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Title of the paper

*Korean Perceptions of Air Pollution and Energy Development:
The Impact of Frames in Isolation and Competition on Opinions*

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Abstract

This paper examines how exposure to frames in a communication influence Koreans' opinions about the causes of pollution and support for a specific polluting energy source that the nation relies on. Two distinct experiments are presented. The first focuses on how frames that attribute blame to China, to Korea, or both simultaneously affect Koreans' satisfaction with national efforts. The second experiment focuses on frames that highlight the costs of coal, the benefits of coal, or both simultaneously on Koreans' support for the usage of coal. The competing frames presented in both experiments represent the crux of this study: comparing frames in isolation with frames in competition on opinion formation. Based on a survey experiment of a representative sample of Seoul Metropolitan Area residents, we find that competitive frames do not consistently have null effects, that the effects of frames blaming China have consistent impacts, and that frames highlighting the positive economic benefits wins out in competition over a frame that highlights the negative environmental effects that result from a reliance on coal.

Keywords: framing effects, competitive frames, Korean air pollution, public opinion, environmental policy, energy policy

Introduction

South Korea (henceforth, "Korea") regularly experiences environmental disasters in the form of hazardous air pollution. The assignment of responsibility and the pursuit of solutions regarding this problem frequently target China. Yet, there is no mention of the fact that foreign investors in China may be contributing to the problem, and that a significant portion of this investment likely originates in Korea (Shapiro, 2016). There has also been very little research on the parallel narratives of domestic and transboundary sources of air pollution, i.e. China-originating air pollution as well as air pollution produced from within Korea's borders. And a dearth of studies addresses how these narratives affect public views regarding China's responsibility, Korea's responsibility, or the necessary policy changes.

Our focus is on the relationship between the media and the general public, i.e. between the sender and the receiver of particular frames with regard to air pollution. We employ two distinct survey experiments to consider the differences between frames in isolation and frames in competition. On its current scale, public awareness of air pollution in Korea is a relatively recent development given that particulate matter measurements were first announced by the Seoul Metropolitan Area government in October 2013 (Son, Kim, & Myllyvirta, 2015).[1]

Attending to the potential effects of media messages on the behavior and intentions of the Korean public, our primary tasks are twofold. First, we must assess how different attribution frames affect Korean views regarding the need to act to reduce Korea's air pollution, and satisfaction with Korea's and China's efforts to reduce air pollution. Second, and given the extent to which coal – a highly polluting energy source – is emphasized in Korea's energy portfolio, we assess how a frame highlighting the negative public health consequences, the

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[1] See the 4/11/201 edaily.co.kr article, "문재인·안철수표 미세먼지 대책…실효성 있나". The most recent shifts in public attention are likely reflected by increased media reports about Korean air pollution as well as statements made about this issue by the 2017 presidential candidates.

positive economic benefits of its usage, or both frames in competition change public views about coal's effect on the environment, energy prices, and Koreans' public health. Finally, we examine both assessments comparatively and bridge them around the most tenable policy outcomes to address Korea's air pollution.

Individual-level framing effects: Exposure to one-sided and competitive frames

Frames in a communication highlight particular aspects of an object (e.g., candidate, issue, policy) that can shape the "weight" that individuals assign to competing considerations in the opinion formation process (Druckman, 2001). For instance, given an example from the literature on energy and framing effects, frames often help define a political or social problem, as well as provide potential solutions for addressing it (Entman, 1993; O'Neill, Williams, Wiersma, & Boykoff, 2015). There is a voluminous literature across disciplines that studies how exposure to frames in a communication influence opinion formation. According to Framing Theory, a "framing effect" occurs when a communicator's focus on a subset of the potentially relevant considerations toward an attitude object caused a receiver or audience to privilege (i.e., increase the weight of) that consideration relative to other potentially relevant considerations (Chong & Druckman, 2007a).

By incorporating a framing study into the case of Korean air pollution, we can address the general public's willingness to change its behavior or support policy change with regard to air pollution. Frames are relative to the audiences targeted by these frames (Scheufele & Tewksbury, 2007), and, outside of Korea, there is evidence that the framing of particular energy sources has effects on an individual's perceived benefit of one or more energy types (Cacciatore, Scheufele, & Shaw, 2012; Clarke et al., 2015). Inside of Korea, we are largely ignorant about how the transboundary air pollution and energy frames are driven by partisanship, demographics,

environmental knowledge, etc. To minimize this gap in our understanding of interventions that can shape people's attitudes about air pollution, we have conducted two separate but related survey experiments.

It is assumed that the media engages in frame building, selecting frames about particular issues and then disseminating them (Scheufele, 1999). The frame building process takes frames originally in isolation, integrates them, and thus results in a crosscutting frame that combines several categories is ideal and reflects "the inherently intersecting context of prominent news frames and the potential of this interplay to shape cognitive responses. Indeed, the combination of certain frames seems likely to intensify or diminish the media effects on audiences" (Shah, Kwak, Schmierbach, & Zubric, 2004: p.103).

Combinations of frames may lead to frames being placed in competition with each another (Nisbet, Brossard, & Kroepsch, 2003). According to Framing Theory, when directionally opposing frames of equal strength (e.g., a frame highlighting the economic benefits alongside a frame highlighting the environmental cost) are pitted against one another they often cancel each other out, leaving opinions unmoved (Chong & Druckman, 2007a) An early study to test for the impact of competing rather than isolated frames was Sniderman and Theriault (2004), where it was shown that free speech and public safety frames negate each other's effects when examined in the context of support for allowing a hate group to hold a demonstration (also see, Nelson, Clawson, and Oxley (1997). In another example, with regard to a new policy to promote clean energy, competing frames have been shown to cancel each other out based on a study of two different samples of Americans (Aklin & Urpelainen, 2013).

To reiterate, when individuals are exposed to one-sided frames (e.g., either emphasizing the benefits or costs of a policy, but not both simultaneously), such messages often lead to opinion change. This is because such communications increase the availability, accessibility,

and something the perceived applicability of a specific consideration when forming an overall evaluation toward any attitude object. When frames appear in competition, there may be one frame that dominates over another, depending on the relative strength (i.e., perceive persuasiveness) of each frame (Chong & Druckman, 2007b). Under these circumstances, there is no canceling out of each frame's effect but rather one frame overpowering the other frame and shifting overall opinions in the direction of the stronger frame. We hypothesize that *frames in competition negate each other's effects*.

Experiment 1: Blame attribution frames

Koreans are regularly exposed to news that highlights the role of China as a contributor to Korea's pollution, i.e. that China is wholly or at least partially responsible (Shapiro, 2016). Research on the effects of attributing causes for problems – i.e. an attribution of causal responsibility frame – has been well documented since Iyengar's (1991) seminal study of the causes of poverty, crime, and other deeply complex policy issue areas.[2] When assigning blame after a crisis (e.g., a poorly handled environmental catastrophe like Hurricane Katrina), attribution frames have shown that partisanship is a factor. People also rely on detailed information about what each participant's role was (or should have been) (Malhotra & Kuo, 2007). In other words, assigning attribution is challenging for individuals given their preexisting biases and a reliance on heuristics when weighing different pieces of information (Ross, 1977). Of particular significance are the potential biases that are present when one is weighing how to attribute negative and positive acts to one's own group relative to another group, known as Pettigrew's (1979) "ultimate attribution error." Reviews of the literature on attribution error are

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[2] Iyengar's (1991) greatest contribution is the acknowledgement of both causal and treatment responsibility; i.e. responsibility for creating the problem as well as responsibility for resolving the problem.

divided but tend to reject Pettigrew's claims.[3] With consistent media exposure to a blame-China

narrative, we hypothesize that ***Koreans experience attribution error when considering***

transboundary air pollution.

Table 1 here

<u>Design</u>

Presented in Table 2, three emphasis frames are employed for this experiment. All invoke

a fabricated news article from the Korean Newswire, *Yonhap News*. The first conveys a blame-

China frame which states that "the majority of Korea's air pollution comes from factories located

in China." Implications are also included: "In other words, China is to blame for Korea's air

pollution." To establish credibility for this statement, the frames included language regarding the

source of the information reported in the *Yonhap News* article, namely "experts from the

National Institute of Environmental Research, the Korea Meteorological Administration, and

Seoul National University." For the second frame, attribution is assigned to Korea in the form of

the "pollution haven hypothesis," which invokes ecological economics and international political

economy to claim that foreign entities effectively export pollution by setting up production in

regions where there are relatively weaker environmental standards. The costs for the pollution

exporter are thus lower than those resulting from producing in their countries of origin. As was

the case for the blame-China frame (regarding China), the implications are stated clearly (i.e. "…

Korea is to blame for Korea's air pollution."). The third and final frame combines both of these

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[3] See Brewer (2007) and Hewstone (1990) for details. One could also invoke notions of populism, which is a recent and burgeoning area of research in this domain. See, for example, Busby (2017) and Hameleers, Bos, and de Vreese (2016), although these types of populism studies do not account for the nationalism that would accompany transboundary air pollution.

frames to create a competitive frame between frames that blame China and those that blame Korea. The clarifying statement for the competitive frame states, "It other words, both countries are to blame for air pollution blowing from China."

Table 2 here

The dependent variables being measured in Experiment 1 are as follows: the extent to which it is important to take action to reduce Korea's air pollution, the extent to which the respondent is satisfied with Korea's efforts to reduce its own air pollution, and the extent to which the respondent is satisfied with China's efforts to reduce its own air pollution.[4] To eliminate priming effects, we randomly ordered the second and third dependent variables after presenting the first dependent variable (importance of taking action to reduce Korea's air pollution).

Among the various control variables included are the following: age, gender, political party affiliation,[5] number of people in household suffering from respiratory problems, number of hours per day spent outdoors, political knowledge, oil production knowledge, pollution knowledge, car ownership status, religious affiliation, education level, employment status, and household income. Because respondents completed the survey over several days during mid-April, which happens to be within Korea's peak air pollution period, we also included a date-time control variable to eliminate variance caused by any pollution fluctuations.

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[4] The exact wording of the dependent variables of Experiment 1 can be found in the appendix.
[5] The Saenuri Party changed their name into the Liberty Korea Party (자유한국당) after the scandal of ex-President Park Geun-hye, and a second party was established to distinguish between former Saenuri Party members supporting the impeached president and those opposed to ex-President Park. Party members remaining loyal to the impeached president were Liberty Korea Party members while anti-Park Saenuri Party members created the Bareun Party (바른정당).

Data & results

Both experiments are based on nationally representative samples of the Korean

population based on the Korean web survey agency, Macromilll-Embrain, Inc. ("Embrain").[6] At

the time of the survey's launch, Embrain's panel was comprised of 1.166 million people from

which we took a quota sample based on Seoul Metropolitan Area residency as well as gender and

age distributions consistent with Seoul-based representative samples. This sample was

determined by population data from the Ministry of Government Administration and Home

Affairs statistical database for April 2017.[7] A quota sampling method was employed to limit bias

and focus solely on a representative sample of the country's largest metropolis. The focus on the

Seoul metropolitan area also eliminates variance in air pollution effects across South Korea.

Ninety-eight percent of all data collection began on April 10 (Korea time) and ended on April

13, 2017.[8]

Respondents were recruited via computer-telephony integration/random digit dialing,

voluntary registration on Embrain's panel site, word of mouth, or banner advertisements on

portal sites. An individual must thus first request to be a panel member for Embrain. Following,

an email is sent from Embrain's Panel Management Team to request additional information to

confirm the validity of the potential panel member's email. To finally confirm that the requesting

individual is who s/he says s/he is, an Embrain Panel Management Team member contacts the

individual via telephone. This process insures that children rather than heads of households are

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[6] Institutional Review Board approval granted by the Illinois Institute of Technology's IRB on February 15, 2017; Protocol #: IRB2017-014.
[7] The exact location for these data is the following website: http://rcps.egov.go.kr:8081/jsp/stat/ppl_stat_jf.jsp.
[8] 2.6 percent of responses for the second survey experiment, a total of thirteen responses, were gathered on April 18.

not registering. Management of the panel is conducted by randomly sent invitations for participation in Internet surveys with monetary incentives for participation. The estimated monetary incentive for respondents participating in the present study was approximately $5. It is also worth noting that selection bias from targeting only Internet users is alleviated given the nearly 89.9 percent Internet penetration rate in Korea.[9]

Treatment effects are reported here as linear regression coefficients.[10] In line with Angrist and Pischke (2009), we base the statistical significance of these coefficients on bootstrapped ($n =$ 1,000) standard errors.[11] We refer to the content of Table 3 when testing hypotheses relevant to Experiment 1. Note that, based on a 7-point scale for our dependent variables, the control group that received no framing treatment places a high priority on taking action to reduce Korea's air pollution (6.467) and coordinating with China (6.789). Opinions are no less extreme regarding the degree to which respondents are satisfied with Korea's efforts to reduce its air pollution (1.694) as well as with China's efforts to reduce its air pollution (1.552). Thus, any statistically significant movements of Koreans' beliefs (higher or lower) will likely appear negligible. Statistically significant effects, however seemingly small, are all that much more relevant as they are already occurring at the margins.

Table 3 here

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[9] This Internet penetration rate is based on 2015 data, according to the CIA World Factbook (https://www.cia.gov/library/publications/the-world-factbook/geos/ks.html).

[10] Results including the control variables are presented in the main body of the paper while those excluding the control variables are available in the appendix. Also available in the appendix are the descriptive statistics for Experiment 1.

[11] We thus avoid imposing parametric assumptions on our interpretations. Our findings were robust to alternative functional forms, e.g., ordered probit regression. For each experiment, the results are presented both with and without control variables, but our interpretations are based solely on the former. Results generated without control variables are useful as references for the uncontrolled group means for each group of the experiment, but our hypothesis tests rely only on those means when accounting for personal attributes.

Tests for Hypothesis E1.1 (i.e. that frames in competition negate each other's effects) are based on whether the competitive frame is significantly different from the baseline. As such, we reject Hypothesis E1.1 in terms of the competitive frame's effect on the necessity of reducing pollution (Table 3, column 1) and on satisfaction with Korea's efforts to reduce pollution (Table 3, column 2). In both of these cases, the statistically significant coefficients move the baseline in the same direction as the blame-China and pollution haven frames. We accept Hypothesis E1.1, however, with regard to people's satisfaction with China's efforts to reduce its own pollution.

A secondary level of tests for Hypothesis E1.1, based on the results of two-sample t-tests for statistically significant differences between the means of the isolated frames (both) and the competitive frames, indicates that there are caveats to our initial results. Across all three dependent variables of Experiment 1, there were no differences between the effects of the pollution haven and competitive frames. There were, however, statistically significant differences between the blame-China and competitive frames with regard to the need to reduce pollution ($p < 0.0180$), satisfaction with Korea's efforts ($p < 0.0646$), and satisfaction with China's efforts ($p < 0.0005$). For the first two dependent variables (Table 3, columns 1 and 2), one could effectively argue that, for the blame-China frame only, the competitive frame weakens but does not necessarily negate the effects of the frame in isolation.

Our test for Hypothesis E1.2 (i.e. that Koreans experience attribution error when considering transboundary air pollution) is conducted by comparing the coefficients of the blame-China and pollution haven frames. If attribution error were not present, there would be no statistically significant differences between people with regard to the effects of the blame-China and pollution haven frames. For all three dependent variables (Table 3, columns 1 and 2), the effects of the blame-China frame are greater than those of the pollution haven frame. There is,

thus, evidence that Koreans are producing attribution error by viewing China as the out-group and Korea as the in-group.[12]

Experiment 2: Coal costs & benefits frames

The costs of air pollution come in several forms and easily translate into impacts on a country's GDP, but they are also peripheral to the broader public's understanding of the problem. Thus, we focus on the health effects of air pollution, which represent 80 percent of all air pollution costs (Pearce, Atkinson, & Mourato, 2006). Health is salient for the public, reinforced by the fact that air pollution of certain types is visible, regularly/seasonally reported in the media, and freely accessible to individuals through weather applications and websites with up-to-the-minute updates. In this way, health costs are likely to be weighed heavily by individuals when considering their daily lifestyles. This is not simply a matter of deciding whether to have a picnic at the beach but deciding whether or not to go outside at all, whether to skip going to work, or whether to opt to keep the children at home from school. In other words, and employing the language of OECD (2016), there are certain non-market costs associated with increased mortality and morbidity from air pollution, measured by "people's expressed willingness to pay to reduce health risks and do not represent an actual cost to the economy. They provide a useful indication for policy makers of the importance of the health impacts of outdoor air pollution" (OECD, 2016: p. 15).

We build on a recent and relevant literature. First, in Goldfarb, Buessing, and Kriner (2016), focus was placed on the U.S.'s transition from fossil fuels toward renewable sources.

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[12] To confirm that the blame-China frame generates statistically significant different effects from the pollution haven frame on people's satisfaction with Korea's efforts to reduce pollution, two-sample t-tests were conducted ($p < 0.07$). There were no other significant differences between the two frames.

Among two frames, an information-based frame that highlighted the health costs of fossil fuel, namely that "pollution from coal burning power plants causes tens of thousands of premature deaths in the U.S. alone every year" (Goldfarb et al., 2016: p. 301), increased support for renewable policies. A second study attempted to understand how public support for fracking responds to arguments about its economic and environmental benefits and costs. In that case, only the benefits frame had a significantly different effect from the control group (Christenson, Goldfarb, & Kriner, 2017). Although we are not examining equivalency framing effects, early research on that subject has implications for Experiment 2, particularly that frames conveying gains and losses – i.e. benefits and costs – have distinct effects (Tversky & Kahneman, 1981). In addition, losses (i.e. costs) have a greater impact on an individual's perceptions and behaviors than gains (i.e. benefits) (Hale & Dillard, 1995; Kahneman & Tversky, 1984; Tversky & Kahneman, 1981).[13] In light of these results, we hypothesize that health frames – i.e. "***costs frames***" for our purposes – ***are more impactful than benefits frames***.

Finally, at an intuitive level, our frames are expected to have impacts only on the dependent variable with which they share dimensionality. To explain, the benefits frame refers to coal power but only in terms of economic outcomes; the costs frame refers to coal power but only in terms of health outcomes.[14] In this way, the dimensions of each frame are limited to producing only a single effect – costs or benefits – and we do not expect there are any other effects. Specifically, we hypothesize that, ***by frame dimension, one-sided frames will shift opinions in the direction of the frame relative to the control group***.

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[13] The research on affective responses to threats of gains and losses, however, may underestimate those characteristics of individuals that motivate responses to benefits (Kinder & Kiewiet, 1981).
[14] We opted for setup as negative economic effects and positive health effects are not consistent with the reality of coal use.

Table 4 here

<u>Design</u>

Presented in Table 5, three emphasis frames are employed for this experiment, all invoking fabricated news articles from *Yonhap News*. The first conveys a coal costs frame which states that "coal is a major cause of air pollution [… which] could mean many more instances of respiratory, eye, and skin problems when [going] outside." As was the case for Experiment 1, to establish credibility for this statement, language was included regarding the source of the information reported in the *Yonhap News* article. The second frame conveys a coal benefits frame, which states that "coal is the most inexpensive source of energy and will soon be the most inexpensive transportation fuel […, leading to] lower energy and fuel costs for everyone." The third and final frame combines both of these frames to create a competitive frame between frames that highlight the costs of coal (in terms of health) and those that highlight the benefits of coal (in terms of economics).

Table 5 here

The following are the three dependent variables being considered in Experiment 2: the respondent's views about reducing or increasing Korea's energy use of coal, the respondent's perceived impact of increased coal use on the price of energy in Korea, and the respondent's perceived impact of increased coal use on health problems in Korea. The second dependent variable has, thus, an economic dimension while the third dependent variable has a health dimension. As before, we randomly ordered the second and third dependent variables after

presenting the first dependent variable.[15] It should be noted that, to eliminate the positive or negative rhetoric surrounding coal use, a problem which can arise when either negative or positive imagery and rhetoric is used in the media and among members of the public about a given energy source (Clarke et al., 2015), we eschew the use of any potentially biased terms such as "clean coal," "dirty coal," or different coal types (e.g., metallurgical coal).

The same control variables included in Experiment 1 are included in Experiment 2.

Data & results

As before, treatment effects are reported here as linear regression coefficients,[16] and we base the statistical significance of these coefficients on bootstrapped ($n = 1{,}000$) standard errors. Table 6 provides the content for our tests relevant to Experiment 2. Note that, based on a 7-point scale for our dependent variables, the control group that received no framing treatment placed moderately low priority on whether Korea's coal use should increase (2.862) but had relatively high beliefs that coal leads to higher energy prices (5.138) and, especially, more health problems (5.847).

Our test of Hypothesis E2.1 (i.e. that frames in competition negate each other's effects) is conducted first with regard to the competitive frame's effect on people's beliefs that Korea's coal use should rise (Table 6, column 1). In this case, with a significant change of 0.388 from the baseline, we reject Hypothesis E2.1. A two-sample *t*-test for statistically significant different means confirms that there are no differences between the isolated benefits frame and the competitive frame; the costs frame is different from that of the competitive frame ($p < 0.0000$).

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[15] The exact wording for the dependent variables for Experiment 2 can be found in the appendix.
[16] Results including the control variables are presented in the main body of the paper while those excluding the control variables are available in the appendix. Also available in the appendix are the descriptive statistics for Experiment 2.

We also reject Hypothesis E2.1 with regard to the competitive frame's effect on people's beliefs that coal leads to higher energy prices (Table 6, column 2). However, two-sample t-tests indicate that the isolated benefits frame and the competitive frame are different ($p < 0.0270$); the costs and competitive frames' coefficients are different ($p < 0.0133$). Compared to the effect of a benefits frame treatment (0.609), the competitive frame's effect (0.347) weakens but does not fully negate the effect of isolated frames on beliefs that coal will lead to higher energy prices. The same is true with regard to the effect of frames on people's beliefs that coal will increase health problems (Table 6, column 3): the competitive frame is not significantly different from the baseline, but it is significantly different from the isolated costs frame ($p < 0.0131$); the benefits frame is not different from the competitive frame.

We reject Hypothesis E2.2 (i.e. that costs frames are more impactful than benefits frames) given that the effect of the coal costs frame were less than those of the coal benefits frame in terms of beliefs that coal use should increase (Table 6, column 1). It is also worth noting with regard to Hypothesis E2.2 that the effect of the competitive frame is in the same direction as that produced from the coal benefits frame (Table 6, column 1). From this, we can infer that the competitive frame's effect on Korean's beliefs regarding coal use is driven by the benefits frame.

We accept Hypothesis E2.3 (i.e. that one-sided frames will shift opinions in the direction of the frame). Relative to the baseline, individuals who receive a frame highlighting benefits will believe that the price of energy in Korea will decrease. Similarly, relative to the baseline, individuals who receive a frame highlighting costs will believe that health problems will increase.

Conclusion

This is the first-ever attempt to understand how and why Koreans approach air pollution given a seasonal media blitz on the subject (Shapiro, 2016). We have attempted to understand precisely how different news frames impact people's perceptions of the air pollution problem. The timing of our experiments was dangerous, but we controlled for variance across the several springtime days in 2017 during which the surveys were conducted, eliminating bias between respondents exposed to the survey on high-pollution days and others exposed on low/medium-pollution days. Targeting April 2017, we were thus able to study the effects on public opinion when it was most volatile rather than when the media's new cycle – and the Korean public's attention to air pollution – experienced a lull.

Frames in competition are ubiquitous, but they are not always ideal, and we find here that their intended effects are driven by imbalances between them. From a policy making perspective, this might confound efforts to set the agenda; these competing and zero-sum outcomes "stand in contrast to frames that emphasize the 'win-win' nature of particular policies, which suggest that no one (or thing) must be forfeited in order to acquire something else" (Pralle & Boscarino, 2011: p. 326). Our research shows, however, that people will easily embrace a blame-China narrative.

Given that the main effects from exposure to a pollution haven frame were largely insignificant, and given that Koreans are much more likely exposed to a debate between the effects of Korean coal consumption vis-à-vis transboundary pollution from China, we would argue for future research to compare Korean coal frames with China-oriented frames. This is unfortunate as the Korean public would be better served by understanding the importance of coordination and collaboration if there is to be a long-term solution to Korea's air pollution problem. Korea cannot decrease its FDI in China given the value of the two countries' trade

relations, but FDI is an ideal vehicle for the transfer of pollution reducing technologies so long as there is adequate regulation and enforcement from both the Chinese and Korean governments (X. Jiang, Zhu, & Wang, 2015; Y. Jiang, 2015).

No post hoc tests were conducted for the present study, but it is worth noting the statistical significance of pollution knowledge across all four dependent variables in Experiment 1. Similarly, for Experiment 2, pollution knowledge was statistically significant in terms of its impact on people's views about increasing coal use and whether more coal results in more pollution. For the latter, in fact, pollution knowledge was the only statistically significant variable in terms of predicting people's views about the coal-pollution connection (Table 5, column 2). There are parallels with existing research on science knowledge, for example, that science knowledge matters across members of the public (Cacciatore, Binder, Scheufele, & Shaw, 2012) or that support for scientific issues is a positive function of knowledge levels (Cacciatore, Scheufele, & Corley, 2011). Both scientific knowledge and attention to news have been shown to impact people's perceptions of scientific issues such as embryonic stem cell research and cloning research (Nisbet & Goidel, 2007). Future research can engage this line of inquiry in order to determine whether pollution knowledge can offset attribution and/or cost-benefit frames.

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Figures and tables

Table 1. Hypotheses for Experiment 1

Hypothesis E1.1	Frames in competition negate each other's effects.
Hypothesis E1.2	Koreans experience attribution error when considering transboundary air pollution.

Table 2. Experiment 1 stimuli

Blame-China frame	Pollution haven frame	Competitive frame[17]
The following news article was recently published: **"China Cause of Air Pollution in Korea"** *-- Yonhap News Agency --* A recent report finds that the majority of Korea's air pollution comes from factories located in China. In other words, China is to blame for Korea's air pollution. The report also states that air pollution is getting worse and that action must be taken immediately to address this problem. The report was authored by experts from the National Institute of Environmental Research, the Korea Meteorological Administration, and Seoul National University.	The following news article was recently published: **"Korean-owned Factories Cause of Air Pollution"** *-- Yonhap News Agency --* A recent report finds that the majority of Korea's air pollution comes from factories owned by Koreans located in China. In other words, Korea is to blame for air pollution blowing from China. The report also states that air pollution is getting worse and that action must be taken immediately to address this problem. The report was authored by experts from the National Institute of Environmental Research, the Korea Meteorological Administration, and Seoul National University.	The following news article was recently published: **"Korea and China Cause of Air Pollution"** *-- Yonhap News Agency --* A recent report finds that the majority of Korea's air pollution comes from China, but it is not all caused by China. The pollution comes from Chinese factories as well as Korean-owned factories in China. In other words, both countries are to blame for air pollution blowing from China. The report also states that air pollution is getting worse and that action must be taken immediately to address this problem. The report was authored by experts from the National Institute of Environmental Research, the Korea Meteorological Administration, and Seoul National University.

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[17] To eliminate systematic bias from the sample, respondents were randomly assigned to one of two competitive frame treatments. Half were assigned to a treatment that presented information about China before information about Korea while the other half were assigned to a treatment that reversed the order of information (i.e. Korea and then China). Any remaining difference in means across the four groups is unbiased, confirmed through ANOVA tests to determine that there are no statistically different means in the sample characteristics across experimental groups.

Table 3. Regression results for Experiment 1

	(1) Reducing pollution is necessary	(2) Satisfied with Korea's efforts	(3) Satisfied with China's efforts
Control (baseline)	***6.467***	***1.694***	***1.552***
	(0.327)	***(0.420)***	***(0.338)***
Blame China	0.409**	-0.493**	-0.326**
	(0.104)	(0.166)	(0.118)
Pollution haven	0.0805	-0.331*	-0.0693
	(0.115)	(0.163)	(0.128)
Competitive	0.250*	-0.338*	0.0132
	(0.112)	(0.156)	(0.141)
Observations	500	500	500
R-squared	0.118	0.099	0.088
Chi2	72.16	60.45	62.49

Note: Standard errors in parentheses; + p<0.10, * p<0.05, ** p<0.01; date/time coefficient not presented; control variables included.

Table 4. Hypotheses for Experiment 2

Hypothesis E2.1	Frames in competition negate each other's effects.
Hypothesis E2.2	Costs frames are more impactful than benefits frames.
Hypothesis E2.3	By frame dimension, one-sided frames will shift opinions in the direction of the frame relative to the baseline.

Table 5. Experiment 2 stimuli

Coal costs frame	Coal benefits frame	Competitive frame[18]
The following news article was recently published: **"Costs of Using Coal Are High"** *-- Yonhap News Agency --* A recent report finds that coal is a major cause of air pollution and contributes to the global warming effect. For Koreans, this could mean many more instances of respiratory, eye, and skin problems when they go outside. The report was authored by experts from the Korea Institute of Energy Research, the Korea Energy Economics Institute, and Seoul National University.	The following news article was recently published: **"Benefits of Using Coal Are High"** *-- Yonhap News Agency --* A recent report finds that coal is the most inexpensive source of energy and will soon be the most inexpensive transportation fuel. For Koreans, this could mean lower energy and fuel costs for everyone. The report was authored by experts from the Korea Institute of Energy Research, the Korea Energy Economics Institute, and Seoul National University.	The following news article was recently published: **"Debate Over the Costs and Benefits of Using Coal"** *-- Yonhap News Agency --* A recent report finds that coal is a major cause of air pollution and contributes to the global warming effect. For Koreans, this could mean many more instances of respiratory, eye, and skin problems when they go outside. At the same time, the same report finds that coal is the most inexpensive source of energy and will soon be the most inexpensive transportation fuel. For Koreans, this could mean lower energy and fuel costs for everyone. The report was authored by experts from the Korea Institute of Energy Research, the Korea Energy Economics Institute, and Seoul National University.

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[18] As before, to eliminate systematic bias from the sample, respondents were randomly assigned to one of two competitive frame treatments. Half were assigned to a treatment that presented information about the costs before information about the benefits while the other half were assigned to a treatment that reversed the order of information (i.e. benefits and then costs). Any remaining difference in means across the four groups is unbiased, confirmed through ANOVA tests to determine that there are no statistically different means in the sample characteristics across experimental groups.

Table 6. Regression results for Experiment 2

	(1) Korea's coal use should increase	(2) More coal means higher energy prices	(3) More coal means more health probs.
Control (baseline)	*2.862*	*5.138*	*5.847*
	(0.462)	*(0.459)*	*(0.464)*
Costs of coal	-0.487**	0.0652	0.357*
	(0.140)	(0.173)	(0.159)
Benefits of coal	0.564**	-0.609**	0.243
	(0.179)	(0.162)	(0.176)
Competitive	0.388*	-0.347*	0.0269
	(0.166)	(0.159)	(0.172)
Observations	500	500	500
R-squared	0.140	0.100	0.049
Chi2	93.66	62.19	25.80

Note: Standard errors in parentheses; + p<0.10, * p<0.05, ** p<0.01; date/time coefficient not presented; control variables included.

Appendix: Descriptive statistics for experiments

Experiment 1 Variable	Obs	Mean	Std. Dev.	Min	Max
Age	500	43.084	12.9015	20	69
Male dummy	500	.494	.500465	0	1
Household respir. problems	500	.568	.794127	0	3
Hours spent outside daily	500	3.698	3.13919	1	18
Political knowledge	500	.442	.497122	0	1
Oil production knowledge	500	.254	.435734	0	1
Pollution knowledge	500	.174	.379489	0	1
Car owner dummy	500	.616	.486845	0	1
Education level	500	1.932	.525288	1	3
Household income	500	3.562	2.0801	1	8

Experiment 2 Variable	Obs	Mean	Std. Dev.	Min	Max
Age	500	43.452	13.0261	20	69
Male dummy	500	.494	.500465	0	1
Household respir. problems	500	.526	.789031	0	3
Hours spent outside daily	500	3.748	3.18572	1	16
Political knowledge	500	.52	.5001	0	1
Oil production knowledge	500	.232	.422532	0	1
Pollution knowledge	500	.198	.398891	0	1
Car owner dummy	500	.578	.494373	0	1
Education level	500	1.934	.534992	1	3
Household income	500	3.724	2.15153	1	8

Appendix. Regression results for Experiment 1, no controls

```
-----------------------------------------------------------------
                           (1)           (2)           (3)
                        Reducing      Satisfied     Satisfied
                        pollution    with Korea's  with China's
                       is necessary    efforts       efforts
-----------------------------------------------------------------
Control (baseline)        6.256         2.808         1.872
                         (0.0831)      (0.113)       (0.0916)

Blame China               0.392**      -0.496**      -0.328**
                         (0.104)       (0.156)       (0.123)

Pollution haven           0.0560       -0.256        -0.0320
                         (0.118)       (0.159)       (0.132)

Competitive               0.192+       -0.264+        0.0960
                         (0.111)       (0.154)       (0.140)
-----------------------------------------------------------------
Observations               500           500           500
R-squared                 0.032         0.019         0.023
Chi2                      18.39         10.07         13.13
-----------------------------------------------------------------
```
Note: Standard errors in parentheses; + p<0.10, * p<0.05, ** p<0.01.

Appendix. Regression results for Experiment 2, no controls

```
-----------------------------------------------------------------
                           (1)           (2)           (3)
                      Korea's coal    More coal      More coal
                      use should    means higher   means more
                       increase     energy prices  health probs.
-----------------------------------------------------------------
Control (baseline)        2.680         4.112         5.272
                         (0.107)       (0.112)       (0.110)

Costs of coal            -0.480**       0.0480        0.336*
                         (0.138)       (0.169)       (0.148)

Benefits of coal          0.592**      -0.664**       0.176
                         (0.177)       (0.160)       (0.165)

Competitive               0.384*       -0.344*       -0.0160
                         (0.168)       (0.162)       (0.157)
-----------------------------------------------------------------
Observations               500           500           500
R-squared                 0.090         0.045         0.013
Chi2                      55.99         24.76         6.994
-----------------------------------------------------------------
```
Note: Standard errors in parentheses; + p<0.10, * p<0.05, ** p<0.01.

Appendix: Survey content

Experiment 1	Experiment 2
[Respondents are randomly assigned to one of the following five groups]	[Respondents are randomly assigned to one of the following five groups]
[Control group E2, n=125]	[Control group E2, n=125]
[Blame China, n=125]	[Coal costs-1, n=125]

Experiment 1 — [Blame China, n=125]

The following news article was recently published:
"China Cause of Air Pollution in Korea"
-- Yonhap News Agency --
A recent report finds that the majority of Korea's air pollution comes from factories located in China. In other words, China is to blame for Korea's air pollution. The report also states that air pollution is getting worse and that action must be taken immediately to address this problem. The report was authored by experts from the National Institute of Environmental Research, the Korea Meteorological Administration, and Seoul National University.

다음 기사는 최근에 발표된 것이다:
"중국이 한국 대기오염의 원인"
-- 연합뉴스--
국립환경과학원, 기상청과 서울대학교 소속 전문가들에 의해 최근 작성된 한 보고서에 따르면 한국의 대기오염의 대부분은 중국 내 공장에서 발생하고 있는 것으로 나타난다. 다시 말해, 한국 대기오염의 원인은 중국이라는 것이다. 또한, 이 보고서에 따르면 대기오염은 계속 악화되고 있으며, 이를 해결하기 위한 대책이 속히 마련되어야 한다.

Experiment 2 — [Coal costs-1, n=125]

The following news article was recently published:
"Costs of Using Coal Are High"
-- Yonhap News Agency --
A recent report finds that coal is a major cause of air pollution and contributes to the global warming effect. For Koreans, this could mean many more instances of respiratory, eye, and skin problems when they go outside. The report was authored by experts from the Korea Institute of Energy Research, the Korea Energy Economics Institute, and Seoul National University.

다음 기사는 최근에 발표된것이다:
"석탄 사용의 높은 대가"
-- 연합뉴스--
한국에너지기술연구원, 에너지경제연구원과 서울대학교 소속 전문가들에 의해 최근 작성된 한 보고서에 따르면 석탄이 대기오염의 주원인이자 지구온난화에 기여한다. 즉, 한국인들은 외출 시 더 높은 확률로 호흡기질환, 안면질환, 피부 질환 등을 경험할 수 있다는 것이다.

[Pollution haven, n=125]

The following news article was recently published:
"Korean-owned Factories Cause of Air Pollution"
-- Yonhap News Agency --
A recent report finds that the majority of Korea's air pollution comes from factories owned by Koreans located in China. In other words, Korea is to blame for air pollution blowing from China. The report also states that air pollution is getting worse and that action must be taken immediately to address this problem. The report was authored by experts from the National Institute of Environmental Research, the Korea Meteorological Administration, and Seoul National University.

다음 기사는 최근에 발표된 것이다:

"중국주재 한국공장이 대기오염의 원인"

-- 연합뉴스--

국립환경과학원, 기상청과 서울대학교 소속 전문가들에 의해 최근 작성된 한 보고서에 따르면 한국 대기오염의 대부분은 중국 내의 한국기업소유공장에서 발생하고 있는 것으로 나타난다. 중국발 대기오염물질은 사실 한국기업들에 의해 발생한다는 것이다. 다시 말해, 중국발 대기 오염의 원인은 한국이다. 또한, 이 보고서에 따르면 대기오염은 계속 악화되고 있으며, 이를 해결하기 위한 대책이 속히 마련되어야 한다.

[Coal benefits, n=125]

The following news article was recently published:
"Benefits of Using Coal Are High"
-- Yonhap News Agency --
A recent report finds that coal is the most inexpensive source of energy and will soon be the most inexpensive transportation fuel. For Koreans, this could mean lower energy and fuel costs for everyone. The report was authored by experts from the Korea Institute of Energy Research, the Korea Energy Economics Institute, and Seoul National University.

다음 기사는 최근에 발표된것이다:

"고혜택의 석탄 사용"

-- 연합뉴스--

한국에너지기술연구원, 에너지경제연구원과 서울대학교 소속 전문가들에 의해 최근 작성된 한 보고서에 따르면 석탄은 가장 값싼 연료이고, 가까운 미래에 가장 값싼 교통수단 연료가 될 것으로 예측된다. 한국인의 연료비가 감소할 것이라는 것이다.

[Blame China + pollution haven (version 1), n=63]

The following news article was recently published:
"Korea and China Cause of Air Pollution"
-- Yonhap News Agency --
A recent report finds that the majority of Korea's air pollution comes from China, but it is not all caused by China. The pollution comes from Chinese factories as well as Korean-owned factories in China. In other words, both countries are to blame for air pollution blowing from China. The report also states that air pollution is getting worse and that action must be taken immediately to address this problem. The report was authored by experts from the National Institute of Environmental Research, the Korea Meteorological Administration, and Seoul National University.

다음 기사는 최근에 발표된것이다:

"한국과 중국이 대기오염의 원인"

-- 연합뉴스--

국립환경과학원, 기상청과 서울대학교 소속 전문가들에 의해 최근 작성된 한 보고서에 따르면 한국 대기오염의 대부분은 중국에서 발생하고 있지만, 중국이 유일한 원인은 아니다. 대기오염물질은 중국 내의 한국기업소유공장뿐만 아니라 중국기업소유공장에서도 발생하고 있다고 한다. 다시 말해, 중국발 대기오염물질에 대한 책임은 양국이 공유한다는 것이다. 또한, 이 보고서에 따르면 대기오염은 계속 악화되고 있으며, 이를 해결하기 위한 대책이 속히 마련되어야 한다.

[Coal costs and benefits debate (version 1), n=63]

The following news article was recently published:
"Debate Over the Costs and Benefits of Using Coal"
-- Yonhap News Agency --
A recent report finds that coal is a major cause of air pollution and contributes to the global warming effect. For Koreans, this could mean many more instances of respiratory, eye, and skin problems when they go outside. At the same time, the same report finds that coal is the most inexpensive source of energy and will soon be the most inexpensive transportation fuel. For Koreans, this could mean lower energy and fuel costs for everyone. The report was authored by experts from the Korea Institute of Energy Research, the Korea Energy Economics Institute, and Seoul National University.

다음 기사는 최근에 발표된것이다:

"석탄사용의 대가와 혜택에 대한 논쟁"

-- 연합뉴스--

한국에너지기술연구원, 에너지경제연구원과 서울대학교 소속 전문가들에 의해 최근 작성된 한 보고서에 따르면 석탄이 대기오염의 주원인이자 지구온난화의 원인 중 하나이다. 즉, 한국인들은 외출 시 더 높은 확률로 호흡기질환, 안면질환, 피부질환 등을 경험할 수 있다는 것이다. 반면에 같은 보고서에 의하면 석탄은 가장 값싼 연료이고, 가까운 미래에 가장 값싼 교통수단 연료가 될 것으로 예측된다. 한국인의 연료비가 감소할 것이라는 것이다.

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"석탄사용의 혜택과 대가에 대한 논쟁"

-- 연합뉴스--

한국에너지기술연구원, 에너지경제연구원과 서울대학교 소속 전문가들에 의해 최근 작성된 한 보고서에 따르면 석탄은 가장 값싼 연료이고, 가까운 미래에 가장 값싼 교통수단 연료가 될 것으로 예측된다. 즉, 한국인의 연료비가 감소할 것이라는 것이다. 반면에 같은 보고서에 의하면, 석탄이 대기오염의 주원인이자 지구온난화의 원인 중 하나이다. 한국인들은 외출 시 더 높은 확률로 호흡기질환, 안면질환, 피부 질환 등을 경험할 수 있다는 것이다.

[Post-treatment questions for Experiment 1 only]	[Post-treatment questions for Experiment 2 only]
To what extent is it important to take action to reduce Korea's air pollution? 한국이 대기오염 감축을 위해 대책을 세우는 일이 얼마나 중요하다고 생각하십니까? Extremely unimportant 전혀 중요하지 않다. Very unimportant 중요하지 않다. Somewhat unimportant 다소 중요하지 않다. Neutral 보통이다 Somewhat important 다소 중요하다. Very important 중요하다. Extremely important 매우 중요하다.	**What do you think about Korea's energy use of coal? 한국의 에너지원으로서의 석탄사용에 대해 어떻게 생각하십니까?** It should be extremely reduced. 매우 감소시켜야 한다. It should be reduced. 감소시켜야 한다. It should be slightly reduced. 조금 감소시켜야 한다. No change 그대로 유지한다 It should be slightly increased. 조금 증가시켜야 한다. It should be increased. 증가시켜야 한다. It should be extremely increased. 매우 증가시켜야 한다.
[The two following questions are randomly ordered.]	[The two following questions are randomly ordered.]
To what extent are you satisfied with Korea's efforts to reduce its air pollution? 대기오염 감축을 위한 한국의 노력에 어느정도 만족하십니까? Extremely unsatisfied 매우 불만족 Very unsatisfied 불만족 Somewhat unsatisfied 다소 불만족 Neutral 중간 Somewhat satisfied 다소 만족 Very satisfied 만족 Extremely satisfied 매우 만족	**To what extent would greater use of coal increase or decrease the price of energy in Korea? 석탄사용의 증가는 한국의 연료비에 어떤 영향을 미친다고 생각하십니까?** Extreme decrease in price of energy 매우 감소시킨다. Large decrease in price of energy 감소시킨다. Slight decrease in price of energy 조금 감소시킨다. No change 영향을 미치지 않는다. Slight increase in price of energy 조금 증가시킨다. Large increase in price of energy 증가시킨다. Extreme increase in price of energy 매우 증가시킨다.
To what extent are you satisfied with China's efforts to reduce its air pollution? 대기오염 감축을 위한 중국의 노력에 어느정도 만족하십니까? Extremely unsatisfied 매우 불만족 Very unsatisfied 불만족 Somewhat unsatisfied 다소 불만족 Neutral 중간 Somewhat satisfied 다소 만족 Very satisfied 만족 Extremely satisfied 매우 만족	**To what extent would greater use of coal increase or decrease health problems in Korea? 석탄사용의 증가는 한국의 건강 문제에 어떤 영향을 미친다고 생각하십니까?** Extreme decrease of health problems 매우 감소시킨다. Large decrease of health problems 감소시킨다. Slight decrease of health problems 조금 감소시킨다. No change 영향을 미치지 않는다. Slight increase of health problems 조금 증가시킨다. Large increase of health problems 증가시킨다. Extreme increase of health problems 매우 증가시킨다.

How old are you? 귀하의 연령은 어떻게 되십니까?

[Drop-down option from 20 to 65, 65+]

What is your gender? 귀하의 성별은 어떻게 되십니까?

Male 남

Female 여

Which political party are you affiliated with? 귀하께서는 다음 중 어느 정당을 지지하십니까?

Democratic/Minjoo Party of Korea 더불어민주당

Liberty Korea Party 자유한국당

People's Party 국민의당

Bareun Party 바른정당

Justice Party 정의당

Another party 가타 정당

What is your primary source of news? Choose one. 귀하께서는 다음 중 어떤 방법으로 정보를 수집하십니까? 하나만 선택해주십시오.

Print news 신문

Internet news 인터넷 뉴스

Social media 소셜미디어

TV/radio 텔레비전/라디오

A source not listed here 기타

I don't follow the news 정보에 관심없음

How many people in your household suffer from respiratory problems? 귀하의 가정에서 몇 분이 호흡기 관련된 문제를 가지고 있습니까?

None 없음

1 person 1 명

2 people 2 명

3 or more people 3 명 이상

How frequently do you miss work/school in order to limit your exposure to air pollution? 귀하는 얼마나 자주 대기오염 노출을 자제하기 위해 학교나 직장에 가지 않습니까?

Very infrequently 매우 드물게

Somewhat infrequently 다소 드물게

Neither infrequently nor frequently 해당 없음

Somewhat frequently 다소 빈번히

Very frequently 매우 빈번히

How hours per day do you spend outdoors? 귀하는 하루 평균 몇 시간을 야외에서 보내십니까?

1 – 24. 1 시간 – 24 시간

[Political knowledge] Which were the two dominant parties in the Korean National Assembly in 2016? (select two)

2016 년 대한민국 국회의 주요 정당은 무엇입니까? (두 개의 주요정당을 선택해 주십시오.)

Saenuri 새누리당

Democratic/Minjoo 더불어민주당

People's Party 국민의당

Another party 기타

[Oil-production knowledge] Which of the following is not among the ten most oil-producing countries in the world? 다음 중 세계의 10 대 석유생산국이 아닌 국가는 어느 것입니까?

Venezuela 베네수엘라

Saudi Arabia 사우디아라비아

Kuwait 쿠웨이트

Brazil 브라질

Iran 이란

[Air pollution knowledge] Which of the following contribute to air pollution? (check all that apply) 다음 중 대기오염에 영향을 미치는 오염물질은 어느 것입니까? (해당되는 사항에 모두 체크해주십시오.)

Carbon dioxide (CO2) 이산화탄소(CO_2)

Carbon monoxide (CO) 일산화탄소(CO)

Nitrogen oxides (NOx) 질소산화물(NO_X)

$PM_{2.5}$ 초미세먼지

Sulfur oxides (SOx) 황산화물(SO_X)

Do you own a car? 귀하께서는 차량을 소유하고 계십니까?

Yes 예

No 아니요

귀하의 종교는 어떻게 되십니까?
What is your religion/belief?

Christian 개신교

Catholic 천주교

Buddhist 불교

Other 기타

No religion 없음

What was the last grade/level of school you completed? 귀하의 최종학력은 어떻게 되십니까?

High School or less 고등학교 이하

College/University 대학교

Graduate School and above 대학원 이상

What is your employment status? 현재 귀하의 고용상태는 어떠합니까?

Employed full time 정규직(계약기간이 정해져있지 않음)

Employed full time, contract for more than 1 year 상용계약직(1 년 이상 계약)

Employed full time, contract between 1 month and 1 year 임시 계약직(1 개월~1 년 미만) 임시
계약직(1 개월~1 년 미만)

Employed full time, contract less than 1 month 일용직(1 개월 미만 계약)

Self employed 자영업

Unemployed 무직

Retired 은퇴함

What is your annual household income? 귀하의 연간총수입은 어떻게 되십니까?

less than 30,000,000 won 3000 만원 이하

30,000,000 – 39,999,999 won 3000~4000 만원

40,000,000 – 49,999,999 won 4000~5000 만원

50,000,000 – 59,999,999 won 5000~6000 만원

60,000,000 – 69,999,999 won 6000~7000 만원

70,000,000 – 79,999,999 won 7000~8000 만원

80,000,000 – 99,999,999 won 8000~9000 만원

100,000,000 won and above 1 억원 이상