is related to the power value of trying to keep a constant distance between individuals and emphasizes the legitimacy of unfair allocation of roles, power, and resources through hierarchical structuralization. "Mastery," the concept meaning progressive domination in a society through self-assertion, emphasizes a positive effort to change surroundings and prevail over others in competition.

Cultural dimensions on the national level included in "self-transcendence" include "egalitarian commitment" and "harmony." "Egalitarian commitment" recommends voluntarily working for the welfare of others beyond egoistic desire. "Harmony," the value emphasizing harmony with nature or environment, is similar to "egalitarian commitment" and contrary to

"mastery."

Schwartz (1992, 1994, 1999) classified China, Thailand, and Turkey as hierarchical cultures and Portugal, Italy, and Spain as egalitarian culture. Moreover, he classified China, Zimbabwe, and Greece into conquering cultures and Italy, Slovenia, and Mexico into harmonious cultures.

Trompenaars and Hampden-Turner (1997) proposed a model focusing on the change in the relationship with value depending on the culture (Table 3.3.). The first cultural dimension focused on whether members of the culture deal with each other on the basis of standard rules or laws or on the basis of individual relationships. "Universalism" means the culture in which social norms and rules generally dominate and in which people are used to those norms and rules and adapt themselves to them. Under the theory that people should be treated equally under the rules, "universalism" implies equality and is characterized by clarity of message and the accurate setting of situations in communication. The US, Germany, and Switzerland showed high universalism. "Particularism" tends to emphasize those in special relationships with friends, brothers, sisters, or the self, instead of general citizens. Thus, "particularism" emphasizes strong paternalism and classification. "Particularism" is remarkably observed in France, Russia, along with most Asian countries. In those countries, people are sensitive to the inflow of "universalism" culture and even resistant to it. Moreover, conflict on the acceptance of a global culture and the persistence of localized native cultures are emerging as social issue.

The second dimension focused on the difference in emphasis on individuals or groups depending on the culture. Trompenaars and Hampden-Turner (1997) named this dimension "Individualism/Communitarianism." It is similar to "individualism/collectivism" as specified in another cultural dimension model. Unlike other models, the regions where Catholic

civilization developed including Germany, England, Canada, France, and Russia showed low individualism, but China and Japan demonstrated a relatively higher individualism tendency.

The next dimension was marked by the degree that roles of reason and emotion dominated the relationship between culture and people. Those in a "neutral" culture thoughtfully restrain and control their emotion. However, people show their unrestricted emotions through smiling, laughing, ridiculing or gesturing in an "affective" culture. The emotion exposure level shows significant differences between cultures. Ethiopia and Japan showed the most neutral emotion exposure level overall. Where Austria showed the most neutral tendency in Europe, Spain, Italy, and France tended to be emotional. Communication also showed differences. Although information dependency was strong in an "affective culture," a "neutral" culture focused on psychological motivations and symbolic expressions emphasizing moderate messages and implicative meanings.

Table 3.3. Trompenaars and Hampden-Turner's cultural dimensions

Cultural dimensions	Scales	
Are rules or relationships more important?	universalism	particularism
Do people derive their identity from within themselves or their group?	individualism	communitarianism
Are people free to express their emotions or restrained?	neutral	affective
Are an individual's roles compartmentalized or integrated?	specific	diffuse
How people are accorded respect and social status?	achievement	ascription

The fourth dimension is whether the relationship level is integrated into one level or distributed into several levels at the same time. "Specific" culture has the individualism tendency classifying individual life and public business. "Diffuse" culture means the collectivism tendency that doesn't classify individual life and public business. "Specific" cultures including the US prefer direct discourse. However, direct discourse is directly

connected to defamation in a "diffuse" culture. Japan, Mexico, France, and Russia are generally included in a "diffuse" culture. With respect to communication in those countries, people can start business or interpersonal relationships only after building a private relationship.

The fifth dimension focused on how position and compensation are situated in a culture. In an "achievement" culture, position and compensation depend on achievement and performance. However, they are based on age, assets, class, and gender in "ascription" culture. Although titles are given when leaders acquire them through distinguished behavior in an "achievement" culture, titles are used as the means to reinforce the hierarchical system in an "ascription" culture.

The GLOBE project is a recent academic effort to identify cultural dimensions. As the acronym GLOBE ("Global Leadership and Organizational Behavior Effectiveness") means, the GLOBE project is a multinational research program to identify cultural effects on leadership and organization processes (House, Hanges, Javidan, Dorman & Gupta, 2004). Proposed by House, the US management scientist, for the first time in the world, the GLOBE project investigated the correlation between social culture, organizational culture, and leadership, with over 170 scientists in 64 cultures participating. This project focused on the difference in leadership depending on the culture, and intensively investigated cultural features to identify such differences. While the GLOBE project is a cultural dimension model related to leadership, it shares the same context as Hofstede's model. The GLOBE project suggests cultural values as a theoretical framework because it was developed according to Hofstede's cultural dimension model as the next section describes.

The GLOBE project identified nine cultural dimensions: "power distance," "uncertainty avoidance," "institutional collectivism," "in-group collectivism," "assertiveness," "gender

egalitarianism," "future orientation," "humane orientation," and "performance orientation" (Table 3.4.). The GLOBE project evaluated these dimensions along with two types of cultural manifestations. The cultural practices of an organization were described as "as-if" and the cultural values as "should be." In other words, "as-if" explains the culture of a country where members are included, and "should-be" explains the culture of a country which each member thinks to be desirable.

Table 3.4. GLOBE's cultural dimensions

Dimension	Definition
power distance	The degree to which members of a collective expect power to be distributed equally
uncertainty avoidance	The extent to which a society, organization, or group relies on social norms, rules and procedures to alleviate unpredictability of future event
humane orientation	The degree to which a collective encourages and rewards individuals for being fair, altruistic, generous, caring and kind to others
institutional collectivism	The degree to which organizational and societal institutional practices encourage and reward collective distribution of resources and collective action
in-group collectivism	The degree to which individuals express pride, loyalty and cohesiveness in their organizations or families
assertiveness	The degree to which individuals are assertive, confrontational and aggressive in their relationships with others
gender egalitarianism	The degree to which a collective minimizes gender inequality
future orientation	The extent to which individuals engage in future-oriented behaviors such as delaying gratification, planning, and investing in the future
performance orientation	The degree to which a collective encourages and rewards group members for performance improvement and excellence

In the GLOBE project, 62 cultures are classified into 10 cultural clusters; Latin Europe, Nordic Europe, Germanic Europe, Eastern Europe, Latin America, Anglo, Confucian Asia, Southern Asia, Middle-East, and Sub-Saharan Africa. Each cultural cluster shows a different cultural dimension score. While Confucian Asia, Germanic Europe, and Anglo showed a higher value in "performance orientation," Latin America and Eastern Europe showed lower values. And while Nordic Europe and Confucian Asia showed higher values in "institutional

collectivism", Germanic Europe and Latin Europe showed lower values.

As explained above, GLOBE is based on Hofstede's model, but results from two models that are not always the same. "As-if" in GLOBE showed strong negative correlation against Hofstede's results for "uncertainty avoidance" but "should-be" demonstrated weak positive correlation. Furthermore, "future orientation" in GLOBE and "long-term orientation" by Hofstede, having similar cultural dimensions had a significant correlation in only 6 of 48 countries, measured by both models. This indicated the difficulty in identifying common factors of cultural dimension models because such results were found by applying the same questions to organizational and national cultures in the GLOBE project (Hofstede, Hofstede, & Minkov, 2010).

### 3.2. Hofstede's 5-D Model

#### 3.2.1. Hofstede's Cultural Dimensions

Hofstede conducted a survey to identify the characteristics of culture using 116,000 subjects in 53 countries working at IBM from 1967 to 1973. Then, he identified four cultural dimensions; "Individualism/Collectivism," "Power distance," "Uncertainty avoidance," "Masculinity/Femininity" (Hofstede, 1980). In 1991, he added "Long-term orientation/Short-term orientation," as a fifth dimension to address the limitation of viewing cultural dimensions based on Western perspectives (Hofstede, 1991).

A number of researchers conducting comparative culture studies have used "Individualism/Collectivism" (IDV) in a variety of fields as the most appropriate variable (Cutler, Erdem, & Javalgi, 1997; Taylor, Wilson, & Miracle, 1997; Triandis, 1995). The key point distinguishing individualism and collectivism is the extent to which individuals

scarifice their own goals for the good of an organization. Individuals are the most important unit of entity in individualism and they pursue self-orientation to which members in a society have no close relationship. In the collectivism culture, the members in a society exist in a social framework with close relationships. The loyalty of members in a social framework is emphasized and the members tend to emotionally depend on an organization (Hofstede, 2001).

Individualism encourages competition rather than cooperation and compensates individuals' achievements. The uniqueness of individuals is the most important value. In addition, individual goals take priority over organizational goals. Individuals tend not to depend on an organization or a group, and can have their own belongings, thoughts, ideas, evaluations or opinions. Such a culture emphasizes the individuals' leadership and achievement and values the individual's decision making in every aspect.

However, the strict social framework classifying internal and external groups is the main feature of collectivism. Collectivism emphasizes group opinions and goals where an individual is included (rather than individual opinions or goals), the social norms and obligations specified by a group (rather than behaviors pursuing pleasure), the belief of sharing in a group (rather than belief in classifying the self and a group), and the readiness to cooperate as much as possible with group members (Triandis, 1995, 2001).

Some studies suggested individualism is the cultural dimension of the Western world and collectivism of the Eastern world (Cutler, Erdem, & Javalgi, 1997; Frith & Sengupta, 1991). Lodge and Vogel (1987) focused on the difference emphasizing individuals between the Western and the Eastern world. Hofstede also found this difference in a study. He pointed out that the IDV score was the highest in Anglo-Saxon countries, including England, the US, Australia, Canada, and also in Scandinavian and German-speaking countries including

Germany and Austria. However, Arab countries and Asian countries showed lower IDV scores. In particular, collectivism was prominent in Confucian countries including Korea (Hofstede, Hofstede & Minkov, 2010).

"Power distance" (PDI) is a cultural orientation to power meaning the extent to which unfair power distribution in an organization is accepted (Hofstede, 2001; House, Hanges, Javidan, Dormans & Gupta, 2004). In other words, it's the extent that hierarchical organizational inequality is accepted (Orr & Hauser, 2008).

Generally, the higher the PDI score was, the more inequity was considered as a legitimate basis for social order, and indicated relatively how much easier the hierarchical relationship was accepted. In such a case, the members are dependent on those in higher ranks and are reluctant to express different opinions than from those in higher ranks. Cultures with higher PDI scores tended to be centralized, emphasizing titles and ranks, and had a higher ratio of supervisors. On the contrary, cultures with lower PDI scores didn't accept inequality and tried to minimize social ranks and to eliminate inequality. Behavior that minimized laws and norms as much as possible predominated in organizations. Those in lower PDI cultures hold that everyone is close to power and believe that they can access power. Accordingly, social ranks constitute inequality, and roles are defined for convenience for members in such culture.

While most Asian, Arab and African countries showed higher PDI scores, German-speaking countries, Scandinavian countries, and Anglo-Saxon countries demonstrated lower PDI scores (Hofstede, Hofstede, & Minkov, 2010).

"Uncertainty avoidance" (UAI) can be defined as the extent that the members in a specific culture feel uncomfortable due to uncertain or unknown situations. Uncertainty avoidance means the tendency to reduce ambiguity (Hofstede, 2001). The UAI culture

strongly trying to avoid uncertainty shows a remarkable tendency to avoid uncertain and ambiguous things in every aspect. Thus, the culture provides stability to its members, doesn't accept thoughts or behaviors beyond the normal course by imposing more official rules and regulations, and trusts experts or professional knowledge in pursuing a consensus of opinions. This culture type insists on the need for stipulated rules, plans, regulations, religious rituals, and ceremonies.

However, a culture that is less active in avoiding uncertainty accepts uncertainty existing in life more easily and doesn't feel significantly threatened by people or thoughts considered outside cultural norms. In addition, this culture type highly rates initiative or uniqueness, doesn't like a human relationship structure bound by a hierarchical system, insists that norms should be minimized, and believes the self rather than experts.

Countries in Latin America and in the Mediterranean showed higher UAI scores, and South Korea and Japan also showed higher UAI scores in Asia. However, other Asian countries demonstrated different cultural features with low or medium UAI scores. German-speaking countries showed medium scores, and Scandinavian countries and English-speaking countries had low UAI scores (Hofstede, Hofstede & Minkov, 2010).

"Masculinity/Femininity" (MAS) determines the orientation to a relationship with others along with "individualism/collectivism" in Hofstede's cultural dimensions. It explains the gender difference in social roles which are culturally determined (Hofstede, 2001).

Masculine culture emphasizes individual achievement, competition, confrontation, and aggressiveness-related values in an outcome-oriented culture. On the contrary, feminine culture is relationship-oriented, emphasizing unity, cooperation, and consideration or service to others (Hofstede, 2001; House, Hanges, Javidan, Dorman & Gupta, 2004). Scandinavian countries, Baltic countries, and South Korea and Thailand in Asia showed lower MAS scores

and German-speaking countries, China and English-speaking countries demonstrated higher MAS scores (Hofstede, Hofstede & Minkov, 2010).

Hofstede's last cultural dimension, "Long-term orientation/Short-term orientation" (LTO) means the extent to which members are satisfied with delaying material, social, and emotional desires (Hofstede, 2001). It was found by the CVS (Chinese Value Survey) of Bond (1988). It addressed the criticism that held that existing studies cultural values were western-oriented and reflected the Asian cultural features.

This cultural dimension compares long-term and short-term viewpoints in Confucian thought. Long-term orientation means the development of virtue by pursuing future compensation. In particular, tenacity and frugality are emphasized. Short-term orientation, the extreme opposite of long-term orientation, means developing virtue related to the past and the present. In particular, it emphasizes the execution of social obligations, respect for tradition and maintenance of dignity.

Meanwhile, Minkov (2007) suggested two new cultural dimensions "indulgence-restraint" and "monumentalism-flexhumility" based on the WVS (World Value Survey) in 2007. "monumentalism-flexhumility" showed very strong correlation with existing LTO. Hofstede and his colleagues estimated new LTO scores based on WVS and named it LTO-WVS, which replaced the existing LTO-CVS. LTO-WVS and LTO-CVS showed very similar results as cultural values with similar concepts. However, LTO-CVS explained the LTO implications related to a Chinese origin, as it was based on questionnaires from Chinese researchers. Furthermore, the studies of national LTO-CVS scores were limited to 23 countries, and the results acquired by expanding the same survey showed low reliability. However, LTO-WVS repeatedly investigated the data from a global survey database and expanded the basic classification from CVS into 93 countries (Hofstede, Hofstede & Minkov,

2010).

The national LTO-CVS scores indicated that East Asian countries pursued LTO. European countries and Anglo-Saxon countries demonstrated medium scores, and Nigeria and Pakistan showed the tendency to pursue short-term orientation. LTO-WVS also showed similar results in that East Asian countries had LTO. However, 6 in 23 countries analyzed in LTO-CVS showed significant differences in LTO-WVS scores. Pakistan, Germany, and England were classified as countries tending to have LTO culture and Brazil and Hong Kong as short-term orientation cultures (Hofstede, 2001; Hofstede, Hofstede & Minkov, 2010).

Table 3.5. Hofstede's cultural dimensions

dimension	Definition
Individualism/Collectivism	The extent which individuals sacrifice their own goals for an organization
Power distance	The extent that unfair distribution of power in an organization is accepted
Uncertainty avoidance	The extent that members in a specific culture feel uncomfortable due to uncertain or unknown situations
Masculinity/Femininity	The difference of gender on the social roles which are culturally determined
Long-term/Short-term orientation	The extent that promotes members being satisfied with delaying material, social, and emotional desires

Hofstede's model provided the practical and conceptual sets of values for comparing culture the first time (Watson, Lysonski, Gillan & Raymore, 2002). Culture studies before Hofstede considered social phenomenon to be a marginal factor because there was no scale to empirically investigate cultural effects. Hofstede's model provides a scale from 0 to 100 by cultural dimension and enables researchers to accurately examine the differences in national culture by placing a country on the scale compared to other countries. This approach enabled researchers to identify the difference in national culture via numbers and to compare cultures among more than 3 countries. Moreover, the cultural distance between countries can be

measured by the difference in scores presented in Hofstede's model (Kogut & Singh, 1988).

By quantitatively comparing national cultural differences, Hofstede's model has been used in diverse fields since the 1990s. In particular, it was used to identify how difference in values depending on culture is expressed in advertising or marketing, what values reflect culture, and to estimate what is suitable for a specific culture (Albers-Miller & Gelb, 1996; De Mooij, 2004; Taylor, Wilson, & Miracle, 1997).

Several studies verified Hofstede's model's reliability and validity. Sondergaard (1994) examined 61 studies using Hofstede's model and found that the model was stable over time and depending on population size. Moreover, in studies reproducing Hofstede's national culture classification, a few countries showed a slight change in value classification, but generally demonstrated the same results as the original study (Cutler, Erdem, & Javalgi, 1997; Fernandez, Carlson, Stepina, & Nicholson, 1997; Wildeman, Hofstede, Noorderhaven, Thurik, Verhoeve, & Wennekers, 1999).

Some criticized Hofstede's model even though his extensive and innovative study improved understanding of and differences between national cultures (Brett & Okumura, 1998; Dorfman & Howell, 1988; Roberts & Boyacigiller, 1984; Schwartz, 1994; Steenkamp, 2001). Such criticism focused mainly on the survey and sample in Hofstede's study. He had developed the model by 2 surveys executed at IBM from 1967 to 1973. The questions used in the surveys were not developed on theories but were selected from the survey, which was designed to evaluate workers' satisfaction, recognition of duties, and individual beliefs and goals. Thus, some criticized that the Hofstede's cultural dimensions couldn't embrace all cultures because it was not designed to identify the national culture dimension (Dorfman & Howell, 1988; Schwartz, 1994). Furthermore, some criticized that the samples selected by Hofstede didn't accurately reflect all spectrums of national culture and the countries added in

the further studies could be classified into different dimensions than he originally proposed. Moreover, some pointed out that IBM workers in the various countries didn't represent the countries' general demographic characteristics with respect to education, scientific and technological background, and exposure to modernizing forces (Huang, 1995; Myers & Tan, 2002; Schwartz, 1994).

In spite of the criticism, Hofstede's model is considered the paradigm of value-based models for comparing cultures and its reliability and validity has been verified through many successive studies. In addition, it has been extensively used in a variety of fields because it can quantitatively identify cultural effects.

### 3.2.2. Hofstede's Model in Communication studies

The cultural dimension which was used the most in Hofstede's model was Individualism/Collectivism (Cutler, Erdem, & Javalgi, 1997; Taylor, Wilson & Miracle, 1997; Triandis, 1990). This was because IDV was the cultural dimension with the highest explanatory power for indicating the difference in communication approaches between the Eastern and Western world (Cai, Wilson, & Drake, 2000; Cho, Kwon, Gentry, Jun, & Kropp, 1999; GudyKunst, Matsumot, Ting-Toomey, Nishida, Kim, & Heyman, 1996; Han & Shavitt, 1994; Lin, 2001; Mortenson, 2002).

The most significant difference in communication between individualism and collectivism is the clarity of message. It corresponds to the "High Context/Low Context" concept explained by Hall (1981, 1992). Collectivism culture has nonverbal and ambiguous expression whereas the individualism culture emphasizes the clarity of message. Since direct speech in the collectivism culture makes a group and an individual distinct, indirect speech is preferred. While communication in Asia is mostly ambiguous, indirect, and implicit,

communication in America and Europe tends to be direct and explicit (Gudykunst & Ting-Toomey, 1988; Hall, 1976; Hall & Hall, 1990; Samovar & Porter, 2004; Triandis, 2001).

IDV is applied to advertising most frequently in communication studies. Such studies focused mainly on content analysis related to the appeal and expression approach in advertising. The most representative case is the correlation between the IDV score and the figures in advertising. Frith and Sengupta (1991) investigated how the IDV score of Hofstede's model explained the difference in advertising techniques among countries. They measured the number of figures in print media advertising in the US, England, and India. In accordance with their analysis, the higher IDV score was, the more likely the advertisement was to depict only one person. However, the lower IDV score was, the more groups were shown, and the less likely it was that only one person was depicted. Alden, Hoyer, and Lee (1993) also analyzed TV commercials in the US, Germany, Thailand, and South Korea. They found that a strong correlation between IDV scores and figures in the commercials. The percentage of commercials depicting fewer than 3 figures was low in Thailand and South Korea which show a collectivism culture where the percentage of low depicted figures was high in commercials in the US and Germany with their individualism cultures. But on the contrary, Cutler and his colleagues identified a weak correlation between the number of characters in advertising and the IDV score. They insisted that the IDV was only a minor factor explaining cultural differences in advertising.

Communication difference measured by PDI are found in terms of bidirectionality. Bidirectional communication is notable in cultures with low power distance. Their communication actors relate to a horizontal relationship and prefer the approach of coming to an agreement through conversation and discussion. In this type of culture, children are allowed to argue with parents and learn how to say "No" in the families in their early years.

Furthermore, students argue with teachers in schools and can criticize teachers. Members in such culture read a variety of newspapers, but show low confidence in newspapers.

Unidirectional communication, however, is prominent in cultures with high power distance. Communicating actors in such a culture emphasize vertical relationships depending on social ranks, and thus the communication types vary in relevant cultures. For example, a superior in a specific organization focuses on how to effectively impose duties rather than discuss them with subordinates, and it is very rare that subordinates provide feedback to superior's opinions. Members in the culture with high power distance read relatively a few newspapers, but had high confidence in the newspapers they read (Hofstede, Hofstede, & Minkov, 2010; Khare, 1999; Khatri, 2009; Mintzberg, 1993; Richardson & Smith, 2007).

Zandpour, Chang, and Catalano (1992) identified that PDI was an important factor affecting differences in advertising among cultures. A culture with a high PDI score tended to depend on more psychological appeals using celebrities. Moreover, figures in TV commercials are relatively old, or the ads predominantly appeal to social class structure by showing student-instructor or father-son relations out of respect for elders.

Communication differences depending on the acceptance of uncertainty are based on the authority of the message. In such a society, it is recommended that communicating actors use more explicit, logical, and direct messages to relieve uncertainty in their communications. To this end, experts are mainly used to provide information in a culture trying to avoid uncertainty. The authority of the message by experts or those having special knowledge maximizes the communication's effect on the receiver. Accordingly, approaches enhancing the authority of the message have been frequently applied in such cultures, including explanation, composition, long advertising copy, experiment, or expert testimony. Conversely, approaches that satirize experts frequently appear in cultures accepting uncertainty and

humor has been used in many cases (Hofstede, Hofstede & Minkov, 2010; Kim, 2004).

Communication difference according to MAS depends on the purpose of the communication. In the culture with strong masculinity, the so called "report" communication type delivering information is prominent. On the contrary, the "rapport" communication type is promoted for improving relationships and friendships in a culture with strong femininity. Masculine culture emphasizes data and facts where feminine culture emphasizes stories (Tannen, 1992). Such features rise to the surface in studies on Internet usage. Although the Internet is basically a personal tool, its purposes varies by culture type. While the Internet is used for relationships in a feminine culture, it can be used for reports in a masculine culture (De Mooji, 1998; Hofstede, Hofstede & Minkov, 2010). Nevertheless, the communication difference in terms of MAS has not been essentially studied before now.

The reflection of masculinity in the advertising focused on exaggeration, persuasion, and comparison, but reflection of femininity emphasized consideration and tenderness. For gender roles, a father and a son, and a mother and a daughter were found in masculine culture advertising. On the contrary, a father and a daughter, and a mother and a son appeared in feminine culture advertising. While masculine culture advertising appeal revolved around pursuing work and success, feminine culture advertising appeal revolved around pursuing friendship and relationships. Moreover, the lower the MAS index was, the more its effect was reflected in advertising (An & Kim, 2007; De Mooji, 1998; Gilly, 1988; Kim, 1996; Milner & Collins, 2000).

Communication difference relating to LTO revolved around the usage of symbolic meaning. Cultures with short-term orientation were interested in categorization and so applied the rules controlling a specific category. In addition, such culture showed a strong tendency to use formal logic in the troubleshooting process.

On the contrary, cultures with LTO tried to identify a specific issue in the whole context. So such cultures considered a number of relevant factors around the issue. Formal logic was almost not used at all for troubleshooting. A LTO culture also frequently used symbols to effectively demonstrate what kinds of relationship a specific issue formed in the whole context. However, not many communication styles symbolically demonstrate a specific issue in a culture with STO, emphasizing the analysis that is required for categorization (Nisbett, 2003).

While LTO is the variable which can represent communication characteristics in the Western and Eastern world in a more thoughtful way, existing studies substantially dismissed its importance. The existing studies related to LTO mainly examined the advertising field. The representative case examines how harmony between nature and human beings, which was investigated as important issue in a culture with LTO, was reflected in advertising. That value was generated because a LTO culture doesn't like severe confrontation or directly mentioning products. Advertising purposes in a relevant region were found to be aimed at building the reputation of a company's reliability rather than directly selling its products. Accordingly, visual images related to nature, including bamboo, flowers, or fallen leaves symbolizing seasons, appear with important meaning (Kim, 2004).

## 4. NANOTECHNOLOGY AND MEDIA FRAME

### 4.1. Nanotechnology

#### 4.1.1. Definition of Nanotechnology

Since Feynman, the physicist, for the first time in 1959 mentioned the possibility that material on the level of individual atoms and molecules was manipulated, in his lecture, "There's plenty of room at the bottom," the discussion became earnest as Norio (1974) described the ability to delicately generate material on the nanometer (nm) level as "nanotechnology."

While nanotechnology has been defined in various ways depending on R&D policies and regulations in each country, it is generally specified as the scientific technology enabling people to understand and control material on the nanometer level. One nm means 1 billionth of a meter. Materials smaller than 100nm have completely different characteristics and are governed by the laws of quantum mechanics rather than physics (Table 4.1.).

Nanotechnology constitutes the materials and systems having physical, chemical, and biological characteristics that are newly emerged, due to their sizes being smaller than 100nm. The change of characteristics at the nanometer level is caused by quantum mechanics, wave features, and interfacial phenomenon. Such nanostructure is the smallest material which human beings can make. Accordingly, nanotechnology aims to acquire the ability to control and effectively use structures and materials at the atomic and molecular level (EU, 2009; Japan, 2001; UK, 2004)

The new phenomenon generated by nanometer size theoretically brings about unexpected results in most cases. If we can control the size of a certain characteristic, we can

improve the functions of the material beyond the limit we identified up to now. For example, reducing the size of structure is linked to the identification of material with unique characteristics including Carbon Nanotubes (CNTs), quantum dots, thin film, DNA structure, and laser emitters. Consequently, nanotechnology controls the basic characteristics and phenomena on the nanometer level and so provides the potential to change goods and products generated by human beings in almost all fields.

Table 4.1. Definitions of nanotechnology

Nation	Definition
U.S. <sup>2</sup>	the science and technology that will enable one to understand, measure, manipulate, and manufacture at the atomic, molecular, and supramolecular levels, aimed at creating materials, devices, and systems with fundamentally new molecular organization, properties, and functions
U.K. (2004)	Nanoscience is the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those at a larger scale, and Nanotechnology is the design, characterization, production and application of structures, devices and systems by controlling shape and size at nanometer scale
EU (2009)	the understanding and control of matter and processes at the nanoscale, typically, but not exclusively, below 100 nanometers in one or more dimensions, where the onset of size-dependent phenomena can emerge and enable novel applications
South Korea <sup>3</sup>	Nanotechnology that can manipulate, analyze and control the materials at the nanometer scale generates systems or substances with new or improved physical, chemical, and biological characteristics
Japan (2001)	Nanotechnology is an interdisciplinary S&T that encompasses IT technology, the environmental science, life science, material science, etc. It is for controlling and handling atoms and molecules in the order of nano (1/1,000,000,000) meter enabling discovery of new functions by taking advantage of its material characteristics unique to nano size, so that it can bring technological innovation in various fields

#### 4.1.2. Benefit and Risk of Nanotechnology

Although it is thought that nanotechnology provides substantial benefits to human beings, some have suggested potential risks. For example, nanotechnology can be applied to improve food safety and quality. However, the food contaminated on the nanometer scale will

<sup>2</sup> 21<sup>st</sup> Century Nanotechnology Research and Development Act (Public law 108-153).

<sup>3</sup> 나노기술개발촉진법 (by Korean 'Law for Promoting R&D of Nanotechnology')

be accumulated in a body directly through the intestines and the nanomaterial included in the food package will penetrate the body and emit toxicity (Handy & Shaw, 2007).

The potential benefits and risks of nanotechnology have been studied in three aspects; environment, health and society. For nanotechnology's environmental impact, manufacturing materials at the nanometer scale will improve environmental benefits by increasing the efficiency of resources and reducing the discharge of contaminants and waste (Drexler, Peterson, & Pergamit, 1991; Mulhall, 2002). Nanotechnology generates new materials that do not exist up to now and control and rebuild existing materials at the nanometer scale. Then, resources that are consumed in daily life can be reduced. Nanotechnology will also improve the product life cycle by preventing the degradation of product performance as parts and components wear out. In addition, nanofilters or molecular films can block the transfer of fine contaminants into the environment (Roco & Bainbridge, 2005).

However, there are potential risks from emerging technology that are not verified and can't be controlled. Nanotechnology can be a new contamination source, which is not biologically decomposed, like POPs (Persistent Organic Pollutants). Furthermore, it is known that nanomaterials cause air, soil, and water pollution. Each nanomaterial is insoluble. However, when they are combined, the resulting compound's property is changed to be soluble and acts like a sterilizer. Moreover, nanotechnology can constitute a severe threat against the ecologic system by killing bacteria in the food chain (Bystrzejewska-Piotrowska, Golimowski, & Urban, 2009; Snir, 2008).

The most extreme outlook on the risks of nanotechnology on the environment is Drexler's "gray goo." It is a worst-case dystopia scenario in which "nanobot" replicating itself eats everything on the earth, and is beyond the control by human beings (Drexler, 1986).

Although mainstream science is relatively dubious of such a scenario, the question of risks has been continuously presented (Joy, 2000; Smalley, 2001).

Regarding health impacts, nanotechnology has potential benefits as it can help identify and treat disease and improve physical functions. Doctors can identify atherosclerosis and Alzheimer's disease earlier using nanotechnology. Moreover, the development of medical imaging using nanotechnology contributes to identifying diseases at the atomic and molecular levels and to tracking malignant cells. In the future, nanobots can destroy viruses and cancer inside a body, can improve the body structure damaged by aging, and can remove waste accumulated in a brain so human beings can live younger and healthier (Roco & Bainbridge, 2005). Nanotechnology will also be used to improve the physical ability. Human beings will be able to have sensory organs equivalent to that of other animals or bones which are resistant to being broken (Wood, Jones, & Geldart, 2003).

However, nanotechnology can be a critical health risk. Recent studies indicated that nanomolecules absorbed through air pile up in a lung due to their very tiny size and so can cause chronic diseases (Chau, Wu, & Yen, 2007; Poland et al., 2008). Furthermore, the risk is more serious because it is not scientifically known what harm could be caused by nanomaterials being directly absorbed through the digestive system (Chaudhry et al., 2008; House of Lords, 2010; Siegrist, Stampfli, Kastenholz, & Keller, 2008). Nanomaterials can easily pass through intercellular barriers and collect in a body or be moved through blood. However, its uncertainty is very high because the long-term impacts of nanomaterials are not known (Chun, 2009)

Another health risk is the toxicity of nanomaterials. When size is reduced to the nanometer level, unique physical, chemical, and biological properties that can't be seen in the world are generated. At this point, toxicity is also produced. Some studies reported that the

toxicity of nanomaterials destroyed the immune system and caused oxidative stress and cancers (Handy & Shaw, 2007; Warheit et al., 2004). In an experiment on lung damage after injection of a single carbon nanotube (SWCNT) in mice, the death ratio within 7 days exceeded 55% among mice exposed to nanomaterials of more than 0.5mg. The experimental also showed weight loss, lung damage, necrosis, granulomas, and peribronchial inflammation (Lam, James, McCluskey, & Hunter, 2004).

Nanotechnology has also been generating social issues. There is a "nanodivide" that is aggravating inequality due to this emerging technology. Nanodivide in the world means the gap between advanced countries and developing countries in their ability to develop nanotechnology an issue directly connected to the national economy. To the extent that nanotechnology affects the competitiveness of goods and services, the economic gap between countries can't help being widened more than it is now. Meanwhile, the inequality between the rich with the ability to purchase goods and services using nanotechnology and the poor without such an ability will also expand even within a country. For example, even when new therapy using nanotechnology is developed in the medical industry, the cost will be expensive due to its technology-intensive properties. Accordingly, the gap between being able to receive medical benefits between the class that can actively use nanotechnology-based therapy and the class which can't will be widened. Moreover, if nanotechnology developed by big enterprises is exclusively controlled by patents or intellectual property rights like bioengineering currently is, the nanodivide between social classes can't help being widened (Arnall, 2003).

There are also potential risks against citizenship and human rights (Royal Society & Royal Academy of Engineering, 2004). Nanotechnology has helped develop innovative sensing devices like micro sensors. In particular, the remote sensors with a network

application have been extensively increased through the convergence of nanotechnology and information technology. Sensors on the nanometer level can be used to monitor individuals and to infringe on privacy (ETC Group, 2003; Mnyusiwalla, Daar, & Singer, 2003; Van den Hoven & Vermass, 2007). Accordingly, Mehta (2003) warned of the risk of "nanopanopticism," the monitoring system using nanotechnology. If nanotechnology is used to monitor the privacy of individuals, it will bring fatal and extensive side effects and then ultimately threaten democracy.

Table 4.2. Potential benefits and risks of nanotechnology

	benefit	Risk
Environment	Reduction of pollutant, Promoting recycle	Source of new pollutant in global environment
Health	Cure and prevention of disease by nanobot, Improvement of physical abilities	Caused toxicity by nanomaterials
Society	Economic Development, Rich quality of life	Nano-divide, Intrusion of privacy, Weapon of mass destruction

#### 4.1.3. Initiatives and Regulations on Nanotechnology

Nanotechnology improves the quality of life and plays a pivotal role in developing an economy. Therefore, many countries in the world have been implementing a variety of initiatives for the R&D of nanotechnology. Investment in nanotechnology is 10 billion USD every year and the related government budgets reached 65 billion USD in the world (Harper, 2011).

The US, with the highest worldwide nanotechnology investment, has pledged to provide 1.5 billion USD to the National Nanotechnology Initiative (NNI) in 2015, and of the invested funds, over a third is invested in basic research (National Science and Technology Council, 2014a, 2014b). The EU selected nanotechnology as the key issue of the seventh Framework

Program (FP7), the research and development funding program. The EU provided 3.5 billion Euro to the investment program entitled "Nanoscience, Nanotechnologies, Materials and new Product Technologies (NMP)" for a total investment amount for the FP7 of 10.8 billion Euro (European Commission, 2010).

Nanotechnology investment in Germany and Austria has also occurred along with the EU's FP7. In 2010, Germany invested 400 million Euro on R&D by establishing the "Nano initiative 2010" and expanded its support of nanotechnology by announcing the new "Action plan nanotechnology 2015" in 2014. Accordingly, there are about 1,000 companies related to nanotechnology and over 70,000 employees who have been working in the nanotechnology business in Germany (BMBF, 2014). Austria also implemented the "Austrian NANO initiative" since 2002 and has invested 23 million Euro for R&D from 2008 to 2010 as well as 45 million Euro from 2004 to 2007 (BMWF, 2009)

In Asia, South Korea and Japan secured high-level nanotechnology through initiatives. Japan selected nanotechnology as one of four key research fields in its "Science and Technology basic Plan" which has been implemented over five years since 2001 (Japan, 2001, 2006). South Korea also invested 230 million USD in 2012 only by establishing a law for R&D (MEST, 2011).

While there commonly are initiatives supporting nanotechnology in most countries, nanotechnology regulations vary country. Such regulations are classified into regulations against the risk of nanotechnology and regulations on materials and goods using nanotechnology. The former deals with the technological risks, evaluation, and social impacts. However, the regulations most are not yet actually implemented but studies on them have been ongoing. Social impact and risk communication related to nanotechnology have been investigated in America and Europe since late the 2000s, but there is no investment on such a

project in other regions (Linkov, Satterstrom, Moinica, Hansen, & Davis, 2009; Nasu & Faunce, 2012; Seong & Hwang, 2012).

Regulations on materials and goods using nanotechnology are implemented mostly to control toxicity of chemicals. The US adopted enforced self-regulation for nanotechnology voluntary regulations by parties related to nanotechnology. The US government focused on collecting information to promote communicating the risks through building a database. In information-based regulations, external pressure plays an important role in implementing voluntary regulations (Linkov, Satterstrom, Moinica, Hansen, & Davis, 2009). In the "Nanoscale Material Stewardship Program (NMSP)" the Environmental Protection Agency (EPA) implemented, the US government provides information on whether new nanomaterials as well as existing nanomaterials are subject to the "Toxic Substances Control Act (TSCA)" as well providing information on nanomaterials produced or imported for commercial purposes (EPA, 2009).

The EU adopted more strict command regulations than the US. The EU introduced the regulations entitled "Registration, Evaluation and Authorization of Chemicals (REACH)" in 2007. It is a monitoring system registering and evaluating all kinds of chemicals produced and traded in Europe, and includes nanomaterials. The nanotechnology of EU countries including Germany and Austria is subject to this EU-level regulation (Mantovani, Porcari, Morrison, & Geertsma, 2012; Nasu & Faunce, 2012).

However, the regulations on nanotechnology other than in the regions mentioned above are currently inadequate. In particular, while South Korea and Japan are seen to have high technological competitiveness, the regulations in those countries have been merely pursued as an academic project up to now (Seong & Hwang, 2012).

In conclusion, most countries have been focusing on support rather than regulation in the situation in which potential benefits and risks related to nanotechnology exist together. And many initiatives concentrate on basic nanotechnology research and commercialization using the results of research. The risks of nanotechnology, however, have not been investigated sufficiently.

## 4.2. Framing of Nanotechnology

### 4.2.1. News Coverage as Heuristic

It is difficult for the public to understand emerging technologies. Since scientific knowledge quickly advances, advanced and professional knowledge is required to understand emerging technologies. Furthermore, such technologies have complicated structures because they are generated by bringing together diverse kinds of technologies (Stephens, 2005). Therefore, although the public in a modern society accesses scientific information more easily than in the past, they are not sufficiently provided with scientific information helping them understand emerging technologies.

Emerging technologies are a theme to be considered in politics, not simply in science. Modern society achieved its modernization based on rationality due to scientific advancement and technological innovation. However, the technology also expanded the risk beyond the control of human beings. In other words, the public don't understand the causes of the risk generated by technology and can't easily control such risks (Beck, 1986). In particular, emerging technologies show far higher uncertainty due to their advanced expertise and complexity. Accordingly, the discussion among social members in the public sphere is the

prerequisite for accepting the emerging technologies with its accompanying potential benefits and risks to society.

Nanotechnology has all the characteristics described above. Nanotechnology deals with new phenomena beyond the limit of physics, chemistry, and biology on the nanometer level. Accordingly, it is a complicated and professional field which the public can't easily understand. Moreover, since nanotechnology has significant impact on the entire society as well as individuals, including health and economy, social acceptance of nanotechnology must be urgently discussed.

Table 4.3. Social awareness of nanotechnology

Nation	Study	Year	N=	Have you heard of Nanotechnology?	
				Yes	No
EU	Eurobarometer 341	2010	26.676	46.3%	53.7%
Germany	Eurobarometer 341	2010	1.531	64.7%	35.3%
	Vandermoere et al.	2009	750	60.3%	39.7%
Austria	Eurobarometer 341	2010	1.000	47.0%	53.0%
US	Hart Research Associate	2007	1.014	58.0%	42.0%
	Hart Research Associate	2008	1.003	21.0%	49.0%
	Hart Research Associate	2009	1.001	63.0%	37.0%
South Korea	Ministry of Environment	2011	1.000	75.0%	25.0%
Japan	Planning Research	2009	685	39.1%	60.9%

To understand the characteristics of nanotechnology and determining how to socially accept it, the public has to accurately understand nanotechnology. However, social awareness on nanotechnology still needs to be improved due to the lack of information on the technology. In an EU survey (Eurobarometer, 2010), only 46% of respondents answered that they had heard about nanotechnology. Sixty-five percent of respondents in Germany answered that they heard about it, which was higher than neighboring countries including

France (53.9%), England (47.5%), and Austria (47%). And in the US 42.0%, 49% and 37% of respondents answered that they never heard about nanotechnology in 2006, 2008 and 2009, respectively (Hart Research Associates, 2007, 2008, 2009). In South Korea, 75% of respondents answered that they heard about the nanotechnology, which was higher than the EU and the US. However, 83% of those who reported answered that they didn't know exactly the nanotechnology. This result indicated the low knowledge level related to the nanotechnology in South Korea (ME, 2011). Only 39.1% of respondents in Japan had heard about nanotechnology. In the survey implemented both in South Korea and Japan, only 2.4% and 2.0% recognized nanotechnology as a science having a social impact in South Korea and Japan, respectively (KOFAC, 2012).

To explain public opinions on nanotechnology, it is necessary to examine how public attitude towards emerging technologies is formed. In the case of emerging technologies including nanotechnology, there is insufficient information provided to help the public judge such technologies. Public opinion on emerging technologies thus has to be created without information or with insufficient information.

Earlier studies on science communication focused on the "scientific literacy model" governing how much information on emerging technologies was collected and used. The model insisted that those with more technological knowledge accepted the relevant technologies more easily than those without knowledge. Thus, the tendency to collect more information on emerging technologies seemed to affect social acceptance and public opinions on the technologies (Bauer & Schoon, 1993; Laugksch, 2000; Miller, 1998). This model is significant because it discovered that the public judged and determined whether to support technologies based on insufficient information, and the model also examined the relationship between social acceptance and the amount of media usage. However, the model had the limit

that scientific knowledge didn't verify the correlation with attitude on technologies. Consequently, a high knowledge level on emerging technologies is not the key factor determining public opinion but merely means better understanding on the general scientific issues (Scheufele & Lewenstein, 2005).

Since the scientific literacy model, science communication research concentrated on the cognitive miser model, dealing with the public's cognition process on emerging technologies. The model assumed that the process where the public judged new technology without information or with insufficient information was rational (Fiske & Taylor, 1991). People generally apply cognitive effort only for the information bringing benefits to themselves. Such behavior is called "low-information rationality" by Popkin (1994), who pointed out that it was rational that people didn't apply any cognitive effort for an individual's pursuit of information related to issues in which it was difficult to identify an individual's interest, such as nanotechnology. Accordingly, the public doesn't use all information for judging emerging technologies. Instead, the public depends on heuristic like value predispositions or news coverage (Ho, Brossard, & Scheufele, 2008).

Heuristic is the basis applied to the minimum effort by individuals to determine a specific issue. Since a heuristic process omits or reduces the steps dealing with decision making, it is a limited mode of information processing that requires less cognitive effort and fewer cognitive resources than a systematic process (Eagly & Chaiken, 1993). By extension, individuals depend mainly on value predisposition and news coverage to determine their attitude on emerging technologies in modern society (Chaiken, Liberman, & Eagly, 1989). The representative case is that the public determines a number of controversial issues related to evolutionary biology and astronomical physics by reference to religious belief.

In particular, news coverage provides key heuristics to the public for emerging technologies requiring political judgment due to significant social impact and professional knowledge, such as nanotechnology (Nisbet, Brossard, & Kroepsch, 2003; Nisbet & Lewenstein, 2002). Science's reality to the public is what access through media (Nelkin, 1987).

The importance of media affecting public determination and social awareness on nanotechnology has been examined by a number of studies (Anderson, Petersen, Wilkinson, & Allan, 2009; Donk, Meta, Kohring, & Marcinkowski, 2012; Ho, Scheufele, & Corley, 2010; Petersen, Anderson, Allan, & Wilkinson, 2009; Scheufele & Lewenstein, 2005; Schmidt Kjærgaard, 2010; Te Kulve, 2006). The media helps the public understand complicated technological issues more easily and facilitates the interaction between the public and science by proposing the laws and regulations maximizing public benefits. Accordingly, the roles of news coverage have been strengthened regarding scientific themes, for example global warming, stem cells, and nanotechnology, which have to be considered together with politics (Ho, Brossard & Scheufele, 2008).

In news coverage, Scheufele and Lewenstein (2005) found that the media frame provides key heuristics to the public. They pointed out that news coverage on nanotechnology was similar to the development pattern of the media frame which was identified when biotechnology became a social issue. While a high knowledge level of nanotechnology hasn't affected its public judgment, the approach of reproducing scientific issues through the media has affected on the attitude on nanotechnology (Figure 4.1.). In conclusion, individuals judge nanotechnology based on media framing and their judgment expands to form the public opinion.

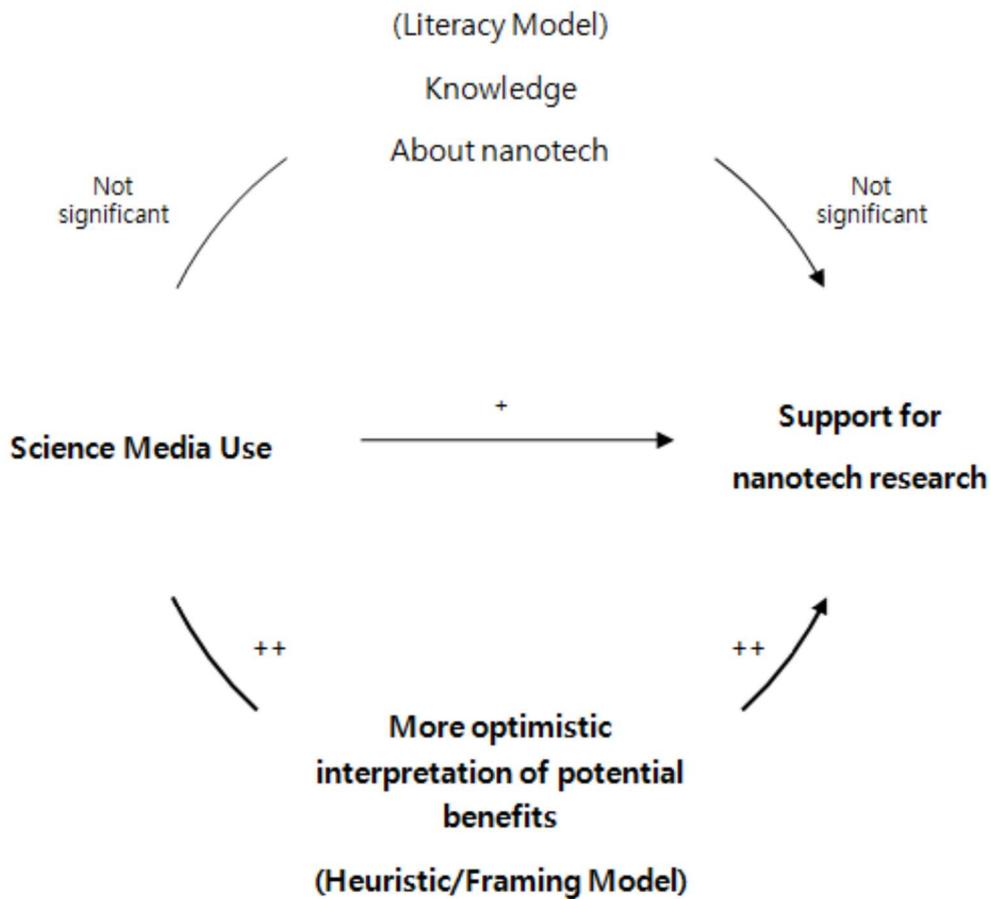


Figure 4.1. Science literacy and heuristic models of attitude formation

#### 4.2.2. Media Frame of Nanotechnology

The media frame of nanotechnology has been investigated in many countries in the recent decade. Most studies covered the US, the United Kingdom, and Canada (Anderson, Allan, Petersen, & Wilkinson, 2005; Laing, 2006; Lewenstein, Gorss, & Radin, 2005; Weaver, Lively, & Bimber, 2009), Germany (Donk, Meta, Kohring, & Marcinkowski, 2012; Kohring, Marcinkowski, Donk, Metag, & Friedemann, 2011), Norway (Kjolberg, 2009), Denmark (Schmidt Kjærgaard, 2010), Slovenia (Groboljsek & Mali, 2012), Poland (Lemańczyk, 2012), Turkey (Kamanlığlu & Güzeloğlu, 2010), and Italy (Arnaldi, 2008). Studies on media representation of nanotechnology also covered Anglo-Saxon countries (Faber, MacKinnon, &

Petroccine, 2005; Fitzgerald & Rubin, 2010; Friedman & Egolf, 2005; Stephens, 2005) and Europe (Grobe, Eberhard, & Hutterli, 2005; Metag & Marcinkowski, 2014; Te Kulve, 2006; Veltri & Crescentini, 2010; Zimmer, Hertel, & Böhl, 2008) However, the studies of the media frame in East Asian countries including South Korea and Japan have not been reported yet.

The media frame on nanotechnology in existing studies is classified into three types: the scientific project frame, the benefit frame, and the risk/regulation frame. The scientific project frame includes themes on R&D, scientific discoveries, and national initiatives. It has shown up in news coverage most frequently. The benefits frame focused on the economic and medical benefits generated by nanotechnology. The risk/regulation frame warns of the potential risk which may occur due to nanotechnology and emphasizes suggesting policies to overcome the risks.

The scientific project frame and benefits frame are frequently discussed along with "scientific advancement" and the risk/regulation frame along with "Pandora's Box." The scientific project and benefits frames are closely related to science and technology policy, and the risk/regulation frame occurs along with social conflicts in many cases (Lemańczyk, 2012; Lewenstein, Gorss, & Radin, 2005).

Besides the above frames, researchers observe other diverse frames including the science fiction and popular culture frames (Anderson, Allan, Petersen, & Wilkinson, 2005), the public accountability frame (Lewenstein, Gorss, & Radin, 2005), the ambivalence frame (Donk, Meta, Kohring, & Marcinkowski, 2012), the education frame (Schmidt Kjærgaard, 2010), and the visionary/futuristic frame (Kamanlıgılı & Güzeloglu, 2010).

While the benefit-oriented frames (e.g. scientific project frame, benefits frame) mainly represent nanotechnology positively, risk-oriented frames (e.g. risk/regulation frame) describe nanotechnology negatively. Positive nanotechnology news coverage is found more

often than negative. The same tendency was observed regardless of the time when and where studies were executed.

Except for studies Lewenstein, Gorss, & Radin (2005) (on the news coverage from 1986 to 2004) and Schmidt Kjaergarrd (2010) (from 1996 to 2006) conducted, most media frame studies on nanotechnology focused on the 2000s. This was because most countries substantially started their nanotechnology initiatives after 2001 when the US started NNI which reflected higher public and media nanotechnology interest. Accordingly, the media frames in the relevant periods emphasized the development and technological benefits of nanotechnology depending on national support. However, the situation gradually changed as the risks of nanotechnology were pointed out starting in the mid-2000s and regulation-emphasizing frames increased (Weaver, Lively, & Bimber, 2009).

As for the differences between countries where media frame studies on nanotechnology were conducted, US media had greater interest in nanotechnology's economic benefits, but European and Canadian media focused relatively more on risks and regulations (Lemańczyk, 2012). Nevertheless, since the frames emphasizing nanotechnology benefits accounted for the overwhelming ratio in all countries' media, the difference between America and Europe or Canada is insignificant. In Laing (2006)'s study, although the US media focused on economic and investment benefits more than Canadian media, the Canadian media focused on scientific and research benefits from nanotechnology more than the US. However, it is difficult to say that there is the essential difference since the rate of media frames emphasizing nanotechnology benefits (71%) was overwhelmingly more than those emphasizing risks (18%).

In addition, there are few studies which directly compared the differences between more than 3 countries. The comparison was generally restricted mainly to English-speaking

countries including America, England, and Canada (Laing, 2006). Indeed, most studies focused on analyzing the media in a single country or in countries speaking the same language. And there are limits to comparing the differences between countries because extraction and identification of frames vary in studies.

Particularly, it should be noted that there are no studies on the media frames of nanotechnology in Asia, especially South Korea and Japan, which have top-level nanotechnology. Most studies are also concentrated on the late 2000s when various initiatives had been implemented. Thus, there is no study on the 2010s, when the public has experienced the efficiency of technology by actually having used the products applying nanotechnology. Moreover, there is insufficient data on the periods when a variety of regulations started to be discussed to address the concern about the side effects of nanotechnology. In this aspect, this current study identified the media frames of nanotechnology and investigated the differences in media frames by country and period.

## 5. RESEARCH QUESTIONS

This study set out to identify the media frame of nanotechnology and to investigate the cultural effects on the media frame. Existing studies on the media frame of nanotechnology were limited to countries speaking the same languages or to individual countries. Moreover, most of studies were conducted before 2010, when nanotechnology regulations were substantially begun to be introduced. Accordingly, there are no sufficient studies containing public discourse on nanotechnology's potential risks.

This study examined the media frames and compared them by country and period to identify differences. More specifically, the first research question was to examine the presence of media frames. This study examined how nanotechnology is framed in news articles, and what the dominant frames are and their variations that exist across countries. This study also looked at whether newspapers in South Korea, Germany, Austria, and Japan represent nanotechnology in different ways, and how media frames of nanotechnology changed from 2001 to 2015.

RQ1a: Which media frames are presented dominantly in the news articles on nanotechnology?

RQ1b: Does the pattern of the presence of media frames be associated with countries like South Korea, Germany, Austria, and Japan? If so, which variations of the presence of media frames are revealed across the countries?

RQ1c: Does the presence of media frames change between 2001 and 2015? If so, which variations of the presence are revealed over time?

Media framing has been influenced by a variety of factors. In particular, public discourse on nanotechnology forms mainly depending on the social value of nanotechnology that doesn't secure sufficient knowledge or isn't individually experienced. While existing studies on media frames focused mainly on the microlevel factors of journalists and media organizations, they didn't examine macrolevel factors, such as culture. A number of researchers did premise culture as a key factor affecting on the media frame, but there is no empirical investigation on this issue up to now.

The second research question was to examine how the presence of media frames on nanotechnology could be explained by cultural dimensions and how these cultural effects on media frames differed across countries. For this, this study adopted Hofstede's cultural dimensions model and empirically investigated the cultural effect on the presence of media frames, which are identified in RQ1.

RQ2: Are there cultural dimensions associated significantly with each media frame on nanotechnology? If so, how do the cultural dimensions contribute to the salience of each media frame?

As discussed in chapter 2.1.3., frame building has a sequential linear order by which the media frame has different presence and salience. Therefore, RQ1 produced the results on the presence of media frames observed in news articles on nanotechnology and then RQ2 analyzed the salience of media frames identified in RQ1, which was differentiated by cultural dimensions.

## 6. METHODOLOGY

### 6.1. Frame as Cluster

Although the concept of the frame has grown as one of most important and applicable methods in communication studies, there is not yet a standard set of content analytic indicators that can be used to reliably measure the prevalence of common frames in the news (Semetko & Valkenburg, 2000).

To address this limitation, Kohring, a German professor at the University of Mannheim, has presented an alternative measurement that improves reliability and validity. With his colleagues, Kohring argued that some elements of frame are grouped systematically in a specific way, and formed by a pattern that is identified in the text (Donk, Meta, Kohring, & Marcinkowski, 2012; Kohring & Matthes, 2002; Matthes & Kohring, 2008). He calls this pattern frame. According to his assumption, "a frame consists of several frame elements, and each frame element consists of several content analytical variables" and "every frame is characterized by a specific pattern of variable" that "signify single frame elements are grouped together by hierarchical cluster analysis" (Matthes & Kohring, 2008, p.264).

As patterns formed by a combination of frame elements, this method posits that frames are not coded directly with a single variable but are combined with frame elements. Therefore, a frame with several content analytical variables can achieve a higher reliability and validity than a frame with a single variable because frames are not subjectively determined but empirically suggested by an inductive clustering method. And this method has also another advantage in that the coding frame is conducted resistant to a coder's schemata or bias because a coder codes not frame but variables (Matthes & Kohring, 2008).

## 6.2. Operationalization

This study aimed to identify media frames of nanotechnology through the cluster of frame elements. Entman (1993) defined the 4 frame elements constituting a frame: problem definition, causal attribution of responsibility, moral evaluation and treatment recommendation. Kohring suggested that "if these elements are understood as variables, each of them can have several categories in a content analysis". (Matthes & Kohring, 2008, p.264). In this study, frame elements are operationalized through the content analysis variable. And content analysis variables were identified in this study's pretest conducted in South Korea, Germany, Austria, and Japan, and also in existing studies on the media frame of nanotechnology.

Table 6.1. Operationalization of frame elements

Frame Element	Categories	Variables
Problem definition	Main Topic	Scientific research, medical service/health care, economy, development of semiconductor, policy, moral/ethics, overview of nanotechnology
	Actor	Science, business, politics, media/Public opinion, NGOs, military
Causal attribution of responsibility	Benefit attribution	Science, economy, politics, medical
	Risk Attribution	Science, economy, politics, medical
Moral evaluation	Benefits	Research, economy, health, consumer, environment
	Risks	Research, economy, health, consumer, environment
Treatment recommendation	Call for regulation	Regulation policy/negative prospects
	Call for support	Support policy/positive prospects

At first, the problem definition element includes the main topics and actors categories, which define the bottom lines of news stories. Main topic is a central issue under investigation or a primary argument around which the other arguments revolve. This study derives several subtopics from earlier studies about nanotechnology, and then subtopics summarized to main topic with seven variables: scientific research, medical service/health

care, economy, development of semiconductors, policy, moral/ethics, and overview of nanotechnology. An actor refers to the person, group, or organization that is most often cited in the news article. Actor includes six variables: science, business, politics, media/public opinion, NGOs, and military.

Second, the causal attribution of responsibility element includes the categories of benefit attribution and risk attribution. These explain who is responsible for the benefits/risks. For instance, science as risk attribution variable means that scientific actors can be blamed for the risks related to nanotechnology. Just like earlier studies, all actor variables which occur in news article are always not responsible for benefits and risks. For example, it simply does not appear in news article that the public is responsible for benefits or risks, but the public can be an actor in news article. Therefore, the benefit attribution and risk attribution categories include only four variables each: science, economy, politics, and medical.

Third, the moral evaluation element executed its operational definition by the elements of assessment of the benefits and risks of nanotechnology. It discussed what topics had benefits or risks due to nanotechnology. For example, economy as benefits variable means "nanotechnology as a benefit for economy." These categories include five variables each: research, economy, health, consumer, and environment.

Finally, the treatment recommendation element was operationalized by the promotion and regulation on nanotechnology categories, and the positive and negative outlook on nanotechnology. Treatment recommendation thus includes two categories "call for regulation" and "call for support." Call for regulation generally highlights the risks of nanotechnology and proposes regulation on it. Meanwhile, call for support generally focused the positive perspective and supports governmental initiatives or policies. Call for regulation includes a variable "regulation policy/negative prospects," and call for support includes a

variable "support policy/positive prospects."

### 6.3. Countries and Newspapers

This study selected South Korea, Germany, Austria, and Japan. South Korea and Japan in East Asia are included in the Confucian Asia cluster (Gupta, Hanges, & Dorfman, 2002). Both countries influenced on each other historically and built closer relationships as South Korea became a Japanese colony in the early 20<sup>th</sup> century. Both countries share cultural characteristics based on Confucian values including hierarchical relationships, social relationships, and authoritarianism (Ashkanasy, 2002). Conversely, Germany and Austria in Central Europe are included in the Germanic Europe cluster (Szabo, et al., 2002). Both countries kept a close relationship for a long time based around Christianity and the German language. Moreover, they share various kinds of values including equalitarianism, emphasis on personal rights, and legalism (Ashkanasy, 2002)

These four countries adopt democracy and the capitalist system and are advanced countries having high-level nanotechnology with a national-level investment in common. However, South Korea and Japan, and Germany and Austria have very opposite cultural background, which is why this study selected those countries. This was to address the fact that a number of researchers postulated that the media frame would differ depending on the culture of a relevant society.

Accordingly, this study assumed that comparing countries with different cultures would more specifically contribute to standardizing the cultural effect on media frame. Furthermore, this study excluded the effects of other macro level factors other than culture on the media frame by selecting countries similar in politics, economy, and ideology but with cultural differences. Since the cultural effects on a media frame can't be properly investigated by

comparing only 2 countries, this study selected 4 countries; 2 countries from each different culture.

Two newspapers issued in each country in its language were selected for the 4 countries: South Korean daily newspapers *Chosun Ilbo* (조선일보) and *Hankyoreh Sinmun* (한겨레신문), German daily newspapers *Frankfurter Allgemeine Zeitung* and *Süddeutsche Zeitung*, Austrian daily newspapers *Standard* and *Presse*, and Japanese daily newspapers *Yomiuri Shimbun* (読売新聞) and *Asahi Shimbun* (朝日新聞). The selected newspapers were recognized as quality newspapers with nationwide influence in each country. Moreover, they substantially covered the public discourse on technology. Therefore, they were frequently used in studies conducting content analysis on news articles related to emerging technologies (Donk, Meta, Kohring, & Marcinkowski, 2012; Hibino & Nagata, 2006; Kim, 2011; Metag & Marcinkowski, 2014; Shineha, Hibino, & Kato, 2008).

#### 6.4. Data Collection

For a comparative study between countries, this study selected individual news articles from 2001 to 2015 because the media's attention on nanotechnology increased rapidly since 2001 when the US announced NNI. Articles including the word "nano" were searched in a database in each country. And then they were collected from the online archives of newspapers. The news articles in Germany and Austria were searched in the Genios GBI, the database of newspaper agencies using German language, and gathered from the online archive of each newspaper.

Similarly, news articles in South Korea were searched in KINDS, the database of newspaper agencies in the Korean language, and collected from the online archive of each newspaper agency. In Japan, there is no database. So articles including the word "nano" were

searched from the online archive of the two newspapers and classified into articles of two types: paper and online versions. And then the news articles on paper were only used for the analysis.

This study aimed to investigate news articles dealing with nanotechnology as the main topic. Thus, this study analyzed only the articles in which nanotechnology accounted for more than 50% of the news article or contained a statement essentially focused on nanotechnology. The analysis excluded news articles published in special supplements, recommendations for events, and the local section, while editorials and columns as well as articles in each section, including politics, society, or science were included in the analysis. Furthermore, news articles which were not related to nanotechnology, while including the word "nano" were also excluded (e.g., Apple iPod "nano", Indian automotive manufacturer Tata's "nano", Albanian prime minister "Fatos Nano"). A total of 1,362 articles were selected to populate the analysis.

## 6.5. Coding

Four trained coders were selected. The coders analyzing the articles from the German, Austrian, and Japanese newspapers had bachelor's degrees or higher. They are bilingual, both in their native language and Korean. Meanwhile, the coders analyzing articles from South Korean newspapers had bachelor's degrees or higher but used only the Korean language. Two German coders analyzed German and Austrian newspapers each, and a Japanese and a South Korean coder analyzed their homeland's newspapers.

In order to measure intercoder reliability, coders coded a random sample of 10% of the South Korean newspaper articles because they understood Korean language well in common. The intercoder reliability of all variables, using Scott (1955)'s  $\pi$ , exceeded .80 which is

generally accepted in content analysis. This test revealed a reliability coefficient of .81 for the main topic, .83 for actor, .84 for benefit attribution, .84 for risk attribution, .80 for benefits, .81 for risks, .87 for call for regulation, and .82 for prospect.

#### 6.6. Cultural Dimension score

As discussed in the literature review on media frame, the frame building process deals with the relationships between media frame and factor affecting the media frame. This study focused on cultural dimension as the independent variable with the salience of media frame as the dependent variable.

This study adopted the cultural dimensions score in Hofstede's model. Hofstede's model can quantitatively examine the cultural differences between countries and enable researchers to compare more than 3 countries. The reliability and validity of Hofstede's model was verified in a number of studies.

Table 6.2. presents the cultural dimensions scores of South Korea, Germany, Austria, and Japan (Hofstede, Hofstede & Minkov, 2010). In Hofstede's model, Germany was the most individualistic country while South Korea was the most collectivist country. Austria showed the lowest power distance score, while South Korea had the highest power distance score. Moreover, Japan had strong tendency towards avoiding uncertainty while Austria had the weakest tendency towards avoiding uncertainty. Masculine culture was prominent in Japan, but feminine culture was primary in South Korea. Austria had a short term-oriented culture, but South Korea had long term-oriented culture. In sum, South Korea and Japan were relatively collectivist, had high power distance scores, a long term-oriented culture, and showed a strong tendency towards avoiding uncertainty. However, Germany and Austria were individualistic, had a low power distance score and short term-oriented culture, and showed a

weak tendency towards avoiding uncertainty.

Table 6.2. Cultural dimension score<sup>4</sup>

	IDV	PDI	UAI	MAS	LTO
South Korea	18	60	85	39	100
Germany	67	35	65	66	83
Austria	55	11	70	79	60
Japan	46	54	92	95	88

### 6.7. Statistics Methods

This study computed binary variables for every original variable. And only binary variables having the frequency higher than 5% were adopted for cluster analysis for statistical reasons.

For the RQ1, this study executed two-step cluster analysis comprising the combination of hierarchical clustering and *k*-means clustering. Thus combination was suitable for determining the optimal number of clusters and processing a large amount of data. Since it is not easy to estimate the specific number of clusters related to nanotechnology due to the comparison between countries and expanded time span, this study determined an automatic decision on the number of clusters.

For RQ2, this study built a logistic regression model to predict whether a type of media frame presents or not:  $\text{logit}(\pi) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5$ , where  $X_1$  stands for Individualism/Collectivism,  $X_2$  for Power distance,  $X_3$  for Uncertainty avoidance,  $X_4$  for Masculinity/Femininity,  $X_5$  for Long-/Short-term orientation.

In fact, the ideal way of measuring the cultural effects on the media frame is to compare newspapers from all countries. This is a method that focuses on the frequency of the media

<sup>4</sup> Hofstede, Hofsted, & Minkov (2010).

frame that appear in newspapers of countries. In this case, since the media frame is on the ratio scale, a multiple regression analysis can be performed. However, due to various constraints such as language and sample size, it is nearly impossible to use the method in actual research. This is why most previous studies analyzing media frames as a dependent variable have used qualitative methodology, instead of quantitative methodology, for statistical testing of causal relationships (Scheufele, 1999; 2000).

However, this study employed logistic regression, because the media frame can also use a binomial coefficient. In essence, a media frame is a categorical data that represents whether a media frame is present or not. However, the use of regression analysis causes a problem in making a statistical inference, because basic assumptions of regression analysis are not met. In other words, in regression analysis it is assumed that the dependent variable is a continuous variable, and the binomial coefficient form of the dependent variable in the present study does not meet this assumption.

Logistic regression analysis is used in this kind of situations. Logistic regression is used when the dependent variable is a binary coefficient of 0 and 1. Logistic regression is an analytical method that predicts the likelihood of occurrence of an event because it uses 1 for the probability that the event occurs, and 0 for the probability that it does not, when there is an independent variable. Therefore, using logistic regression, it is possible to statistically test a causal relationship in which the media frame varies according to cultural dimension.

This study used PASW Statistics 18 as a statistical software program for descriptive statistics, ANOVA, cluster analysis and logistic regression analysis.

## 7. RESULTS

### 7.1. Descriptions of the Sample

South Korea (n=482) showed the highest number of articles on nanotechnology followed by Japan (n=324), Germany (n=323), and Austria (n=233), in that order (Figure 7.1.). Interest in the semiconductor drove more articles on nanotechnology in South Korea than in other countries. Samsung Electronics and its affiliates have been exerting a significant impact on the national economy enough to account for 20.4% of the South Korean GDP in 2014. Accordingly, South Korean newspapers focused on the improvement of semiconductor manufacturing using nanotechnology by Samsung Electronics.

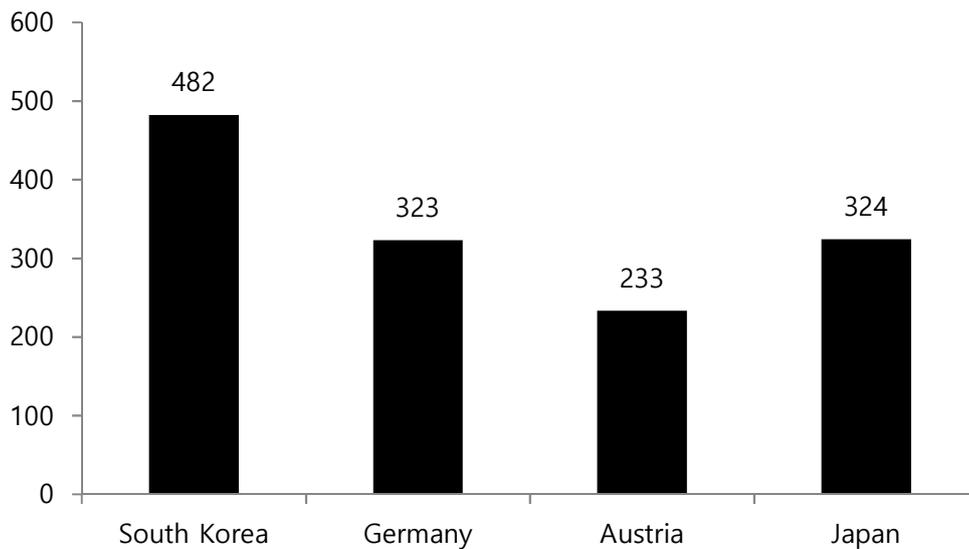


Figure 7.1. Numbers of news articles on nanotechnology

As shown in Table 7.1., *Chosun Ilbo* brought in the highest number of articles as 20.7% (n=282) and *Presse* showed the lowest as 7.4% (n=101). As for the other newspapers, with *Hankyoreh Sinmun* accounting for 14.7% (n=200), *Yomiuri Shimbun* for 12.0% (n=164),

*Asahi Shimbun* for 11.7% (n=160), *Frankfurter Allgemeine Zeitung* for 14.5% (n=197), *Süddeutsche Zeitung* for 9.3% (n=126), and *Standard* for 9.7% (n=132), the newspapers in East Asia brought in more articles on nanotechnology than German-speaking countries.

Table 7.1. Number of articles on nanotechnology in newspapers<sup>5</sup>

Country	Newspaper	Number of articles (%)
South Korea	Chosun	282 (20.7%)
	Hankyoreh	200 (14.7%)
Germany	FAZ	197 (14.5%)
	SZ	126 (9.3%)
Austria	Presse	101 (7.4%)
	Standard	132 (9.7%)
Japan	Yomiuri	164 (12.0%)
	Asahi	160 (11.7%)
Total		1,362 (100.0%)

Figure 7.2. shows how the articles are distributed over time. While 2006 was the year in which the most articles were published in a year (n=153), they were least published in 2014 (n=35). There were a number of articles on nanotechnology in the mid-2000s, but the numbers rapidly decreased in the early 2010s. It is worth noting that while the articles decreased by about half in 2005 over the previous year, they reached the highest ratio in 2006 again.

In South Korea 2007 showed the most articles published (n=59) and the least published in 2015 (n=12). Respectively, the highest and lowest number of articles were published in 2006 (n=54) and in 2014 (n=6) in Germany, in 2006 (n=47) and in 2014 (n=3) in Austria, and in 2007 (n=42) and in 2015 (n=9) in Japan.

South Korea and Japan showed the highest number of articles in 2007 while Germany

<sup>5</sup> Chosun: *Chosun Ilbo*, Hankyoreh: *Hankyoreh Sinmun*, FAZ: *Frankfurter Allgemeine Zeitung*, SZ: *Süddeutsche Zeitung*, Presse: *Presse*, Standard: *Standard*, Yomiuri: *Yomiuri Shimbun*, Asahi: *Asahi Shimbun*

and Austria published the most in 2006. The development of semiconductor manufacturing technology using nanotechnology and the earnest research commencement on carbon Nanotube and Graphene caused the highest number of articles in South Korea and Japan. Germany and Austria had the most in 2006 because of the dispute on the efficiency of nutritional supplements launched by Neosino, the official sponsor of FC Bayern München and the "NanoCare Project" initiated by the German federal government, which investigated the impact of nanomaterials on health.

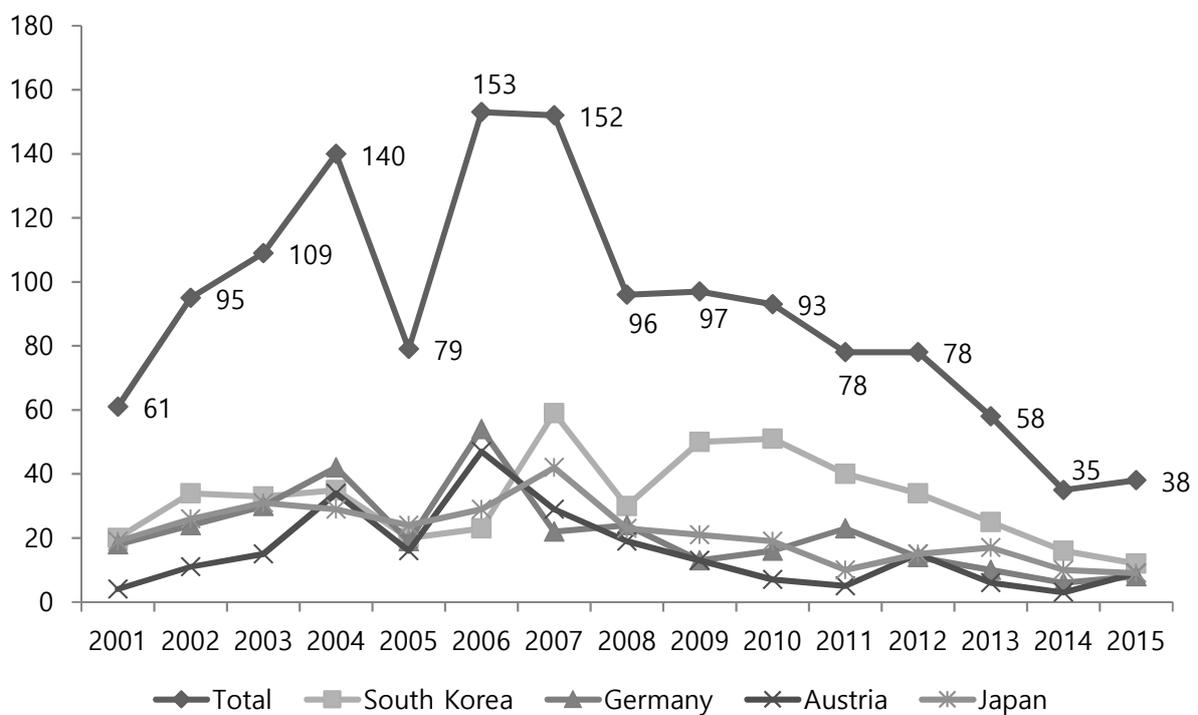


Figure 7.2. Number of news articles on nanotechnology between 2001 and 2015

Articles in South Korea increased in 2009 and 2010 over the previous year unlike other countries because Samsung Electronics successfully developed DRAM (Dynamic Random Access Memory) using nanotechnology. The articles in Germany showed a decreasing trend from the peak in 2006 (n=54) but rebounded once in 2011 (n=23) because of an increase in

articles related to the "Aktionplan Nanotechnologie 2015" considered by the German parliament at that time. Similar to Germany, articles in Austria kept decreasing from the peak in 2006 (n=27) but rebounded once in 2012 (n=15). The articles in Japan demonstrated relatively less change than in other countries.

## 7.2. Media Frame of Nanotechnology

A total of 1,191 articles, whose individual variable was less than 5% in frequency, were selected for cluster analysis. A hierarchical cluster analysis was executed to determine the similarity between subjects using a distance measurement. On the basis of a Dendrogram acquired from the cluster analysis, it was determined that six clusters were the most suitable (Figure 7.3.). Then, they were finally selected through a *k*-means cluster analysis. To verify the validity of the clusters, this study conducted ANOVA identifying the differences between clusters depending on variables. According to ANOVA results, all clusters showed significant difference,  $p < .05$ .

Table 7.2. show the distance between centers of each cluster. The cluster 4 and 6 are closest (1.431), and cluster 2 and 6 are farthest (3.423). The proximity of the centers means that the characteristics of cluster 4 and 6 are more similar than the other clusters. On the other hand, the characteristics of cluster 2 and 6 are the most different. Therefore, clusters with similar and different characteristics are identified among the clusters.



Table 7.2. Distances between final cluster centers

cluster	1	2	3	4	5	6
1		2.486	2.120	2.253	2.206	2.624
2	2.486		2.224	3.152	2.214	3.423
3	2.120	2.224		2.926	1.742	3.237
4	2.253	3.152	2.926		2.685	1.431
5	2.206	2.214	1.742	2.685		3.009
6	2.624	3.423	3.237	1.431	3.009	

Six frames as clusters were assigned the labels shown in the last row of Table 7.3. The last two and three rows of the table show the number of articles in which these frames occur. This number and percentage give an impression of the importance of the frame in the public nanotechnology discourse in South Korea, Germany, Austria, and Japan.

**Frame I: "Overview of Nanotechnology."** The first frame accounting for 8.2% (n=98) of articles was named "Overview of Nanotechnology." The articles included in this frame focused on extensive description of and introduction to nanotechnology. Scientist (40.8%) was the most frequently observed among actors followed by media (26.5%) and economic actor (21.4%). The call to support nanotechnology was 8.2%, and the call for regulation was merely 3.1%. The benefits and risks of nanotechnology were not found in "Overview of Nanotechnology."

<Sample article>

The term, nano, comes from the ancient Greek "nanos" meaning dwarf. The nanometer is a billionth of a meter, or approximately the size of a molecule. Because the naked eye cannot see smaller than 0.1 millimeter, it is difficult to even guess the size of one nanometer.

Table 7.3. Media frames on nanotechnology

Frame Element	Categories	Selected Variables (Frequency ≥ 5%)	Frame I	Frame II	Frame III	Frame IV	Frame V	Frame VI
Problem definition	Main topic	Scientific Research	-	-	-	100.0	62.3	100.0
		Medical implementation	-	74.0	1.7	-	10.3	-
		Economy	-	-	49.6	-	-	-
		Development of Semiconductor	-	21.9	21.4	-	9.1	-
		Policy	-	4.1	7.1	-	9.8	-
	Actor	Overview of Nanotechnology	74.5	-	-	-	-	-
		Scientist	40.8	4.1	8.4	52.6	89.5	54.3
		Economic actor	21.4	2.7	82.4	5.3	8.8	5.3
		Political actor	11.2	86.3	2.1	21.1	0.3	25.5
		Media	26.5	6.8	7.1	21.1	1.4	14.9
Causal attribution	Benefit attribution	Science	-	6.8	68.9	2.6	100.0	1.1
		Economy	-	2.7	30.3	-	-	-
	Risk attribution	Politics	-	90.4	0.8	-	-	-
		Science	-	-	-	100.0	-	100.0
Moral judgment	Benefits	Research	-	74.0	1.7	-	70.2	1.1
		Economic	-	21.9	71.0	2.6	2.5	-
		Health	-	4.1	7.1	-	18.6	-
	Risks	Consumer	-	-	20.2	-	8.8	-
		Health	-	-	-	-	-	100.0
		Environment	-	-	-	100.0	-	-
Treatment recommendation	Call for support/regulation	Support	8.2	95.9	10.9	-	3.7	-
		Risk regulation	3.1	-	0.4	65.8	-	45.7
		N (= 1,191)	98	73	238	38	650	94
		% (=100.0)	8.2	6.1	20.0	3.2	54.6	7.9
			Overview of Nanotechnology	Policy	Economic Benefits	Environmental Risks	Research & Development	Health Risks

Nanotechnology has been used in pursuit of precision to the point of nanometers, as well as to control atoms and molecules. Horst Störmer, who received the Nobel Prize in Physics in 1998, said, "The possibilities for creating new things seem unlimited." Richard Feynman, who received the Nobel Prize in Physics in 1968, first proposed the concept of nanotechnology in 1959. Later, Eric Drexler, author of the Engines of Creation in 1986, wrote that 0.1 nanometer atoms and 1 nanometer molecules could be manipulated at will using a machine called the "assembler." It was considered an outrageous statement at the time. However, nanotechnology has begun to take shape as demonstrated by Samsung Electronics' success in developing semiconductors using 50-nm technology. They claim that it is electronics, materials, medicine, and energy. In particular, gene manipulation could fundamentally solve the food problem. In addition, the development of terahertz ( $10^{12}$ hz) semiconductors could make supercomputers as small as personal computers. Like many developed countries, the Korean government is striving to support technology development, considering nanotechnology as the core technology to lead the 21st century. (Hankyoreh Sinmun, 2005/09/15)

#### <Sample article>

What is nanotechnology? It is about the extremely small. One nanometer is one millionth of a millimeter. With its thickness, one nanometer can divide a hair strand 50,000 times. Nanotechnology mimics the self-organizing structure and the principles of functional characteristics by learning the principles that exist in nature. Nanotechnology also reveals the mechanism of the invisible world, and creates very small structures for new materials. Engineers anticipate the advent of a technological revolution through nanotechnology in the next decade. (Standard, 2002/12/14)

**Frame II: "Policy."** The second frame accounting for 6.1% of the articles was named "Policy." The articles included in this frame focused on technology policy. In particular, most of them were related to medicine and health care using nanotechnology. Medical implementation (74.0%) was observed most in the articles, followed by the development of

the semiconductor (21.9%) which was mainly found in South Korea and Japan. The political actor (86.3%) was the most dominant among actors. Politics (90.4%) and research (74.0%) showed up as highest as the benefit attribution and the benefit, respectively, in the second frame. Call for support (95.9%) of nanotechnology was overwhelmingly highest. Risk attribution and risks were not found in "Policy."

<Sample article>

The military is also interested in nanotechnology. In May, the United States invested 90 million dollar to establish the Institute for Soldier Nanotechnologies. The goal of the institute is to improve the function of the textile fiber surface to reduce the weight of the rucksack by half. Europe is on a par with the United States in the field of nanotechnology. Although more research papers were published in Europe than in the United States in the 1990s, their number of patents is similar. Currently, 2.8 billion euro have been invested in nanotechnology globally. A nano research center, where approximately 30 million euro was invested, will open at the end of March. It is expected to employ 1,500 researchers. Nano research is also very active in East Asia. To date, China has invested 1.8 billion euro in 900 research programs. It is also estimated that sales of nanofibers will reach 400 million euro within two years in Taiwan. (Presse, 2003/04/12)

<Sample article>

The framework of their "Nanotechnology Comprehensive Development Plan," which was reviewed and approved by the National Science and Technology Commission (NSTC), plans to inject 1,485 billion Korean won in research and development in this field in the next 10 years, as well as train more than 12,000 nanotechnology experts. The Korean government has set the following objectives: "to build a major infrastructure for nanotechnology development within five years, and to secure at least top 10 most technologies with comparative advantage in order to ensure technological competitiveness at the level in top five highly developed countries by 2010." Under these objectives, the government selected the following areas and fields for intensive support: five areas of technology, such as electronic devices, new materials, processes,

equipments, and biotechnology, as well as key technical fields "to secure competitive in," such as catalyst materials, molecular devices, and gene therapy devices.

Other aims included training more than 12,000 specialists by creating and restructuring departments related to nanotechnology in universities, and providing educational programs such as master's and doctoral programs in nanoscience.

Establishing the "Joint Research Equipment Center" for researchers' joint use of cost analysis, test, and manipulation equipment, the government decided to review the feasibility of establishing a nanotechnology research institute and creating "Nano Town" where nanotechnology research agencies are concentrated. (Hankyoreh Sinmun, 2001/07/23)

### <Sample article>

The Kurchatov Institute, named after the Soviet nuclear scientist, has become the hub of Russian nanotechnology development. Russia is currently poised to reclaim the field of science and technology through nanotechnology. With the successful launch of the world's first satellite, the country competed with the United States in the Soviet era. However, top-notch researchers left the country and the science and technology in the country declined following the collapse of the Soviet Union.

The Russian government's commitment to nanotechnology development is due to its potential for industrialization. At an international conference held in Moscow last October, Medvedev revealed that Russia will spend 318 billion rubles by 2015 for the industrialization of nanotechnology. He said, "The technology for mass production of nanomaterials was still in the early stages of development. Russia must move away from the economy that depends on natural resources using nanotechnology."

Russia has a world-famous Russian Academy of Science (RAS). Founded in 1724, RAS consists of 50,000 researcher and 400 laboratories. However, Zhores Alferov, Vice Chairman of the RAS and Nobel physics winner in 2000, said, "The institute's facilities are too old to conduct world-class research." However, this is not why the government designated the Kurchatov research center as the hub in nanotechnology development instead of the RAS. The real reason was the concern that the RAS, which focuses on basic research, may hinder the development of

nanotechnology, which requires applied research. Kovalchuk, Director of the Kurchatov Institute, said, "Unfortunately, the reform of RAS has not yet been achieved. This is the only place in Russia where it is possible to conduct research on nanotechnology that combines biotechnology, IT , and cognitive science." He also stressed, "I have been thinking about how Russia would evolve after the collapse of the Soviet Union. Nanotechnology is at the heart of this issue." According to local reports, President Putin expressed that he would increase the size of the Kurchatov Institute and spend an additional 10 billion rubles over the next three years. (Yomiuri Shimbun, 2010/01/29)

**Frame III: "Economic Benefits."** The third frame accounting for 20.0% (n=238) of the articles was named "Economic Benefits." The articles included in this frame focused on the economic effects nanotechnology was to bring. Economy (49.6%) was the highest topic in this frame, followed by the development of the semiconductor (21.4%). Similar to "Policy," development of the semiconductor was observed mainly in South Korea and Japan. The economic actor (82.4%) including enterprises and entrepreneurs, showed overwhelmingly highest among actors. Science (68.9%) and economic (71.0%) were identified the most as the benefit attribution and benefit, respectively, in the third frame. Economy accounted for 30.3% in benefit attribution and consumer for 20.2% in benefits. Call for support (10.9%) of nanotechnology was more than call for regulation (0.4%), but didn't account for the significant ratio of overall articles. No risk attribution and risks were identified in the news articles found in "Economic Benefits."

<Sample article>

The world of Marco Beckmann moves by very small things. Founder of Nanostart, a venture capital, he was fascinated by nanotechnology during his school days. He explained the size of the

nanoparticles in an easy manner. He said nanoparticles are the size of a soccer ball in the globe, but the impact of nanotechnology on the global economy is greater than soccer.

Describing that "Nanotechnology is about new manufacturing technology as well as new products. We change everything we produce," Beckmann noted its potential for various applications including self-cleaning ovens, scratch-resistant car coating, performance improvement of computer CPU, and breathable fabric. He added, "Nanotechnology has long been routinely applied to industry. And a nano product is not the only label nano products are sold on." Experts estimate the current nanotechnology end-product market at 250 million dollar. It is expected to reach 1 billion dollar by 2015.

Since its establishment in 2003, Nanostart has raised approximately 30 million euro and invested in many areas of nanotechnology. The nine nanotechnology companies Beckmann invested in were listed on the stock market or acquired by large corporations. Beckmann was convinced that the companies could be sold at a high value next year.

For example, Magforce, of which Nanostart has 65% share, is using nanoparticles for cancer treatment. The first commercial brain tumor treatment with Magforce's new technology was performed in October in Berlin. Beckamnn was convinced the technology would be the fourth axis of cancer treatment along with surgery, radiation, and chemotherapy. Beckmann therefore replaced the Margforce board chairperson to accelerate the economic development of nanomedical companies.

On the other hand, countries are investing huge amount of money on nanotechnology every year. Nanostart took advantage of this opportunity. Nanostart was selected as the fund manager of the Singapore Nanotechnology Venture Fund and attracted 1,090 Singapore dollars, approximately 6 million euro. "There is a niche in venture finance like ours," Beckmann said. "The small is big." He presented the goal, "We will be an global venture capital fund in nanotechnology." (Frankfurter Allgemeine Zeitung, 2011/12/13)

<Sample article>

Samsung Electronics has begun mass production of 16 GB NAND flash using the 51nm process for the first time ever. The 51nm process means that the electronic circuit of a semiconductor is composed of minute wires as thick (line width) as 1/2000th of a hair in thickness.

In August last year, the company began mass production of 8 GB NAND flash using the 60nm process. In eight months it has mass-produced the products, doubling the storage capacity. The company explained that this semiconductor is approximately twice as fast in reading and storing data than the existing 60nm products.

Samsung Electronics said it would be able to take the lead in the next-generation NAND flash market, because its products are more efficient than its competitors', who mainly produced it using the 55nm-57nm processes. The 50nm NAND flash market is expected to become a flagship market in the next year, and grow to 21 billion dollar by 2010.

In this regard, Hynix semiconductor announced, in a company information session held in the 26th, that it was planning to mass-produce 16 GB NAND flash using the 48nm process, which was under development. (Chosun Ilbo, 2007/04/30)

**Frame IV: “Environmental Risks.”** The fourth frame accounting for 3.2% (n=38) of the articles was named "Environmental Risks." This frame focused on the environmental risks or side effects caused by nanotechnology. All articles in "Environmental Risks" adopted scientific research as the topic. Scientist (52.6%) was identified highest among actors, followed by political actor and media, which accounted for 21.1% each. No articles showed benefit attribution or benefits in the fourth frame. However, science was identified as the risk attribution and the corresponding risks were all about the environment. Call for regulation (65.8%) on nanotechnology was significantly high.

<Sample article>

Nanomaterials may affect the environment. All products and equipment release their components into the environment during or after their use. Therefore, in addition to the direct impact on the

human body, nano products may have indirect impact on human body through the nanomaterials released into the ecosystem. It has been reported that carbon nanotubes bind well to organisms in the natural world, and that when this occurs, the substance might spread rapidly.

Different views may certainly exist regarding extrapolating animal toxicity results to human cases. There is also a lot of controversy regarding the impact of nanomaterials released into the environment. However, seemingly minor issues can still cause a disaster as they have in the past; therefore, the environmental impact of nanomaterials requires careful examination. Yet, there is not even the data on the status of release and treatment of nanomaterials to the environment in Korea.

The technological advancement of mankind is not a race to a predetermined destination to break a record. Individuals are granted a limited amount of time, but the whole of mankind is granted with eternity. The sustainability of society is more important than the speed of development. Examining the impact of new technologies or substances on the environment, including humans, and finding ways to prevent associated problems are another task given to technologists along with that of technological advancement. (Chosun Ilbo, 2007/05/28)

#### <Sample article>

As the recently held the annual meeting of the American Chemical Society, scientists from Arizona presented an example of negative environmental impact of silver nanotechnology. The researchers reported that when they analyzed the washed water from the 'odor-preventing silver nanosock' at room temperature, the amount of silver ions detected were such that they could harm aquatic organisms. "The silver nanoparticles used for antibacterial and deodorant removal can come off the socks during the washing process, and if the washing sewage flows into the river, it may kill the fish," said the researcher. They also noted that "The finding suggests that they will destroy the river ecosystems and inflict damage on humans." silver ions are known to damage aquatic organisms in much lesser amounts than are harmful to humans.

Scholars have previously warned of the potential for nano products to destroy aquatic ecosystems. In November 2006, the U.S. Department of the Environment began regulating household appliances and products that used silver nanotechnology for antibacterial purposes. As a result,

silver nanotechnology washing machines, food storage containers, and air cleaners have been designated as regulated products, and producers have the obligation to prove that silver nanoparticles do not harm ecosystems. The decision of the U.S. Department of Environment was made based on the determination that abusing silver nanotechnology may kill beneficial organisms coexisting with humans and destroy ecosystems. This well demonstrates that the principle of "government intervention" that the government should resolve the conflict when public and private interests clash.

When using silver nano products, consumers should consider the properties of silver nano. Silver nanoparticle product manufacturers must increase the adhesive power of nanoparticles so that they do not fall off while consumers are using them. In addition, just like listing the food ingredients on product package, manufacturers need to indicate the nanoparticle use on product tags to inform consumer choice. The government should closely evaluate the potential of silver nanoproducts to inflict damage on aquatic ecosystems and humans. (Hankyoreh Sinmun, 2008/04/11)

***Frame V: "Research & Development."*** The fifth frame accounting for 54.6% of the articles was named "Research & Development." This frame provided scientific-oriented news articles. The articles focused mainly on presenting the research process and results on nanotechnology without social context. Accordingly, the highest topic was scientific research (62.3%), followed by medical implementation (10.3%), policy (9.8%), and development of the semiconductor (9.1%), in that order. Scientist (89.5%) showed overwhelmingly highest among actors. The benefit attribution and benefits having the highest percentage in this frame were science and research (70.2%), respectively, followed by health (18.6%) and consumer (8.8%), respectively. While call for support on nanotechnology was identified, its ratio was negligible (3.7%). No risk attribution and risks were found in this frame.

<Sample article>

Sony has developed a tape with the world's largest storage capacity. One cassette has the storage for 7,400 2-hr-long movies or 30 million 4-min-long songs. It can store 18.5 GB per square inch, approximately  $6.5\text{cm}^2$ , which is 74 times the size of the largest existing tape.

The tape is made by attaching magnetic metal particles. Sony succeeded in reducing its size from the currently available tens of nanometer (nano=1/billion) to 7.7 nanometers. This increased recording density and capacity. The tapes are inexpensive to manufacture, compared with optical disks and other storage media. However, it takes time to find the necessary data in the tapes. Development of this technology is expected to help the government, financial institutions, and data centers of IT companies to store large amounts of information in preparation for disasters. (Asahi Shimbun, 2014/05/11).

<Sample article>

A stamp-size nanomaterial made by Pulickel Ajayan can swallow all light. The nanomaterial reflects just 0.045% of light. Ajayan and colleagues at the Rensselaer Polytechnic Institute in New York, USA, pulled the material out of carbon nanotubes and set the record for the darkest material in the world. Since the light is reduced by the process, only a very small fraction of the light is observed, the rest is absorbed by the dark material. Nanotechnology up until then has shown only the light in the visible area.

The darkest material in the world, made from nickel and phosphorus, reflects 0.16% of the light from the surface. The color commonly called black reflects only 5-10% of light. The researchers are planning to apply for a listing on the Guinness Book of World Records after publishing their study in *Nano Letters*. Ajayan has already been on the *Guinness Book of World Records* in 2006 for designing of the world's smallest toothbrush.

His research is not confined to the academic field. Norbert Kaiser, an applied optics scientist at the Fraunhofer Institute, said the study could be applied to the field of solar energy. The material can be used for effective absorption of sunlight in electricity production. (Süddeutsche Zeitung, 2008/01/19)

**Frame VI: "Health Risks."** The last frame accounting for 7.9% (n=94) of the articles was named "Health Risks." The frame focused on the medical side effects or health risks caused by nanotechnology. All articles in this frame adopted scientific research as the topic. Scientist (54.3%) showed highest among actors, followed by political actor (25.5%) and media (14.9%), in that order. Science was identified as the risk attribution in this frame. The corresponding risks were all about medicine and health. Call for regulation on nanotechnology accounted for 45.7%.

<Sample article>

Nano cosmetics, nano-antibacterial lunch boxes, silver nano washing machines, and nano toothpaste are some of the most commonly found products in stores these days. Nanotech products are already an integral part of our lives due to functions such as waterproofing, antibacterial, and decomposition of pollutants. Despite its excellent features, recent research has revealed the risks of nanomaterials. In the Forum on "Nanotechnology and Health Risk" held on October 30th, Professor Kim Younghoon at Department of Chemical Engineering in Kwangwoon University presented the finding of a foreign study that carbon nanotubes may have the negative health effects such as pneumoconiosis. In addition, the study warned that titanium oxide (TiO<sub>2</sub>) can be absorbed into the skin when the skin cuticle is peeled off, and be carried by the blood to the brain. The OECD established the Working Party on Manufactured Nanomaterials under the Chemicals committee in September 2006 to discuss countermeasures against the impact on the environment and human body. The U.S. Environmental Protection Agency (EPA) is also reviewing whether to include nanomaterials in the new chemical materials registration system using the Toxic Substance Control Act (TSCA). The United Kingdom adopted the Greenpeace's proposal and implemented Nanojury since November 2005. In Korea, the nanomaterials safety policy council was organized in March 2007; however, research and policymaking on its safety is still in its infancy. (Hankyoreh Sinmun, 2008/11/10)

<Sample article>

There is a world where the smaller gets stronger. As the particle size becomes smaller, the surface area increases and the chemical reaction force becomes stronger. A carbon nanotube through which only one water molecule can pass is stronger than any metal, and highly conductive. But these small particles, which do not exist in the natural world, could easily pass through the protective membranes of the human body and cause unexpected problem. This possibility is closer to becoming reality.

Dr. Bellina Veronesi of U.S. EPA recently published a report in *Environmental Science & Technology* suggesting that titanium oxide nanoparticles included in sunscreens have the potential to damage cranial nerves. Titanium oxide is used in toothpastes and paints in addition to sunscreen. It is usually white, but becomes transparent when made of nanoparticles. Accordingly, sunscreen containing nanoparticles is gaining popularity, because it does not give a pale feel to the skin.

The team injected this material into mice' microglia, which protects cranial nerves. The cells immediately attacked this material by releasing free radicals. The problem is that titanium oxide exposure longer than one hour causes excessive secretion of free radicals, and damages adjacent brain cells. Brain diseases, including Parkinson's disease and Alzheimer's disease, are known to occur because nerve cells are damaged by free radicals. This is not the first time that research found that nanoparticles can inflict damage on a life form. In 2004, Professor Günter Oberdörster from Rochester University in the United States reported that mice that inhaled a 20nm sized "Polytetrafluoroethylene (PTFE)" nanoparticle for 15 minutes died in 4 hours. Teflon is used in a wide range of products from frying pan coatings to spacesuits, and artificial heart valves. It is not harmful in its solid state, but becomes toxic as it becomes nanoparticles. Plants are no exception. Professor Daniel Watts from the New Jersey Institute of Technology published a study in *Toxicology Letters* in November last year that aluminum oxide nanoparticles used as abrasion resistant clear coatings inhibited the growth of plants including corn, cabbage, and beans. Nanoparticles are dangerous because of their size. Particles present in the natural world cannot get in the brain, whereas smaller nanoparticles cannot be blocked. Due to their small size, they do not get caught in the airways, so they enter pulmonary cells directly. Moreover, smaller particles

may induce toxicity that was not originally present due to increased their surface area. (Chosun Ilbo, 2006/07.03)

Meanwhile, the positive or negative tone of news articles in each frame was determined based on casual attribution and moral judgment in frame elements. In other words, the positive or negative description of a specific frame is determined according to the ratio of benefit attribution and benefits, or risk attribution and risks, in the relevant frame.

"Economic Benefits," "Research & Development" and "Policy" were positively described among all frames. Science (68.9%) showed the highest benefit attribution in "Economic Benefits" and economy (71.0%) accounted for the highest as the corresponding benefits. In other words, news articles included in each frame investigated economic benefits of science and technology and covered such economic benefits positively. The only benefit attribution in "Research & Development" was science. Research (70.2%) showed the highest in the corresponding benefits. This indicated that the articles in a relevant frame positively described the development of nanotechnology mainly through R&D. Politics (90.4%), in "Policy" showed up overwhelmingly highest among benefit attribution and research (70.4%) had the highest percentage among corresponding benefits. Considering that the medical implementation (74.0%) topic showed the highest ratio in "Policy," the articles included in the relevant frame positively described the research on the medical application of nanotechnology mainly according to policy. However, "Environmental Risks" and "Health Risks" were covered negatively. Science was the only risk attribution in both frames and the corresponding risks were the environment and health, respectively.

While benefit attribution and benefits comprised several variables in the frames which were positively described, risk attribution and risks in the frames which were negatively

described comprised a single variable. The frames positively describing nanotechnology were overwhelmingly higher (80.7%) than the frames negatively describing it (11.1%).

### 7.3. Framing differences across countries.

"Research & Development" (45.1%) showed up as highest among articles on nanotechnology in South Korea (n=426), followed by "Health Risks" (22.1%), "Economic Benefits" (11.5%), "Environmental Risks" (8.9%), "Overview of Nanotechnology" (7.7%) and "Policy" (4.7%), in that order.

"Research & Development" (41.4%) was identified most in *Chosun Ilbo* (n=249), the South Korean newspaper, followed by "Health Risks" (30.9%), "Economic Benefits" (13.7%), "Overview of Nanotechnology" (8.0%), and "Policy" (6.0%), in that order. "Research & Development" (50.3%) also was identified most in *Hankyoreh Sinmun* (n=177), another South Korean newspaper, followed by "Environmental Risks" (21.5%), "Health Risks" (9.6%), "Economic Benefits" (8.5%), "Overview of Nanotechnology" (7.3%), and "Policy" (2.8%), in that order.

"Health Risks" (30.9%) accounted for a high ratio in *Chosun Ilbo*, "Environmental Risks" didn't show up at all. But *Hankyoreh Sinmun* showed a high percentage of "Environmental Risks" (21.5%), and "Health Risks" (9.6%) were relatively low.

"Research & Development" (57.7%) showed the highest percentage in Germany (n=260), followed by "Economic Benefits" (33.5%), "Overview of Nanotechnology" (6.9%), and "Policy" (1.9%), in that order.

"Research & Development" (55.3%) showed the highest percentage in the German newspaper, *Frankfurter Allgemeine Zeitung* (n=161), followed by "Economic Benefits" (33.5%), "Overview of Nanotechnology" (8.1%), and "Policy" (3.1%), in that order.

"Research & Development" (61.3%) also had the highest percentage in another German newspaper, *Süddeutsche Zeitung* (n=99), followed by "Economic Benefits" (33.3%), and "Overview of Nanotechnology" (5.1%), in that order.

Where "Research & Development" and "Economic Benefits" accounted for 95% in *Süddeutsche Zeitung*, "Policy" was nonexistent. While "Research & Development" and "Economic Benefits" showed a lower percentage in *Frankfurter Allgemeine Zeitung* than in *Süddeutsche Zeitung*, "Overview of Nanotechnology" and "Policy" showed higher percentages in *Frankfurter Allgemeine Zeitung* than in *Süddeutsche Zeitung*.

Table 7.4. Media frame on nanotechnology in each country

Nation	Newspaper	Frame						Total
		I	II	III	IV	V	VI	
South Korea	Chosun	8.0	6.0	13.7	.0	41.4	30.9	100.0 (n=249)
	Hankyoreh	7.3	2.8	8.5	21.5	50.3	9.6	100.0 (n=177)
	$\Sigma$	<b>7.7</b>	<b>4.7</b>	<b>11.5</b>	<b>8.9</b>	<b>45.1</b>	<b>22.1</b>	<b>100.0 (n=426)</b>
Germany	FAZ	8.1	3.1	33.5	.0	55.3	.0	100.0 (n=161)
	SZ	5.1	.0	33.3	.0	61.6	.0	100.0 (n=99)
	$\Sigma$	<b>6.9</b>	<b>1.9</b>	<b>33.5</b>	<b>.0</b>	<b>57.7</b>	<b>.0</b>	<b>100.0 (n=260)</b>
Austria	Presse	11.0	11.0	29.3	.0	48.8	.0	100.0 (n=82)
	Standard	14.0	11.4	15.8	.0	58.8	.0	100.0 (n=114)
	$\Sigma$	<b>12.8</b>	<b>11.2</b>	<b>21.4</b>	<b>.0</b>	<b>54.6</b>	<b>.0</b>	<b>100.0 (n=196)</b>
Japan	Yomiuri	8.9	10.8	13.4	.0	66.9	.0	100.0 (n=157)
	Asahi	5.3	5.9	25.7	.0	63.2	.0	100.0 (n=152)
	$\Sigma$	<b>7.1</b>	<b>8.4</b>	<b>19.4</b>	<b>.0</b>	<b>65.0</b>	<b>.0</b>	<b>100.0 (n=309)</b>
<b>Total</b>	<b>8.2</b>	<b>6.1</b>	<b>20.0</b>	<b>3.2</b>	<b>54.6</b>	<b>7.9</b>	<b>100.0 (n=1,191)</b>	

"Research & Development" (54.6%) showed the highest percentage in Austria (n=196), followed by "Economic Benefits" (21.4%), "Overview of Nanotechnology" (12.8%), and "Policy" (11.2%).

The "Research & Development" frame showed up the most in the Austrian newspaper, *Presse* (n=82), followed by "Economic Benefits" (29.3%). "Overview of Nanotechnology" and "Policy" accounted for 11.0% each. "Research & Development" (58.8%) also showed up the most in another Austrian newspaper, *Standard* (n=114), followed by "Economic Benefits" (15.8%), "Overview of Nanotechnology" (14.0%), and "Policy" (11.4%), in that order.

Like other countries, Austrian newspapers also showed the common tendency that "Research & Development" accounted for the highest ratio. However, "Research & Development" showed a higher ratio in *Standard* than in *Presse*, while "Economic Benefits" accounted for a lower ratio in *Standard* than in *Presse*.

"Research & Development" (65.0%) showed the highest percentage in Japan (n=309), followed by "Economic Benefits" (19.4%), "Policy" (8.4%), and "Overview of Nanotechnology" (7.1%), in that order. "Research & Development" (66.9%) showed up the most in the Japanese newspaper, *Yomiuri Shimbun* (n=157), followed by "Economic Benefits" (13.4%), "Policy" (10.8%), and "Overview of Nanotechnology" (8.9%), in that order. "Research & Development" also accounted for the highest number in another Japanese newspaper, *Asahi Shimbun* (n=152), followed by "Economic Benefits" (25.7%), "Policy" (5.9%), and "Overview of Nanotechnology" (5.3%), in that order.

While Japanese newspapers had the common feature that the "Research & Development" frame accounted for a high ratio, "Economic Benefits" varied depending on the newspaper. Notable was the relatively higher ratio of "Economic Benefits" in *Asahi Shimbun*, having a progressive tendency, than in *Yomiuri Shimbun*, having a conservative tendency.

Table 7.5. Accumulative percentages of media frames in each country

Rank	South Korea	Germany	Austria	Japan
1	Research & Development (45.1%)	Research & Development (57.7%)	Research & Development (54.6%)	Research & Development (65.0%)
2	Health risks (67.2%)	Economic Benefits (91.2%)	Economic Benefits (76.0%)	Economic Benefits (84.4%)
3	Economic Benefits (78.7%)	Overview of Nanotechnology (98.1%)	Overview of Nanotechnology (88.8%)	Policy (92.8%)
4	Environmental risks (87.6%)	Policy (100.0%)	Policy (100.0%)	Overview of Nanotechnology (100.0%)
5	Overview of Nanotechnology (95.3%)			
6	Policy (100.0%)			

Of the four countries selected for analysis, Germany showed the highest frame concentration (Table 7.4.). The ratio of the top two frames in accumulative percentages of media frames was 91.2% in German newspapers, which was relatively higher than Japan (84.4%), Austria (76.0%), and South Korea (67.2%).

#### 7.4. Framing Dynamics Over a Time Span

While "Overview of Nanotechnology" showed up as highest in 2001 (16.1%), it was lowest in 2012 (1.5%). Its percentage had been declining since 2001 and is experiencing a sudden rise since 2010. In particular, it recorded the most drastic change by falling down by 10% over the previous year in 2012. This occurred because of the change in the roles of news articles in "Overview of Nanotechnology." While this frame was found mainly in articles introducing nanotechnology in the 2000s, in the 2010s it was accompanied with articles included in other frames. For the news articles on the economic consequences of nanotechnology, for example, "Overview of Nanotechnology" appeared as the supplementary

articles explaining nanotechnology on the same page

"Policy" showed its highest percentage in 2009 (9.1%), but its lowest in 2003 (2.1%). "Policy" had a relatively more stable tendency than other frames because all countries selected for analysis implemented the national-level initiative on nanotechnology and then news articles continuously reported on that initiative. A nanotechnology policy or initiative was actually announced in the US in 2001 (the National Nanotechnology Initiative), in Austria in 2002 (Austrian NANO initiative), in Japan in 2005 (Science and Technology Basic Plan), in Germany in 2010 (Nano Initiative 2010), in Korea in 2012 (Nanotechnology Comprehensive Development Plan), and again in Germany in 2014 (Action Plan Nanotechnology 2015), and newspapers in each country gave major coverage to those policies/initiatives.

"Economic Benefits" accounted for its highest percentage in 2003 (34.0%), but its lowest in 2010 (9.2%). While the frame exhibited dynamic change from its fast rise until the mid-2000s, it kept a stable percentage around 10% since 2010. This was because the nanotechnology's economic effects have been felt since the late 2000s.

"Environmental Risks" showed up temporarily from 2003 to 2009. It had its highest percentage in 2008 (11.3%) but experienced a sudden change from 2007 to 2009. It was observed only in *Hankyoreh Sinmun*, in South Korea. Therefore, "Environmental Risks" had its limits in describing the nanotechnology frame dynamics.

While "Research & Development" accounted for the highest percentage of all news articles, with its peak in 2001 (62.5%), and its lowest year in 2009 (44.3%). While it declined in the 2000s, its percentage rebounded in the early 2010s. However, it declined again from the mid-2010s. With the US National Nanotechnology Initiative in the early 2000s, each government began large-scale nanotechnology investment. Following this trend, newspapers

also showed increasing interest in nanotechnology. While their interest gradually decreased since then, it increased again as the achievements in nanotechnology arose in the 2010s. Since "Research & Development" was observed in the news articles covering successful nanotechnology research processes and developments, the dynamics of "Research & Development" most properly reflected newspapers' nanotechnology interest.

"Health Risks" showed up from 2007 on. This frame had its peak percentage in 2010 (23.7%), but didn't appear in 2003 at all. In spite of a sudden increase around 2010, it showed a stable tendency to stay around 10% since then. While "Health Risks" accounted for a lower percentage than "Overview of Nanotechnology" and "Policy" until the mid-2000s, it arose from 2007. Such change reflected the gradually increasing interest of newspapers on nanotechnology's risks as well as its benefits.

The following is the change of frame by country during the relevant period. In South Korea, "Overview of Nanotechnology" showed its highest percentage in 2001 (22.2%), but it never appeared several years. "Overview of Nanotechnology" accounted for a substantial percentage of the total articles in the early 2000s, but rapidly decreased since 2006 and didn't appear at all thereafter except for 2010, 2011, and 2014. "Policy" accounted for its highest percentage in 2002 (12.5%), but never appeared several times. Similar to "Overview of Nanotechnology," "Policy" frame appeared frequently in the early 2000s. However, with its rapid decline since the mid-2000s, this frame repeatedly appeared and disappeared.

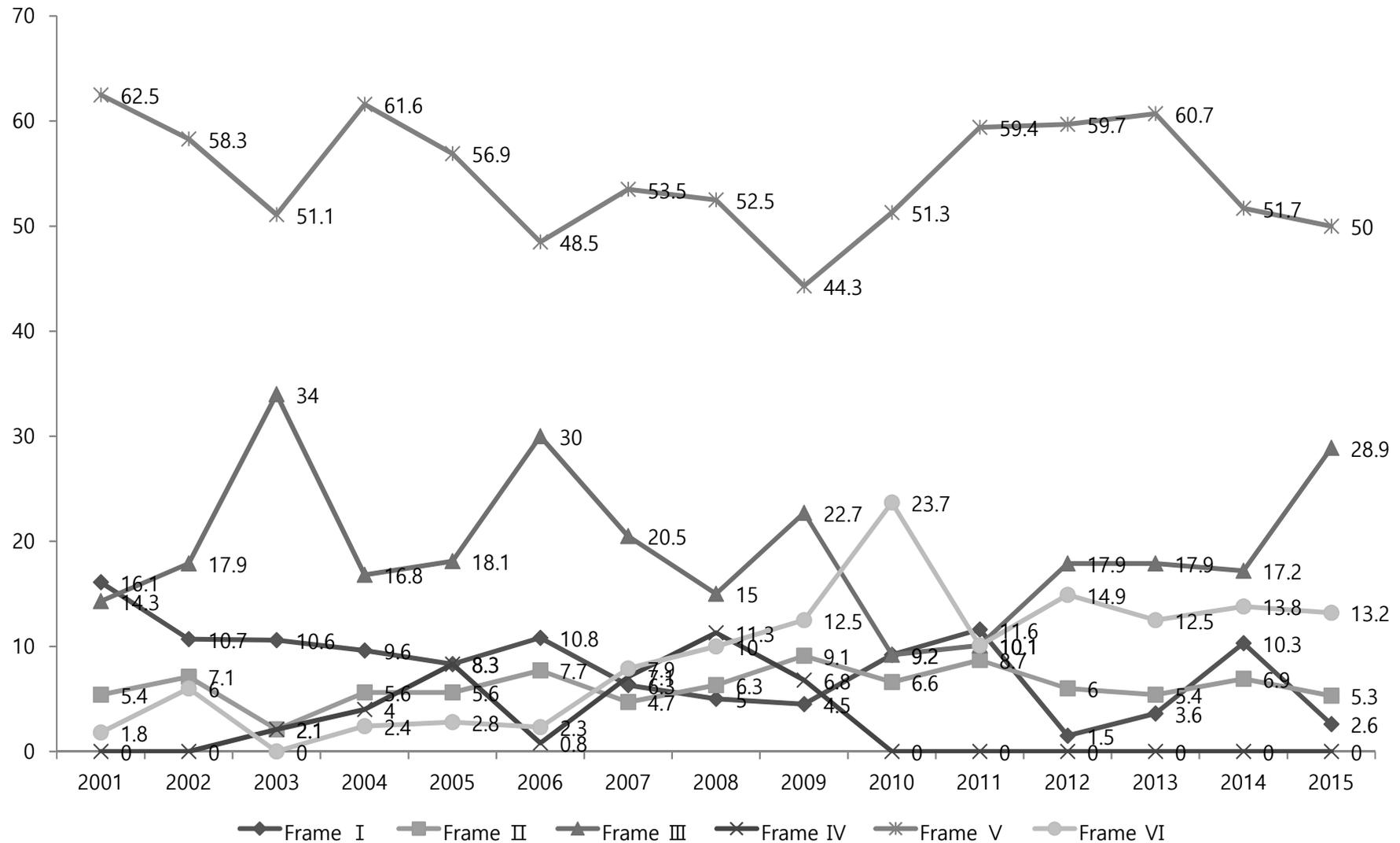


Figure 7.4. Frame dynamics on nanotechnology between 2001 and 2015

While "Economic Benefits" showed its highest percentage in 2003 (34.5%), it didn't appear in 2001 and 2011. It had significant change around 2003, 2009, and 2013, but tended to stay stable from 2013 on. "Environmental Risks" had its highest percentage in 2008 (34.6%), but has not appeared since 2010. The frame percentage changed on a regular basis with 2005 and 2008 as its peak years.

"Research & Development" accounted for its highest percentage in 2001 (66.7%), and its lowest in 2008 (30.8%). It had been on a downturn but took an upturn from 2008 on. However, then it again showed a downturn since 2012. "Health Risks" showed its highest percentage in 2010 (41.9%) but didn't appear in 2003. In spite of its sudden rise several times, it was gradually taking an upturn as time went by. In particular, it was more frequently observed than the "Research & Development" frame in 2015.

In Germany, "Overview of Nanotechnology" had its highest percentage in 2010 (20.0%). However, it didn't appear several times and has not appeared since 2011. "Policy" showed its highest percentage in 2010 (10.0%). However, it failed to appear 10 times between 2001 and 2015. "Economic Benefits" accounted for its highest percentage in 2007 (53.3%) but didn't appear in 2014. "Research & Development" showed its highest percentage in 2014 (100.0%), but its lowest in 2009 (41.7%). However, even with dramatic change in "Economic Benefits" and "Research & Development," those frames were the limited in explaining because there were only 6 articles in those relevant frames in German newspapers at that time.

In Austria, "Overview of Nanotechnology" showed its highest percentage in 2014 (50.0%), but didn't appear several years. Since the number of frames in Austrian newspapers from 2010 was not sufficient, the change was relatively dramatic. "Policy" accounted for its highest percentage in 2005 (25.0%), but didn't appear several years. In particular, the frame

was rapidly decreasing from 2010 on. "Economic Benefits" had its highest percentage in 2015 (44.4%), but didn't appear several years. "Research & Development" showed its highest percentage in 2011(100.0%), and its lowest in 2006(41.5%).

In Japan, "Overview of Nanotechnology" accounted for its highest percentage in 2001 (22.2%) but didn't appear from 2008 to 2014. In 2015, the frame accounted for 11.1%. "Policy" had its highest percentage in 2011 (30.0%) and its lowest in 2007 (2.6%). The frame kept its percentage around 10% until 2007 and gradually increased since then. "Economic Benefits" had its highest percentage in 2013 (88.2%) and its lowest in 2015 (44.4%). While "Policy" and "Research & Development" accounted for a higher ratio than in other countries, the change of those frames was not significant.

#### 7.5. Cultural Effect on Media Frame

Table 7.5. presents the results from a logistic regression model with the simultaneous estimation of variables applying five cultural dimensions. In the logistic regression model, "Overview of Nanotechnology" was not statistically significant, but other frames showed statistical significance with  $p < .0001$ .

Two cultural dimensions, Power Distance (PDI) and Uncertainty Avoidance (UAI), were significantly associated with the presentation of "Policy." PDI showed a negative correlation with "Policy," but UAI had a positive correlation. Without the influence of any other cultural dimensions, a country with a UAI score of one unit more was 1.091 times more likely to present a "Policy" as much as its reference country. However a country with a PDI score of one unit more was 0.947 times less likely to present a "Policy" frame. Accordingly, the higher the UAI score was, the more "Policy" appeared. Conversely, the higher the PDI score was, the less "Policy" appeared.

Table 7.6. The effect of cultural dimensions on the media frame

	B	S.E.	Wals	OR	95% CI
<b>Policy Frame</b> ( $R^2=.050$ , $\chi^2=22.142$ , $df=3$ , $p<.0001$ )					
PDI	-.054	.014	15.702	.947	.922~.973
UAI	.087	.023	14.028	1.091	1.042~1.141
<b>Economic Benefits Frame</b> ( $R^2=.063$ , $\chi^2=48.018$ , $df=3$ , $p<.0001$ )					
IDV	.027	.006	20.959	1.028	1.016~1.040
<b>Research &amp; Development Frame</b> ( $R^2=.034$ , $\chi^2=30.421$ , $df=3$ , $p<.0001$ )					
IDV	.022	.005	23.918	1.022	1.013~1.031
UAI	.029	.009	10.080	1.029	1.011~1.047

"Economic Benefits" correlated only with the Individualism/Collectivism (IDV) culture dimension. Without the influence of any other cultural dimensions, a country with an IDV score of one unit more was 1.028 times more likely to present an "Economic Benefits" frame than its reference country. Therefore, "Economic Benefits" was observed more frequently in news articles in countries with an individualist culture.

"Research & Development" had significant correlation with IDV and UAI among cultural dimensions. IDV and UAI showed a positive correlation with "Research & Development." Without the influence of any other cultural dimensions, a country with an IDV score of one unit more was 1.022 times more likely to present a "Research & Development" than its reference country. And a country with an UAI score of one unit more was 1.029 times more likely to present a "Research & Development" frame than its reference country. In other words, the more a culture tended to be individualistic and the stronger it avoided uncertainty, the more the "Research & Development" frame appeared.

Meanwhile, since "Environmental Risks" and "Health Risks" were identified only in South Korean newspapers, the study did not compare a cultural dimension having affecting

both frames.

In addition, this study compare the proportion of the media frame and the score on the cultural dimension of each country. The study results are as follows. First, the higher the IDV score, the higher the proportion of the "Economic Benefits" frame. Germany (67), which has the highest IDV score among the four countries, has a higher proportion of the "Economic Benefits" frame (33.5%) among all media frames, than other countries. Furthermore, the four countries were in the same order in terms of the magnitude of the IDV score and the proportion of the "Economic Benefits" frame: Germany (67/33.5%), Austria (55/21.4%), Japan (46/19.4%), and South Korea (18/11.5%).

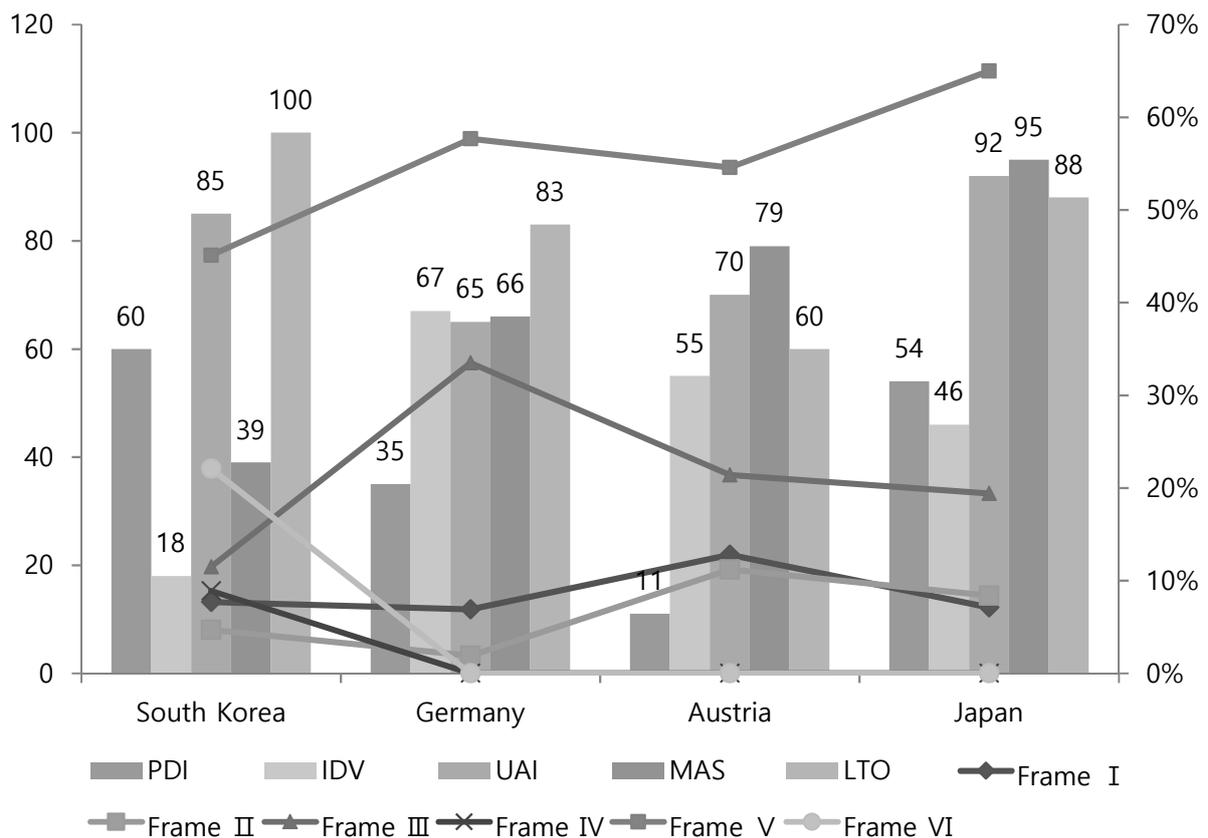


Figure 7.5. Proportion of the media frame and cultural dimension score

Second, the proportion of "Policy" frames and "Research & Development" frame did not

exactly coincide with cultural dimension score. Regarding two cultural dimensions affecting the "Policy" frame, the PDI was generally in inverse proportion to the "Policy" frame, but the UAI did not show a specific correlation. Similarly, regarding the two cultural dimensions that influence the "Research & Development" frame, IDVs are generally found to be proportional to the "Research & Development" frame, but the UAI scores showed no specific correlation.

## 8. DISCUSSION

### 8.1. Presence of Media Frame

Research Question 1a was to identify the media frame on nanotechnology in newspapers in South Korea, Germany, Austria, and Japan. Six media frames were identified through cluster analysis.

"Overview of Nanotechnology" answered the inquiries including "what is nanotechnology?", "what is the origin of the word 'nano'?", and "how tiny is nanometer?". And news articles on "Overview of Nanotechnology" supplemented articles on other frames generally as being published on the same page. The reason why the media appeared as the actor in "Overview of Nanotechnology" frame relatively more than other frames was that the media itself, in a number of news articles, explained nanotechnology to readers. It was also found that various types of actors had the chance to be mentioned equally in news articles because the frame focused on general explanation and introduction to nanotechnology rather than emphasizing the specific aspects.

"Policy" indicated that the public discourse on nanotechnology was formed at the political dimension. Political actors (governments or politicians) effected the use of nanotechnology in the medical field. It showed up by the overwhelming call for support of nanotechnology in the "Policy" frame. Therefore, "Policy" frame indicated the tendency related to nanotechnology in the sequence of "Policy → R&D → Health Care/Medical Service."

"Economic Benefits" discussed nanotechnology's practical and feasible benefits. Accounting for 20% of all frames, "Economic Benefits" is one of the main frames specifying public discourse on nanotechnology. News articles included in "Economic Benefits" had lesser calls for support because they focused on the economic results which would be realized

soon. Thus, this is compared to "Policy" emphasizing politics as the benefit attribution. For "Economic Benefits," science and economy as benefit attributions, and the economy as benefits were highlighted. Consequently, "Policy" included a benefit-oriented tendency and a call for support in news articles on nanotechnology while "Economic Benefits" showed only benefit-oriented tendencies. This indicated that business was positioned as the core in relevant news articles rather than political support, because of how efficiently nanotechnology was already verified in the economic sector.

The political actor and the media had high percentages among various actors in the "Environmental Risk" frame. It indicated that the discourse on environmental risks to be caused by nanotechnology was formed in the political sector as well as in science. In other words, "Environmental Risk" explained role sharing among actors as scientists investigated the negative effects of nanotechnology, the media warned society, and politicians tried to create policies to control it.

"Research & Development" accounted for the highest percentage in 6 frames. It indicated that the public discourse on nanotechnology was still formed around technological development and scientific discovery. The results of this study were mirrored in existing studies (Anderson, Allan, Petersen, & Wilkinson, 2005; Donk, Meta, Kohring, & Marcinkowski, 2012; Laing, 2006; Schmidt Kjærgaard, 2010; Weaver, Lively, & Bimber, 2009) because "Research & Development" appeared in the general deployment process of emerging technologies. Indeed, emerging technologies and their efficiency rose as a social topic in their development phase. And then, as they enter into the popularization and commercialization phases, their practical effects are verified and public awareness on potential risks caused by those emerging technologies develops.

While the technological benefits of nanotechnology presently have been realized as it has entered into the popularization and commercialization phases, its risks are not yet scientifically verified. Accordingly, news articles on nanotechnology keep focusing on technological developments and corresponding benefits unless there otherwise is a definite risk that the public can perceive.

The "Health Risks" frame is similar to "Environmental Risks." Specifically, both frames showed a higher ratio of the media as actor than other frames because the media role which explains the risks of nanotechnology well enough to be easily understood is reflected in both frames. Unlike the benefits of nanotechnology, its risks and side effects are not definitively determined. Accordingly, there are more opinions and judgments by the media itself compared to news articles on nanotechnology benefits. However, calls for regulation on nanotechnology differed in both frames. While calls for regulation showed up in both frames, "Environmental Risks" showed relatively higher calls for regulation than "Health Risks." The benefits and risks of nanotechnology to medicine and health are relatively known well. Conversely, the risks of nanotechnology were mentioned more than its benefits related to the environment. Thus, while nanotechnology use and its regulation is supported with respect to medicine and health, only regulation is supported with respect to the environment.

Research Questions 1b and 1c were to examine the differences in media frames by country and period. The most significant feature of media frames in South Korean newspapers is the appearance of the risk-oriented frame ("Environmental Risks" + "Health Risks"). Only newspapers in South Korea showed the risk-oriented frame. It accounted for 31.0% of all media frames in South Korea and indeed the news coverage on nanotechnology's benefits and risks were relatively more balanced than in Germany, Austria, and Japan.

The appearance of the risk-oriented frame is based on the unique way South Korean

newspapers deal with scientific issues. In South Korea, discussing scientific issues frequently changes into political discourse and finally causes serious ideological conflicts. Such conflicts arise because of two scientific scandals causing an enormous impact on South Korean society in the 2000s. One was the manipulation of stem cell research. In 2004, Dr. Hwang Woosuk at Seoul National University in South Korea published a paper stating that he successfully extracted stem cells from a cloned somatic cell. His research results rose to national prominence because they promised to treat incurable diseases using stem cells and to innovatively strengthen the competitiveness of South Korean bio-industry. At that time, the South Korea government designated Dr. Hwang as a 'national scientist' and provided a tremendous amount of financial research subsidy. Moreover, a biography of Dr. Hwang was even published for kids. However, *PD Notebook*, the investigative journalism program of *MBC*, the public broadcasting network in South Korea, raised doubts as to whether Dr. Hwang intentionally manipulated the research results. The next year, Dr. Hwang admitted to the manipulation.

Another issue arose regarding mad cow disease.<sup>6</sup> Seoul and Washington DC had been negotiating on importing American beef in 2008. At that time, *PD Notebook* broadcasted an investigative program criticizing the risks of American beef that was causing mad cow disease. In spite of the argument that *PD Notebook* exaggerated the risks of mad cow disease, a number of citizens who watched the program continued an antigovernment demonstration for about 100 days. Finally, the President of Korea apologized publicly and some ministers in his cabinet resigned.

Both scandals definitely indicated that the public discourse in South Korea was dramatically changed due to the media and public frenzy on scientific issues. While media

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<sup>6</sup> Bovine Spongiform Encephalopathy (BSE)

frames in South Korean newspapers related to science and technology focused mainly on "Scientific Achievement," "Heroes," or "Economic Benefits" before both scandals (Chung, 2004; Kim & Lee, 2005; Kim & Cho, 2005), "Risks" and "Social Conflicts" appeared after both scandals (Kim, 2011). In a study comparing media frames in newspapers in South Korea to those in the UK related to stem cells (Kim, 2011), the media frames in the UK passed through process of "early concerns → British interest → medical progress." However, the media frames in South Korea were changed leading to the sequence of "bioethics → societal irrationality/national success → social problems/legitimization" with the scandal of Dr. Hwang as the turning point. Consequently, the risk-oriented frame in South Korea was formed as news articles reflected a unique viewpoint which considered the uncertainty of technology not by its scientific aspect but by its political aspect.

Meanwhile, risk-oriented frame varied in South Korean newspapers. While "Health Risks" was strong in *Chosun Ilbo*, "Environmental Risks" was found relatively more often in *Hankyoreh Sinmun*. Both newspapers showed differences in the risk-oriented frame because while nanotechnology effects on medical and health care issues was discussed both as to its benefits and risks, nanotechnology discussion related to environmental issues mainly highlighted the risks. This was evident from the fact that "Economic Benefits" and "Policy" had relatively smaller percentages in the conservative *Chosun Ilbo* than in the liberal *Hankyoreh Sinmun*. And building on the aspect that the articles in "Policy" deal mainly with medical implementation, *Chosun Ilbo* focused on both positive and negative impacts of nanotechnology on the medicine field. However, *Hankyoreh Sinmun* emphasized the risks inherently caused by nanotechnology more than *Chosun Ilbo* by focusing on issues related to the environment.

The media frames of nanotechnology in Germany were mainly positive and benefit-oriented. Compared to the study of Kohring and his colleagues (Donk, Meta, Kohring, & Marcinkowski, 2012) adopting the same methodology as this study, the tendency of news articles on nanotechnology in Germany to comprise two main frames, "Research & Development" and "Economic Benefits," was identified again. The researchers identified 4 media frames from German daily newspapers from 2000 and 2008; "Research & Development," "Economic Benefits," "Medical," and "Ambivalence." "Research & Development" and "Economic Benefits" also were identified in this study. Moreover, individual variables comprising the two frames were almost identical.

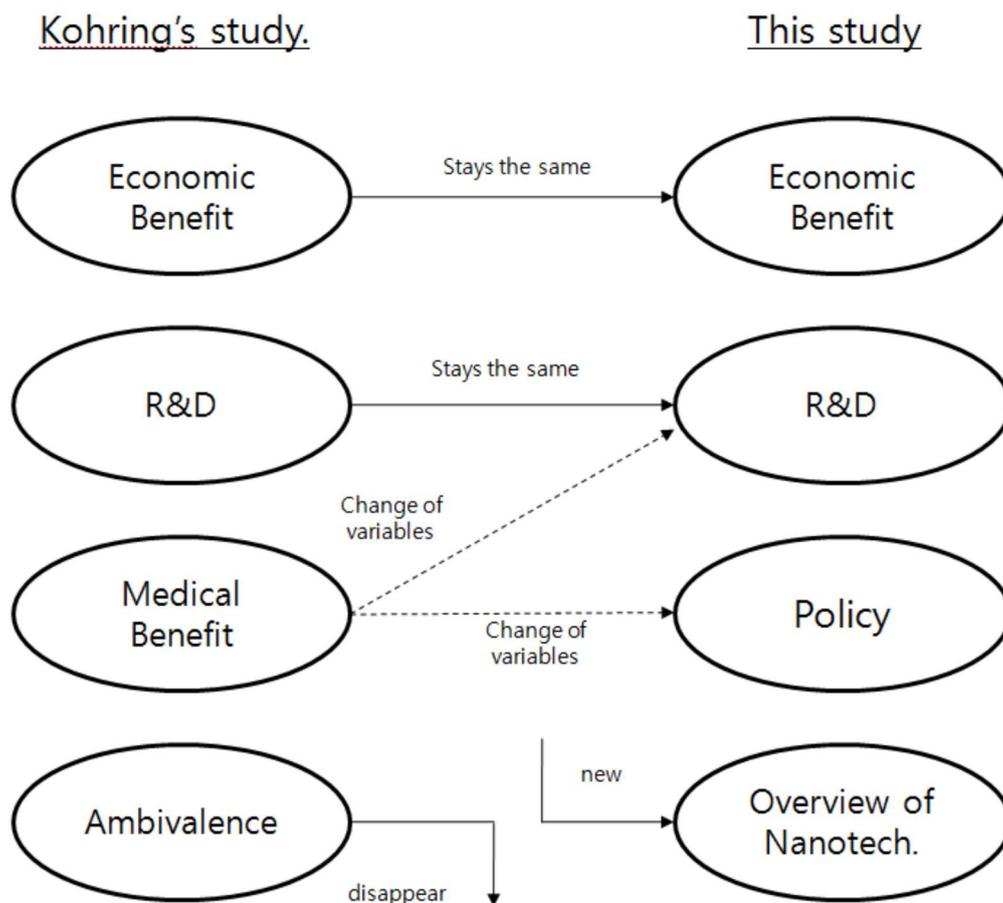


Figure 8.1. Changes of media frame in German newspapers

For example, the variable selected as the main topic in "Research & Development" was scientific research in both studies. Furthermore, the ratio of selected variable in the relevant frame was very similar; 61.7% in Kohring and his colleagues' study, and 62.3% in this study. However, the ratio of variable selected in "Medical" and "Ambivalence" differed from this study. The main topic in "Medical" was similar to "Policy" in this paper, but the variable in actor and benefit attribution was similar to the "Research & Development" frame in this study. Moreover, while the main topic was partially similar to "Overview of Nanotechnology", 'Ambivalence' was not observed in this study.

It is notable that "Overview of Nanotechnology" playing the role of explaining nanotechnology was newly identified and "Ambivalence" dealing with social risks and benefits disappeared in the results of Kohring and his colleagues. Although only "Ambivalence" was related to risks of nanotechnology in earlier results, "Overview of Nanotechnology" newly identified in this study didn't deal with the risks. This indicated that media frames on nanotechnology in the German newspapers had a strengthened benefit-oriented tendency. This was also showed by the ratio of "Research & Development" and "Economic Benefits". While both frames in the earlier study accounted for 73.6%, they comprised 91.2% of all frames in this study. The increasing percentage of both frames positively describing nanotechnology in this study suggested the enhancement of a benefit-oriented tendency.

The benefit-oriented frame was found relatively more often in Germany because Germany has no issues triggering the public to recognize the risks of nanotechnology up to now. Moreover, substantial time is needed for nanomaterials to accumulate in a body or environment and expose either to serious damage. The only negative issue regarding

nanotechnology in German newspapers during the analysis period was the Neosino case. This case was related to health supplements using nanotechnology. It didn't point out nanotechnology risks but raised doubts about its efficiency. While it damaged public confidence on nanotechnology, it didn't intrinsically raise the risks of nanotechnology.

Another reason for the benefit-oriented frame predominance in Germany is the policy of the German federal government focusing on the benefits of nanotechnology. The German government has been concentrating on nanotechnology development and commercialization by announcing the "Action Plan Nanotechnology 2015." This indicates that Germany aims to maximize the benefits of nanotechnology. While the government supports research on risks including the "NanoCare Project," which is investigating the impact of nanotechnology on health, German policies mainly reflect the expectation of economic consequences.

In Austria, the introduction to and policy on nanotechnology frames were relatively prominent. "Overview of Nanotechnology" and "Policy" accounted for 24.0% in Austria, which was higher than the 12.5% in South Korea, 8.8% in Germany, and 15.5% in Japan. Both frames were frequently observed in the early development phase of nanotechnology. In this study, both frames were also identified often in the early 2000s when nanotechnology initiatives were introduced in each country and nanotechnology projects were seriously started. Such feature was identified as the policies of each country promoting nanotechnology potential were introduced in the media, gradually increasing the need to explain that emerging technology.

In this aspect, the "Overview of Nanotechnology" and "Policy" frames were found relatively more often in Austria because there were the development of nanotechnology and the formation of corresponding public discourse behind the other 3 countries. It's only since 2009 that the discourse on nanotechnology expanded from the science sector to society at

large in Austria (Nentwich, Kurath, Fleischer, Grunwald, & Eisenberger, 2010). This means that news articles in Austria had less impact from social discussion of nanotechnology than in other countries during the analysis period.

The most unique result in Japanese newspapers was that "Research & Development" was found more often than in other countries. "Research & Development" accounted for 65.0% in Japanese newspapers, higher than the 57.7% in Germany, the 54.6% in Austria, and the 45.1% in South Korea. A similar result was also found in biotechnology frames which drew attention as an emerging technology earlier than nanotechnology (Hibino & Nagata, 2006; Shineha, Hibino & Kato, 2008). The theme on biotechnology in the Japanese newspapers was changed from application to research and the media frame related to research and development was positioned as the core consistently dominating news articles in Japan for 15 years.

Existing studies, and this study as well, identified that scientific research and development and economic benefits were the main frames in nanotechnology news articles. This is because there is still no definite and direct risk caused by the technology which the public can clearly recognize, and because nanotechnology still has no cultural stigma that specifies the negative aspects of emerging technology like biotechnology, which has genetically modified crops described as Frankenstein food. Nevertheless, the reasons above alone are not enough to explain the unique significance of "Research & Development" in Japan. One possible explanation is that so called, "*Honne* (本音) & *Tatema* (建前)"<sup>7</sup> culture,

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<sup>7</sup> *Honne* (本音) is unique thoughts, emotions or wishes of an individual, *Tatema* (建前) means behaviors and words which are accepted to be right from the other's perspective. *Honne* & *Tatema* indicates the unique contradictory culture of Japan which tries to hide the true heart of the self but to act in accordance with the 'right ways' determined by a society.

the unique culture of Japan reluctant to publicly link academic achievement to economic success, might be reflected in the media representation on emerging technology.

Looking at the dynamics of the media frame, "Research & Development" and "Economic Benefits" kept accounting for around 70% in the entire analysis period as the main way by which media portrays nanotechnology. However, when "Research & Development" increased, "Economic Benefits" was generally accordingly reduced. The correlation between both frames running in opposite ways during the same period is based on the characteristics of nanotechnology. Since nanotechnology has still been in the development phase, the recursive phases in the change of both frames were understood. A similar correlation was identified in an earlier study Kohring and his colleagues conducted by applying the same methodology used in this study.

The risk-oriented frame observed only in South Korean newspapers had different risk topics per time period. The frame dealing with environmental risks was concentrated in the mid-2000s, but disappeared after 2010. Conversely, the frame dealing with health risks was not significant until the mid-2000s, but became prominent since 2008. The reason for the difference between environmental and health risks per period was that there are no concrete risks related to nanotechnology which the public can clearly recognize until now. As nanotechnology has been brought to society's attention, its environmental risks arose earlier than other issues. However, since the negative impacts of nanotechnology on the environment only can be identified after accumulating for a long time, there are no negative issues which the public and media can visually recognize. On the contrary, while there is no negative issue on health risks which can be visually identified up to now, like environmental risks, the media's interest in risks has naturally moved to health as nanotechnology applications and policies focused on medicine.

## 8.2. Cultural Resonance and Salience of Media Frame

Research Question 2 was to examine the cultural effect on media frame using a logistic regression model. When other factors were not considered, it was verified that the media frame resonated with a specific cultural dimension.

The cultural dimensions power distance and uncertainty avoidance had an effect on "Policy." It indicated resonance between both cultural dimensions and "Policy." The stronger the tendency to avoid uncertainty and the lower the power distance was, the more frequently "Policy" was observed.

The effect of power distance on "Policy" was classified largely into two perspectives. The first is the effect of the cultural dimension itself on the frame. According to Hofstede's research, the lower the PDI score a society had, the higher the social position and academic background of its scientists were. In other words, the power distance was lower in a society with a more advanced higher education system. Power in such a society was based on official position and specialty. Thus, a society with lower power distance acquires political effects on a specific issue through system based on special knowledge. The society with lower PDI score related to nanotechnology emphasizes the necessity of technology policy more than a society with a higher PDI score, and it has an effect on the emergence of the media frame.

Next comes the effect of national characteristics comprising cultural dimensions on the frame. Power distance is closely related to national wealth. The lower the power distance is, the richer a country becomes. There is also a feature applied to power distance and national wealth in common. The more modern science and technology, advanced education system, and middle class a country has, the lower the power distance is and the richer a country is. Accordingly, technology policy like nanotechnology needing tremendous amounts of finance

and advanced special knowledge is observed mainly in rich countries. Lower power distance thus has an effect on the salience of media frames.

An uncertainty avoidance culture also resonates with "Policy." A culture strongly avoiding uncertainty focuses not on avoidance of adventure but on reduction of ambiguity. Moreover, such a culture pursues rules and organization to clearly analyze and evaluate a specific issue. Accordingly, a society with a higher UAI score has relatively stronger rules and emphasizes the necessity for reducing anxiety of ambiguity, and as results, its members believe in the system. Nanotechnology has high uncertainty and its potential benefits and risks have socially discussed in society up to now. Accordingly, the media in a society with a strong uncertainty avoidance culture uses more "Policy" for nanotechnology.

A culture with a higher IDV score had more "Economic Benefits." The basic characteristics of individualism include the responsibility of an individual, free market, and economic growth. It means the tendency to maximize benefits by accepting risks, and emphasizes economic compensation. Thus, it is inevitable that media in an individualism culture uses more "Economic Benefits." "Economic Benefits" in the individualistic society showed more cultural resonance because an individual is defined as "Homo economicus" and economic benefits are emphasized as compensation for the acceptance of the uncertainty of nanotechnology. The close correlation between individualism culture and economic results is natural because capitalism is based on individualism. To this point, Neuman and his colleagues pointed out that the economic consequence frame extensively reflected the benefits, losses, and values of capitalism (Neuman, Just, & Crigler, 1992). They identified that the media's application of an economic frame reflected the values of dominant capitalists.

The cultural dimensions resonating with "Research & Development" were Individualism/Collectivism and Uncertainty Avoidance. The stronger the individualism

tendency and the uncertainty avoidance tendency were, the more frequently "Research & Development" was observed. Individualism is based on an individual's autonomy and the increase of individualism expands the intelligent openness. All ideas in such a society are the target of competition and skeptical criticism. Individualism has the tendency to be extremely intelligent and questioning and demands the highest standards. Accordingly, uncertainty is an opportunity for an individualist. Indeed, individualists think there is no uncertainty, risk of loss, individual compensation, and business prospective. In this aspect, the individualism culture considers technology as a good. Compliance with market principles accelerates technology innovation, and the extraordinary economic benefits obtained through technology innovation is connected to a premise for a better life (Wildavsky & Dake, 1990). "Research & Development" appears relatively more frequently by resonating with the technology preference in an individualism culture because it describes nanotechnology's positive aspects.

As described above, a culture strongly avoiding uncertainty uses rules to reduce ambiguity. Moreover, it relies on the experts for pursuing the absolute truth. Thus, the basic property of Uncertainty Avoidance culture has an effect on "Research & Development." Since scientific research aims to clarify the absolute rules in the natural order, the media in a culture strongly avoiding uncertainty has a relatively greater interest on the research on nanotechnology. In addition, as the media depends more on experts for reducing uncertainty on nanotechnology, it naturally focuses on the scientific work experts perform.

However, the presence and salience of the media frame was not necessarily in agreement. As in the relationship between IDV and the "Economic Benefits" frame, the countries that are stronger in a specific cultural dimension sometimes showed increased salience and presence of the corresponding cultural dimension. However, the influences of all cultures on frame building did not determine the presence of the media frame of each country. This shows that

the variation in media frame among the countries is determined not only by cultural factors empirically tested in this study but also by the combined effects of other micro- and macrolevel factors.

In addition, the study results corroborated with the theoretical concept of salience of the media frame. However, it was partially confirmed that the salience has a sequential linear order relationship with the presence of media frame.

### 8.3. Conclusions and Implications

The most important conclusions from this study are as follows. First, newspapers in South Korea, Germany, Austria, and Japan had a common point related to the media frame of nanotechnology in spite of differences in cultural background. In all countries' newspapers, positive description on nanotechnology was overwhelmingly greater than negative. The primary frames defining nanotechnology were "Research & Development" and "Economic Benefits." These results are similar to existing studies. Therefore, the study again found that the media frame on nanotechnology had common characteristics in positive description, research and development, and economic consequences.

Second, there were obvious differences among countries even though the 4 countries showed similar media frame patterns. The risk-oriented frame was found only in South Korean newspapers. German newspapers emphasized economic benefits relatively more than other countries. In addition, "Research & Development" and "Economic Benefits" reached 91.2% of all frames. The frame concentration in Germany was higher than in other countries. This reflected that the German newspapers couldn't report on nanotechnology with various perspectives. In Austria and Japan, newspapers demonstrated relatively higher "Policy" and "Research & Development" scores.

Third, the more "Research & Development" increased per time period, the more "Economic Benefits" decreased. Furthermore, the environment and health themes were identified in a risk-oriented frame in that order.

Finally, the differences in media frame by countries included the cultural characteristics of each country. Consistent with the analysis on the effect of cultural dimensions on media frames using a logistic regression model, a specific cultural dimension and a media frame resonate with each other. The lower the power distance was and the stronger the uncertainty avoidance was, the more frequently the "Policy" frame was identified. This meant that the cultural dimensions of relying on experts and preferring a system based on expertise was reflected in the "Policy" frame.

The "Economic Benefits" frame was observed more frequently in a culture with stronger individualism. Germany had the strongest individualistic culture followed by Austria, Japan, and South Korea in that order. Correspondingly, Germany showed the highest ratio of "Economic Benefits" followed by Austria, Japan and South Korea in that order. It indicated that the cultural dimension emphasizing competition and economic benefits resonated with the media frame related to economy.

This study compared the media frame of nanotechnology observed in the newspapers in South Korea, Germany, Austria, and Japan. Moreover, this study found that cultural factors had effect on the media frame, but were ignored in existing studies up to now. Accordingly, using culture dimension as the independent variable in the research model, comparing the difference in media frames expands the theoretical perspective of the framing study.

Existing studies were limited to descriptive methods measuring the number of cases from which media frames were extracted. However, this study added a new approach to framing theory and methodology divided into three perspectives. First, this study empirically

examined the cultural effect on media frame. While a number of studies assumed that macrolevel factors including culture had an effect on frame building, there was no previous empirical investigation. Therefore, this study was significant in that it built a regression model evaluating the media frame using cultural dimensions and verified the quantitative variables for comparing countries.

Second, this study examined not only the presence of the media frame but also its salience. Existing studies focused only on the "presence" of media frame. They demonstrated only the difference in media frames but failed to empirically demonstrate the correlation of factors affecting the media frame. Therefore, this study empirically verified how the salience of each media frame was observed differently depending on its attribution as well as on a specific factor.

Third, the media frame was identified by clustering frame elements. This approach excluded coders' influence on frames based on the complexity of an issue but clarified the emergence of new frames and disappearances of old frames. Compared to existing studies using the same method, for example, "Ambivalence" in earlier study disappeared and "Overview of Nanotechnology" was emerged in German newspapers, and "Medical Benefit" in earlier study was changed into "Research & Development" and "Policy" in this study. Additionally, the risk-oriented frame was observed only in South Korea. Thus, because a media frame is determined not subjectively but empirically, the study approach to extract a new frame by clustering elements overcame the methodological limitations of existing studies.

This study also contributed to the literature comparing media content between cultures and to science communication studies. While existing studies focused on the early development phase of nanotechnology, this study identified long-term tendencies by

analyzing news articles for 15 years, including 2010s when the potential risks of nanotechnology were discussed in society. Moreover, unlike existing studies limited to national comparisons between Europe and the US or between the US and Asia, this study expanded into regional and cultural comparisons that included German-speaking culture and Confucian culture. In addition, as comparing 2 countries has a limit in how it can inform generalizing results, this study attempted to overcome such a limit by studying 4 countries with different cultures.

#### 8.4. Limitations of the Study

The limitation of this study is its sampling countries. The 4 countries were intentionally selected because the Eastern and Western countries were compared in a conventional way. Furthermore, this expanded the academic research landscape by comparing German-speaking culture and Confucian culture which were neglected until now. Nevertheless, the number of samples was still small, creating several methodological problems. First, the range of culture dimension scores per country may cause biased results. Since the risk-oriented frame was activated only in South Korea, the effect of that culture dimension on the relevant frames was limited. Moreover, one has to be very careful to generalize the results and apply them to other societies because 4 countries are not a representative sample.

Another study limitation was that the effect of the presence and salience of the media frame was not examined in interaction between macro- and microlevel factors. This study found that each country showed diverse media frame presence and so cultural dimension of each country had a different effect on the salience of a media frame. To this end, this study selected countries having similar macrolevel factors (except culture), including ideology, political freedom, economic system, educational competitiveness, and nanotechnology

development status. Nevertheless, this failed to effectively control the microlevel factors affecting on frame building including media routines, political orientation, and the expertise of newspaper science journalists. Furthermore, this study empirically verified the effect of culture on media frame, but the explanatory power of the effect was not large. This leaves the room for the possibility that macrolevel factors other than culture can influence frame building.

The study's content analysis also had a limitation. Content analysis is effective for identifying a difference in issues and events, but can't determine the causality because of its limited inference ability. Since qualitative analysis was not applied, this study has some limitations in providing insight and understanding on each frame element on clustering.

#### 8.5. Opportunities for Further Study

When this study is further applied to countries with diverse cultures, the explanatory power of the regression model on media frames will be strengthened. In particular, further studies can more definitely identify cultural effects on the media frame of nanotechnology more definitely by including English-speaking and Chinese-speaking countries having leading technology. In addition, more diverse kinds of media have to be included, for example, TV, news agencies, magazines, and the Internet, to more clearly understand media's representation of nanotechnology. Thus approach is also significant to be able to compare investigations of the cultural effects beyond the different kinds of media boundaries.

Further study needs to focus on the interaction between factors having an effect on frame building. To this end, this study adopted the culture dimensions of Hofstede. While the analysis identified the effect of individual culture dimensions on the media frame, the effect of the interactions between culture dimensions was not verified. Accordingly, further study

will measure the multiple effects of culture dimensions. Moreover, the effect of other macrolevel factors including politics, the economy, and religion on frame building should be investigated.

Regarding methodology, this study improved reliability and validity by clustering frame elements. To maximize the efficiency of the methodology, with the media frame as the cluster, it is necessary to additionally select and examine the definitions of frames from a variety of researchers. Furthermore, diverse alternatives including interviews, surveys, or experiments will be combined for supplementing the limitation of content analysis whose causality can't be easily identified.

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**APPENDIX A**  
**CODING FORM FOR CONTENT ANALYSIS**  
**ORIGINAL VERSION**

## 섹션 I : 나노기술 보도의 기본 정보

### 1. ID

### 2. 국가

- ① 한국
- ② 독일
- ③ 오스트리아
- ④ 일본

### 3. 신문

- ① 조선일보
- ② 한겨레신문
- ③ FAZ
- ④ SZ
- ⑤ Presse
- ⑥ Standard
- ⑦ 요미우리신문
- ⑧ 아사히신문

### 4. 연도

- ① 2001
- ② 2002
- ③ 2003
- ④ 2004
- ⑤ 2005
- ⑥ 2006
- ⑦ 2007
- ⑧ 2008
- ⑨ 2009
- ⑩ 2010
- ⑪ 2011
- ⑫ 2012
- ⑬ 2013
- ⑭ 2014
- ⑮ 2015

## 섹션 II: 프레임 요소

5. 뉴스 기사는 어떠한 주제를 다루는가? 오직 하나를 체크하십시오

- ① 과학기술 연구개발
- ② 의료/건강
- ③ 경제
- ④ 반도체 공정
- ⑤ 정책
- ⑥ 윤리/도덕
- ⑦ 사회적 효과
- ⑧ 나노 설명 및 개요
- ⑨ 기타

6. 뉴스 기사는 어떠한 주체(행위자)를 다루는가? 오직 하나를 체크하십시오

- ① 과학자
- ② 경제인
- ③ 정부 및 정치인
- ④ 미디어 및 여론
- ⑤ 시민단체
- ⑥ 군인
- ⑦ 기타

7. 뉴스 기사에서 나노기술이 불러올 이익 혹은 혜택에 주된 원인이 되는 것은 무엇인가? 오직 하나를 체크하십시오

- ① 과학
- ② 경제
- ③ 정책
- ④ 의료

8. 뉴스 기사에서 나노기술이 불러올 위험 혹은 피해에 주된 원인이 되는 것은 무엇인가? 오직 하나를 체크하십시오

- ① 과학
- ② 경제
- ③ 정책
- ④ 의료

9. 뉴스 기사에서 나노기술이 불러올 이익 혹은 혜택은 어느 분야에서 나타나는가? 오직 하나를 체크하십시오

- ① 연구개발
- ② 경제
- ③ 의료 및 건강
- ④ 소비자
- ⑤ 환경

10. 뉴스 기사에서 나노기술이 불러올 위험 혹은 피해는 어느 분야에서 나타나는가? 오직 하나를 체크하십시오

- ① 연구개발
- ② 경제
- ③ 의료 및 건강
- ④ 소비자
- ⑤ 환경

11. 뉴스기사에서 나노기술에 대한 규제 정책 혹은 부정적 전망이 포함되어 있는가?

- ① 예
- ② 아니오

12. 뉴스기사에서 나노기술에 대한 지원 정책 혹은 긍정적 전망이 포함되어 있는가?

- ① 예
- ② 아니오

**APPENDIX B**  
**CODING FORM FOR CONTENT ANALYSIS**  
**ENGLISH VERSION**

## Section I: Basic Information of the news article on nanotechnology

### 1. ID

### 2. Country

- ① South Korea
- ② Germany
- ③ Austria
- ④ Japan

### 3. Newspaper

- ① Chosun Ilbo
- ② Hankyoreh Sinmun
- ③ Frankfurter Allgemeine Zeitung
- ④ Süddeutsche Zeitung
- ⑤ Presse
- ⑥ Standard
- ⑦ Yomiuri Shimbun
- ⑧ Asahi Shimbun

### 4. Year

- ① 2001
- ② 2002
- ③ 2003
- ④ 2004
- ⑤ 2005
- ⑥ 2006
- ⑦ 2007
- ⑧ 2008
- ⑨ 2009
- ⑩ 2010
- ⑪ 2011

- ⑫ 2012
- ⑬ 2013
- ⑭ 2014
- ⑮ 2015

## Section II: Frame Elements

5. What topic is taken mainly in the news article? Please check only one.

- ① scientific research
- ② medical service/health care
- ③ economy
- ④ development of semiconductor
- ⑤ policy
- ⑥ moral/ethics
- ⑦ overview of nanotechnology
- ⑧ other

6. What actor is take mainly in the news article? Please check only one.

- ① science
- ② business
- ③ politics
- ④ media/public opinion
- ⑤ NGOs
- ⑥ military
- ⑦ other

7. What is responsible for benefits of nanotechnology in the news articles? Please check only one.

- ① science
- ② economic
- ③ politics
- ④ medical

8. What is responsible for risks of nanotechnology in the news articles? Please check only one.

- ① science
- ② economic
- ③ politics
- ④ medical

9. What issue is taken as benefit of nanotechnology in the news article? Please check only one.

- ① research
- ② economy
- ③ health
- ④ consumer
- ⑤ medical

10. What issue is taken as risk of nanotechnology in the news article? Please check only one.

- ① research
- ② economy
- ③ health
- ④ consumer
- ⑤ medical

11. Is(Are) regulation policy or negative prospects for nanotechnology mentioned in the news article?

- ① yes
- ② no

12. Is(Are) support policy or positive prospects for nanotechnology mentioned in the news article?

- ① yes
- ② no

I hereby declare that the doctoral dissertation presented is my own work. I have employed no other sources or means except the ones listed. I clearly marked any quotations derived from the works of others. I did not seek unauthorized assistance from a third party.