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Comparing the economic effects of climate change and zooanthroponosis in Korea: Prerequisites for the creative economy?☆

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A B S T R A C T
Societies in the 21st century require more proactive management of risks in many areas owing to the complexities people have built into socioeconomic systems, ranging from science and technology, economics, and finance to education, entertainment, and tourism infrastructure. All these systems thrive on stability, which can easily be challenged by unexpected risks. This study compares zooanthroponosis and climate change-induced sea level rise through a cost–benefit analysis in Korea. Borrowing from other methodological approaches, this study shows that the cost–benefit estimation is consistent with the existing macroeconomic speculations, which assume potential loss of GDP due to the two risks. This paper also presents a policy alternative of creating research institutions specializing in the two risks from a cost–benefit perspective as a prerequisite for the “Creative Economy”.

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1. Introduction

Societies in the 21st century require more proactive management of risks in many areas due to the complexities people have built into socioeconomic systems, ranging from science and technology, economic, and finance to education, entertainment, and tourism infrastructure. These systems thrive on stability, which can easily be challenged by unexpected risks (Commission, 2008; Fraser et al., 2004). Thus, preparing for unexpected risks is a significant component of sustainable growth management. We have focused more on traditional factors of production even when we consider creative economy. Theoretical and practical debate, such as the introduction of more robotics can be an agenda from the supply side. Yet, in thinking of creative economy, just considering supply and demand will not be sufficient. Our global economy as a whole can be endangered with an unexpected outbreak of a symptom, whether it could come from naturally or unnaturally. Actualizing the creative economy depends on risk management at social and global levels, and especially depends on the most serious upcoming risks this research selected, which we tend to under invest due to our socio-economic decision making system. This paper, with the backdrop, compares economic risks that may arise from climate change-based sea level increases (Stern, 2007b) and zooanthroponosis by conducting a cost–benefit analysis using data on the Korean economy (Parker, 2013b). By comparing the two risks, this study suggests the relative magnitude of preparation that societies may choose to undertake. Second, this study shows how a policy measure could be cost effective by proposing the hypothetical alternative of creating research institutions for both the climate change and zooanthroponosis cases. Specifically, a cost–benefit analysis was presented to examine whether these institutions can be effective against the risks related to climate change and disease.

2. Literature review

2.1. Economic impact of zooanthroponosis

Zooanthroponosis refers to diseases common to animals and humans (Newcomb, 2004a). Such diseases have become a global...
concern since the late 20th century owing to the increase in air and surface traffic (Newcomb, 2004a; Institute of Medicine of the National Academies, 2009). In addition to the independent economic analysis conducted and presented in this study, the literature on zoonanthroposis is presented and utilized to check the robustness of the study’s calculations.

2.1.1. West Nile Virus case in the US

In a study, the West Nile Virus, which is carried through mosquitoes and was once foreign to the US environment, was found to be epidemic enough to be traced. In the past 15 years in the US, about 17,367 medical cases have been reported, of which 1654 lives were lost (Barrett, 2014). Delving further into the cases, in 2003, in 17 hospitals in four counties in the state of Colorado, 80 of 221 hospitalized patients were investigated. Among them, 38 patients participated in a longitudinal study for 5 years. From this patient group, a median medical cost of US$22,628 was found. The same research has estimated that during 1999–2012, the West Nile Virus led to a cost of US$778 million, which can be converted to an annual figure of US$56 million (Bode et al., 2006).

Applying the result to the national level in the US was found to be meaningful, considering that the national average medical cost per patient because of the virus was US$28,151 in 1997. Especially, the case from Colorado took a conservative approach in calculating the average medical costs by including diagnosed patients but not non-hospitalized ones. Further, the Colorado medical costs did not include sanitation costs or diagnosis-related costs (Newcomb, 2004b).

To compare and apply this estimation to the Korean context, this study tried an independent calculation and reached the following estimation. While the difference between the actual GDP size between the US and Korea is more than 10 times, an individual level consumption or PPP level comparison roughly gives about a ratio of 1:2 between the two countries. Based on this assumption, if cases of the West Nile Virus should arise, individual level medical costs could be between US$14,000 and 15,000; and if about 0.027% of the total population of 48 million people in South Korea contracts the virus, the estimated total medical costs would be approximately KRW195 billion. The calculation is based on 1300 patients, of which 500 patients were from the Seoul and Gyung gi Province, which takes about half of the population, and the other 800 patients from 8 major cities generating 100 patients each. This figure is compared in terms of absolute size with the estimation from this study in the following section.

2.1.2. Economic impact of SARS from the US Geological Service — National Wild Life Health Center data

According to the USGS and its Wild Life Health Center, the economic impact from SARS could be between US$50 and 100 billion (Newcomb, 2004b). In other words, the size of the impact could be about 2% of the national GDP of the US. Considering this proportionally in the Korean case, an impact of US$5–10 billion can be anticipated.

For comparison purposes, as shown in Fig. 1, SARS in Asian countries was estimated to have an economic impact of US$30–50 billion during 2002–2005. It is estimated that this figure will still be valid after considering inflation factors.

2.1.3. Other economic estimations

According to the Asian Development Bank’s estimation, if the incidence of zoonanthroposis is mild, it will cause about a 2.6% decrease in GDP in Asian countries (Asia Development Bank, 2005). If the incidence of zoonanthroposis is significant, regional Asian GDP will drop by a maximum of 6.8%. While the USGS has estimated losses of approximately US$50–100 billion for SARS, other estimations have predicted about a 50 billion worldwide loss of economic value (Fineberg and Wilson, 2010; Wilson, 2010b).

Avian Flu is another zoonanthroposis case. AI was estimated to have caused a US$150–200 billion loss in the US, or a 3% loss in the GDP of the originating country (Smith, 2005; Nelson Rodrigo da Silva Martins, 2012). The same study estimated a 0.5% loss in GDP worldwide. Another study showed a 2% GDP loss in East Asia from AI (Nelson Rodrigo da Silva Martins, 2012). For AI, the World Bank has estimated a 0.6%–2% loss in GDP and loss of US$800 billion worldwide (Bank, 2005; Wilson, 2010a).

2.2. Economic impact of the sea level rise from climate change

Scholars and organizations have been keenly monitoring the rise in sea level due to climate change. Especially, the United Nation’s Fifth IPCC (Intergovernment Panel on Climate Change) report has mainly focused on the issue of sea level rise with scientific evidence gathered through different studies in many countries (Stocker et al., 2013). According to the report, between 1901 and 2010 (about 110 years), the sea level has risen by 19 cm. Moreover, since 1993, the average annual rise in sea level was estimated to be 3.2 mm. Based on the evidence and trend, toward the end of the 21st century, the sea level is expected to rise by 28–98 cm, based on different scenarios (Cayan et al., 2008; Russell et al., 2000).

Korea is not an exception from this global trend. According to research conducted in Korea, in recent years, the sea level has risen by 2.37 mm annually in Korea and by 5.14 mm annually near Jeju island, which has been higher than the global average (Kim and Cho, 2013). Even more concerning is the fact that another study has estimated that the sea level could go up to a maximum of 1.36 m.

The sea level rise has repercussions on different dimensions. Sea level rise will reduce wet land, but the impact does not end there (Perrette et al., 2013; Milly et al., 2003). According to a scenario-based forecast for Korea, in 2100, the loss of residential
areas would lead to a loss of approximately US$29.5 billion and affect about 3% of the total population. In the same scenario, 6.2% and 5.8% of total roads and railroads, respectively, could be affected and lost. Major ports will lose their functions in the sense that they will lose or rebuild their “breakwater.” As much as 84% of reclaimed land near the shore will be affected. With all the damage and losses, it was tentatively estimated that monetary costs could be up to US$286 billion (Kim and Cho, 2013).

With the future increase in risks, in addition to international joint research and operations on the climate change-induced sea level rise, several countries have established special research institutions to cope with the problem in research areas. In the US, the University of Hawaii has opened the University Hawaii Sea Level Center (UHSLC), and in the UK, the Perman Service for Mean Sea Level (PSMSL) is the equivalent organization for the same purpose. Australia has established the National Tidal Center (NTC), and Japan, the Coastal Movement Data Center (CMDC), both of which are designed to cope with the risks associated with sea level rise. With these organizations taking their duty and with organizations and research groups working on the issue, several publications of these institutions warn of the danger of sea level rise, such as “Coastal Sensitivity to Sea level Rise: Focus on the Mid-Atlantic Region” by the Climate Change Science Program (2009) and National Climate Assessment (2013) and the UK’s “Adapting to Climate Change” (2013).

In Australia, research initiatives such as “Climate Change Risks to Australia’s Coast: National Assessment” (2009) can also be considered a valid effort in this field (Parker, 2013a; National Research Council, 2012; Katsman et al., 2011).

3. Methodology

3.1. Data

This study adopted the Bank of Korea’s statistical database for economic output by sector to estimate the economic impact of climate change and zooanthroponosis.

3.2. Methodology

To fulfill the study objectives, a cost–benefit analysis was conducted on both climate change induced sea level rise and zooanthroponosis, which was proxied in this study as the SARS case, with an expected impact of a 0.15% loss in GDP (Adams et al., 1995).

After the two cost–benefit analyses were conducted, this research performed a hypothetical cost–benefit analysis of establishing research institutions for both cases to show the impact of both sea level rise and the disease on GDP so that rational and cost-efficient measures can be taken to prepare for the risks.

4. Research findings from the economic impact of epidemic diseases

The findings in this research focused on whether the forecasts and trends introduced in the previous section could be found in the Korean data set. Of course, the validity of the forecasts previously given may be challenged by different standards. However, taking it as a reference point, this section tries to present similarities and differences between the earlier forecasts as well as the empirical data based on the Korean case.

4.1. Cost–benefit analysis of zooanthroponosis: A case of SARS impacting 0.15% of GDP

4.1.1. Estimating the loss of GDP from zooanthroponosis

Relying on literature from a Canadian case which estimated a 0.15% loss on GDP from SARS, 2 this research tried to calculate, in a bottom up industry level, a cost benefit analysis in the case of Korea to show the feasibility of a 0.15% of GDP. Table 1 below contains time series data of individual industrial sectors and their output in Korea Won by quarter, from the fourth quarter in 2012 to the third quarter in 2013, based on recent data at the time of the analysis. In a typical cost–benefit analysis used for industries, the expected rate of profit can be calculated as follows.

\[ \text{Expected rate of profit} = \frac{\text{impact from 0000}}{\text{information usage increase rate} \times \text{decision rate}} \]

Table 1
Impact of SARS in Korea: Applying the Canadian case as the lower bound estimate of 0.15% of GDP.

| Sector                        | 2012 4th Q | 2013 1st Q | 2013 2nd Q | 2013 3rd Q | Recent 4 Qtrs | Expected impact on GDP | Info usage increase rate | Decision rate | Impact of disease | GDP loss       |
|-------------------------------|------------|------------|------------|------------|--------------|------------------------|-------------------------|---------------|------------------|---------------|
| Agriculture fishery           | 8194.1     | 6819.4     | 7065.2     | 7461.6     | 29,540.3     | 10%                    | 15%                     | 0.15%         | 44.31           |
| Manufacturing                 | 88,315.1   | 91,944.4   | 92,333.5   | 92,078.4   | 364,671.5    | 10%                    | 5%                      | 2%            | 36.47           |
| Electricity, gas, water       | 6517.5     | 7576.1     | 6423.7     | 6404.5     | 26,921.8     | 10%                    | 5%                      | 2%            | 2.682           |
| Construction                  | 16,741.5   | 17,358.8   | 17,687.7   | 18,582.5   | 70,370.5     | 10%                    | 5%                      | 2%            | 7.03            |
| Wholesale retail, restaurant hotel | 31,445.3   | 30,900.1   | 31,291.3   | 31,779.6   | 125,436.3    | 10%                    | 5%                      | 10%           | 62.71           |
| Transportation & storage     | 10,527.2   | 11,125.3   | 11,280.4   | 11,307.0   | 44,239.9     | 10%                    | 5%                      | 0.025%        | 11.05           |
| Finance insurance            | 19,466.3   | 18,487.2   | 18,501.9   | 18,349.6   | 74,805       | 10%                    | 5%                      | 2%            | 7.48            |
| Real estate & rental          | 20,441.8   | 20,396.9   | 21,040.3   | 21,226.5   | 83,105.5     | 10%                    | 5%                      | 2%            | 8.31            |
| Public sector & defense       | 18,352.7   | 19,362.3   | 19,297.2   | 19,767.7   | 76,779.9     | 10%                    | 5%                      | 2%            | 7.68            |
| Health & social welfare      | 13,445.9   | 13,924.6   | 14,337.8   | 14,742.1   | 56,450.4     | 10%                    | 5%                      | 2%            | 5.65            |
| Entertainment                | 3969.9     | 3940.3     | 4045.1     | 4112.4     | 16,067.7     | 10%                    | 5%                      | 2%            | 1.60            |
| Total value added             | 287,909.7  | 292,589.3  | 295,170.9  | 298,470.8  | 1,174,140.7  | 10%                    | 5%                      | 2%            | 194,982         |
| GDP (market price)            | 319,808.5  | 325,159.1  | 328,162.0  | 331,500.5  | 1,304,630.1  | 10%                    | 5%                      | 2%            | 194,982         |

Note: SARS refers to severe acute respiratory syndrome.
This formula can be adapted to the context of this study as follows.

$$\text{Impact from a disease} = \frac{\text{expected impact from disease}}{\text{information usage increase rate} \times \text{decision rate}}$$

By using the formula for the agricultural and fishery sector in Korea, the impact of SARS expressed as a loss in GDP is calculated as KRW29,540.3 billion × 0.15%, which is KRW344.31 billion. To get the 0.15%, one should multiply impact of a disease = expected impact from the disease (0.1) × information usage increase rate (0.1) × decision rate (0.15) = 0.0015, or 0.15%. By performing this calculation for each sector, the loss in GDP for each sector can be attained, which adds up to the total loss in GDP from SARS, which was KRW194.982 billion (approx. US$194 million).

In the formula, the expected impact of the disease implies a hypothetical expectation of the disease. In the meteorological field, it has been established that severe damage from extreme weather conditions may lead to a loss in GDP by 10% or in the output of the sector by a maximum of 10% (WMO, 2007; Stern, 2007a). Based on this logic, this analysis assigned a 10% a priori impact expectation for each sector. While this seems to be very significant, other factors to be multiplied in the formula will dramatically reduce the absolute size of the impact from SARS. The information usage rate, another element in the formula, denotes the possibility of given scientific knowledge of the impact of the disease (in this case 10%) on a specific sector, and seeks to determine the possibility that the sector will utilize the information. In this analysis, the agricultural and fishery sectors were given 10% for both expected impact on GDP and information usage increase rate as an exception. Together, the calculation of the impact is designed to be conservative. The last element of the decision rate denotes the possibility that each sector will actually use the information in decision-making, when knowing the expected impact and increased usage of information. The outcome from the formula is conservative in estimating the impact from SARS for two reasons. The first reason is that this is the lower bound estimate. Second, to produce a macroeconomic level estimation, it seems safer to be conservative, especially in the cost–benefit analysis, by not exaggerating.

### 4.1.2. Comparing with a top down approach with upper bound 2% loss of GDP

To derive a comparison number, this study utilized an upper bound estimate, which was 2% of GDP loss owing to SARS (Wong and Siu, 2008). In this case, we tried a top-down approach by multiplying 2% directly. The table shows a comparison of how the 2% loss is attained; using a top-down approach we estimated KRW26,092.6 billion (approx. US$26 billion, if Korean Won: US$ is 1000:1), while applying the 2% logic to the table for the lower bound estimate we estimated approximately US$19 billion. Thus, the 2% estimate of GDP loss was estimated to be between US$19 billion and US$26 billion in Korea in 2013. Table 3 shows how the bottom-up approximation can be divided by sectors. (See Table 2.)

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3 KRW refers to Korean Won.
4.1.3. Cost–benefit analysis of policy preparation: establishing a research institution to protect against the risk

After calculating the possible loss in GDP from zoonanthroponosis, which in this case is SARS, this study attempted to undertake a cost–benefit analysis of a policy measure, that is, to establish a research institution to deal with the risk of the disease. The underlying logic is that establishing a research institution will not prevent the risk of the disease entirely, but with the calculation of the cost–benefit analysis, it was assumed that a certain portion of the risk could be reduced.

For comparison purposes, the analysis for the climate change-induced sea level rise case can also be adopted by establishing a research institution as a policy measure to have a one-to-one comparison of the risk itself and cost–benefit result from the two risks.

For the analysis, it was assumed that an organization that begins construction and development in 2014 will be operational as of 2016. Within this timeframe, the cost–benefit element was calculated up to year 2030. Going back to the earlier calculation of the loss in GDP, utilizing the Bank of Korea statistics, approximately KRW194.99 billion was estimated. This figure was important because it is consistent with an independent research example showing that the lower bound estimate from SARS damage will be around 0.15% of GDP. The figure this study found was almost 0.15% of Korea’s GDP in 2013, which validates both research cases.

It was assumed in this study that about one-third of the risk can be prevented by establishing an institution designed to perform research functions to reduce all the possible risks from the diseases. Thus, it was calculated that annually about KRW64.9 billion (US$6.49 billion) worth of benefit would be generated, while after year 2022 the estimation would be increased to reflect potential benefits from the vaccine products this institute may produce.

Table 4
Flow of costs and benefits (5.5% discount rate) (unit: billion Korean Won).

| Year | Benefit Benefit | NPV Of benefit | Cost Construction | Operation | Total cost | NPV cost | Net present value |
|------|----------------|----------------|-------------------|-----------|-----------|----------|-----------------|
| 2014 | 0.2            | 0              | 0.2               | 0.1895    | −0.1895   |          |                 |
| 2015 | 4              | 0              | 4                 | 3.594     | −3.594    |          |                 |
| 2016 | 64.9667        | 55.3516        | 22.7              | 48.42     | 41.25384  | 15.1402  |                 |
| 2017 | 64.9667        | 51.19373       | 29.43             | 29.43     | 23.19084  | 31.5565  |                 |
| 2018 | 64.9667        | 48.45762       | 30.65             | 30.65     | 22.88023  | 29.61528 |                 |
| 2019 | 64.9667        | 45.9564        | 32.78             | 32.78     | 23.29824  | 26.94024 |                 |
| 2020 | 64.9667        | 44.26363       | 34.01             | 34.01     | 22.82071  | 25.98077 |                 |
| 2021 | 64.9667        | 41.9548        | 34.25             | 34.25     | 21.783    | 25.02445 |                 |
| 2022 | 65.96667       | 39.7779        | 34.50             | 34.5      | 21.4065   | 23.33747 |                 |
| 2023 | 65.96667       | 37.69995       | 34.76             | 44.76     | 25.58034  | 15.7776  |                 |
| 2024 | 65.96667       | 35.75933       | 35.02             | 35.02     | 18.98084  | 22.34349 |                 |
| 2025 | 65.96667       | 33.87388       | 35.29             | 35.29     | 18.12142  | 21.50434 |                 |
| 2026 | 65.96667       | 32.12577       | 35.57             | 35.57     | 17.32259  | 20.70013 |                 |
| 2027 | 65.96667       | 30.44362       | 35.86             | 35.86     | 16.54939  | 19.90051 |                 |
| 2028 | 65.96667       | 28.86042       | 36.15             | 36.15     | 15.81563  | 19.1423  |                 |
| 2029 | 65.96667       | 27.37617       | 36.46             | 36.46     | 15.1309   | 18.38265 |                 |
| 2030 | 65.96667       | 25.95788       | 36.77             | 36.77     | 14.469    | 17.66398 |                 |
| Total| 1115.433       | 699.0558       |                   | 545.12    | 322.297   |          |                 |

Table 5
Flow of costs and benefits (3% discount rate) (unit: billion Korean Won).

| Year | Benefits Benefit | NPV of benefit | Costs Construction cost | Operational cost | Total cost | NPV cost | NPV |
|------|------------------|----------------|-------------------------|----------------|-----------|----------|
| 2014 | 0.2              | 0              | 0.2                     | 0.1942         |          |          |
| 2015 | 4                | 0              | 4                       | 3.772          | −3.594    |          |
| 2016 | 64.9667          | 59.4445        | 22.7                    | 48.42          | 44.3043   | 14.09776 |          |
| 2017 | 64.9667          | 57.6904        | 29.43                   | 49.34          | 26.13384  | 28.00289 |          |
| 2018 | 64.9667          | 56.0866        | 30.65                   | 60.72          | 26.45095  | 25.61739 |          |
| 2019 | 64.9667          | 54.3771        | 32.78                   | 65.56          | 27.43866  | 22.78816 |          |
| 2020 | 64.9667          | 53.6309        | 34.01                   | 67.02          | 27.65013  | 21.44292 |          |
| 2021 | 64.9667          | 52.0477        | 34.25                   | 66.29          | 27.02325  | 20.1718  |          |
| 2022 | 65.96667         | 50.53047       | 34.50                   | 65.00          | 27.193    | 18.3714  |          |
| 2023 | 65.96667         | 49.0792        | 34.76                   | 63.82          | 27.7144   | 17.1196  |          |
| 2024 | 65.96667         | 47.62793       | 35.02                   | 62.04          | 25.28444  | 16.77309 |          |
| 2025 | 65.96667         | 46.24263       | 35.29                   | 61.58          | 24.79280  | 15.75247 |          |
| 2026 | 65.96667         | 44.9233        | 35.57                   | 60.54          | 24.22317  | 14.80318 |          |
| 2027 | 65.96667         | 43.60397       | 35.86                   | 63.52          | 23.70346  | 13.89423 |          |
| 2028 | 65.96667         | 42.3506        | 36.15                   | 68.50          | 23.2083   | 13.04479 |          |
| 2029 | 65.96667         | 41.09723       | 36.46                   | 67.55          | 22.71458  | 12.24527 |          |
| 2030 | 65.96667         | 39.90983       | 36.77                   | 76.74          | 22.24585  | 11.48889 |          |
| Total| 1115.433         | 862.9682       |                         | 545.12         | 322.297   |          |      |

NPV stands for net present value.
develop. For the cost side, year 2014 has a marginal preparation budget, while 2016 reflects the main construction budget. From 2016 to 2030, total costs would include operating costs and the research budget.

For each cost and benefit section, the net present value was calculated by applying a discount rate of 5.5%, which is the official rate for government budgetary expenditure up to Spring 2014. Reflecting interest rate changes in the market, the government's discount rate has been adjusted; this was reflected as a 3% discount rate, which this study also used as shown in Table 5. (See Table 4.)

Tables 6 and 7 show a cost–benefit ratio and a net present value of establishing a research institution from 2014 to 2030. In terms of the cost–benefit ratio, with the change in the discount rate, the ratio was slightly reduced, which shows the relatively stable nature of the flow of costs and benefits. In the 3% discount rate case, costs increased more sharply than the benefits in the 5.5% case.

5. Research findings from economic impact of climate change

5.1. Estimating the loss from climate change-induced sea level rise

For comparison purposes, this study performed a cost–benefit analysis of the sea level rise affected by climate change. As shown in Table 8, output data for different industrial sectors in Korea from the fourth quarter of 2011 to the third quarter of 2012 was utilized. (See Tables 9 and 10.)

Similar to the zoonanthroposonosis case, the base model for the cost–benefit calculation was adopted from atypical private sector cases, where expected rate of profit = impact from 0000 × information usage increase rate × decision rate. From this formula, this part applied an approach for the sea level case, which can be presented as impact form the sea level rise = expected impact from the sea level rise × information usage increase rate × decision rate. In this case, based on the WMO (World Meteorological Organization) and the US NOAA reports, industries and people were assumed to have approximately 10% of expected impact from the sea level rise. In fact, WMO has shown that research on meteorology can have an approximately 10 times benefit (WMO, 2003, 2007; World Bank, 2008), compared to the costs; moreover, NOAA has estimated that about 10% of GDP will be affected by climate change and related information (Fettweis et al., 2011; Stern, 2007). (Marcelja, 2010; Kim and Cho, 2013).

Based on this background, for each industrial sector, GDP loss can be calculated. From this calculation, a loss of KRW128.1 billion was deduced, and this could be considered the direct benefit of establishing a research institution aimed at preventing sea level rise risks. According to a report in Korea by KEL, if the sea level rises by 0.2 m, the maximum damage could be nearly US$7 billion (KRW, 0.568.5 billion). Considering the magnitude of the estimated damage, the calculation from this study could be regarded as the least conservative one (Marcelja, 2010; Kim and Cho, 2013).

5.2. Cost benefit analysis of policy preparation: Creating a research institution to protect against the sea level rise risk

By applying the calculation above, we conducted a cost–benefit analysis of establishing a research institution aimed at reducing sea level rise-related risks. As mentioned earlier, other major countries have established similar organizations, yet the size varies depending on national characteristics. Considering this factor, this study prepared a small organizational design to perform an organizational cost–benefit analysis. As the table shows, with a 10-year time horizon, costs can be itemized, and taking place. For example, in reflecting the information usage increase rate, agricultural and fishery sectors were given 10%, while other sectors were assigned 5%. Similarly, the decision rate, which shows whether industries actually make decisions based on calculated risks, for the agricultural and fishery sectors was 12%, while other sectors were given only 2%.

With the deliberate calculation, the approximate figure of KRW128.1 billion was deduced, and this could be considered the direct benefit of establishing a research institution aimed at preventing sea level rise risks. According to a report in Korea by KEL, if the sea level rises by 0.2 m, the maximum damage could be nearly US$7 billion (KRW, 0.568.5 billion). Considering the magnitude of the estimated damage, the calculation from this study could be regarded as the least conservative one (Marcelja, 2010; Kim and Cho, 2013).

| Year | Total costs | NPV of total costs |
|------|-------------|--------------------|
| 2014 | 0.2         | 0.1895             |
| 2015 | 4           | 3.59               |
| 2016 | 48.42       | 41.25              |
| 2017 | 29.43       | 23.19              |
| 2018 | 30.65       | 22.88              |
| 2019 | 32.78       | 23.20              |
| 2020 | 34.01       | 22.82              |
| 2021 | 34.25       | 21.78              |
| 2022 | 35.5        | 21.40              |
| 2023 | 44.76       | 25.58              |
| 2024 | 35.02       | 18.98              |
| 2025 | 35.29       | 18.12              |
| 2026 | 35.57       | 17.32              |
| 2027 | 35.86       | 16.54              |
| 2028 | 36.15       | 15.81              |
| 2029 | 36.46       | 15.31              |
| 2030 | 36.77       | 14.89              |
| Total| 545.12      | 322.297            |

Table 6

| Year | Total costs | NPV of total costs |
|------|-------------|--------------------|
| 2014 | 0.2         | 0.1895             |
| 2015 | 4           | 3.59               |
| 2016 | 48.42       | 41.25              |
| 2017 | 29.43       | 23.19              |
| 2018 | 30.65       | 22.88              |
| 2019 | 32.78       | 23.20              |
| 2020 | 34.01       | 22.82              |
| 2021 | 34.25       | 21.78              |
| 2022 | 35.5        | 21.40              |
| 2023 | 44.76       | 25.58              |
| 2024 | 35.02       | 18.98              |
| 2025 | 35.29       | 18.12              |
| 2026 | 35.57       | 17.32              |
| 2027 | 35.86       | 16.54              |
| 2028 | 36.15       | 15.81              |
| 2029 | 36.46       | 15.31              |
| 2030 | 36.77       | 14.89              |
| Total| 545.12      | 322.297            |

Table 7

4 NOAA stands for the National Oceanic and Atmospheric Administration.
in year 1, total costs were estimated to be KR₩11.64 billion (or US$11 million approximately). One peculiar element in the table is the benefit element from “direct research.” This element was to highlight a case in which a small institute outsources most of its research projects. In this case, it was argued that this outsourcing is minimized, and therefore, the amount that was to be outsourced was added as a benefit element in the lower cells of the table.

With the adding, for example, in year 1, the total benefit was estimated to be KR₩13.117 billion, while in the same year, the total cost was KR₩11.64 billion. The total benefit was added for the inflationary factor for the upcoming years by multiplying the 3% annual increase. With these settings, the cost–benefit ratio of establishing a special institute aimed at sea level rise risks was between 11.26 and 11.27, which shows that about 11 times, the benefits can be attained through the establishment of an organization. This is consistent with what WMO has claimed as the benefit size from weather-related research for the economy (Adams et al., 1995). WMO claims that about 10 times the benefits will be generated with research (WMO, 2003, 2007). In this case, slightly higher numbers are suggested as a policy measure for establishing an institute (Frei, 2009).

### 5.3. Main functions for the institution

If policy alternatives for making the research institution specialized for the type diseases was its implication for the conventional economic numbers. Second, this research tried to stereotype the risks that making creative economy may be considered more on traditional factors of production even when we consider creative economy. Theoretical and practical debate, such as the introduction of more robotics can be an agenda from the supply side. Yet, in thinking of creative economy, just considering supply and demand will not be sufficient. Our global economy as a whole can be endangered with an unexpected outbreak of a symptom, whether it could come from naturally or unnaturally.

What makes this research applicable for the creative economy comes from the notion that managing risks will determine whether we can make our economy prosper or not. Traditionally, we have underestimated the importance of prevention from the risks this paper has raised. We have focused more on traditional factors of production even when we consider creative economy. Theoretical and practical debate, such as the introduction of more robotics can be an agenda from the supply side. Yet, in thinking of creative economy, just considering supply and demand will not be sufficient. Our global economy as a whole can be endangered with an unexpected outbreak of a symptom, whether it could come from naturally or unnaturally.

First, maintaining the risk management, in some sense, can be at least equally important as improving factors of production in creative ways. Against the understanding, this research tried to show the relative magnitude of the zooanthroponosis in conventional economic numbers. Second, this research tried to stereotype the risks that making creative economy may be faced. This study focused on both zooanthroponosis and climate changed based sea level change. Both risks can endanger our civilization from the bottom. Especially, the reason why this study focused on the zooanthroponosis case with a special attention to establishing a research center specialized for the type diseases was its implication for the creative economy in a narrow sense. While people can easily be expanded into basic research, vaccine related research as well as prevention type surveillance for wild life diseases.

### 6. Conclusion

#### 6.1. Implications for the creative economy: implications for vaccine research and industry against the risk and climate change adaptation

What makes this research applicable for the creative economy comes from the notion that managing risks will determine whether we can make our economy prosper or not. Traditionally, we have underestimated the importance of prevention from the risks this paper has raised. We have focused more on traditional factors of production even when we consider creative economy. Theoretical and practical debate, such as the introduction of more robotics can be an agenda from the supply side. Yet, in thinking of creative economy, just considering supply and demand will not be sufficient. Our global economy as a whole can be endangered with an unexpected outbreak of a symptom, whether it could come from naturally or unnaturally.

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drawn by the sheer numbers of potential danger from such diseases, it is not easy to get the public budget for preventing the risks. Making a research center like this will need public money, which is tax money. This will require a series of thorough feasibility tests. Ironically, however, to pass the test, cost benefit analysis results should not be big enough. An implication from the dynamic is that as a society as a whole, we may underinvest in vaccine research and production until we finally acknowledge the risks.

Third, the same story can be told for the climate change. Society has traditionally underestimated the potential danger from the risk. After the Stern report of the U.K., people hailed the implications from the report until people have turned away from them, due to slowly changing nature of the phenomenon. After the Stern report, research communities have, in some sense, over reacted by reproducing the implications, which have undermined the original intention and warning from the phenomenon. This chain reaction has eventually may result in underinvestment at the societal level as well as global level.

In sum, actualizing the creative economy depends on risk management at social and global level, and the most serious upcoming risks will be the zoonanthroponosis and climate change, which we tend to under invest due to our socioeconomic decision making system. This is what this research can speak up in preparing the upcoming creative economy.

6.2. Comparison of the two risks [41]

This study has presented a cost–benefit analysis of two risks that apparently do not seem closely related. One common perspective this study provided is that both of them are risks to the socioeconomic aspect of today’s civilization. The results of applying cost–benefit analysis to both cases show an interesting comparison.

First, while both cost–benefit analyses in this study were conducted in a conservative manner, most of the earlier research examples dealing with diseases have produced more serious economic figures than climate change related research cases. A consequence was that disease-related research easily attracted attention from society, probably because with the existing record of zoonanthroponosis cases. People already have enough awareness of the problem, while climate change is at a research stage and its impact or damage is something to be materialized in the future.

Second, because of the first reason, even though the numbers of disease cases handled are more conservative, the total costs were still much greater than in the climate change case.

Third, because of the existence of real-world data on damage from zoonanthroponosis in the past 20 years, in the cost–benefit analysis, only a small fraction of the damage was used to make it more realistic. In comparison, climate change-related circles were trying to better describe the potential magnitude of future risks.

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