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# Human Resources and Disasters in China: A Comparative Study

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***Abstract:*** We analyze the nexus between human resources and disasters in China using a comparative approach. Two types of disaster damages to human resources used in this research comprise the number of deaths (mortalities) and the number of people affected (affected people). We first compare the effects among six Administrative Regions in China. The results show that the effects of mortalities are mostly adverse and statistically significant. However, the impacts of affected people differ for different economic regions depending on the region's developmental level. We then compare China with the other East Asian nations: Japan, Mongolia, and South Korea. The paper examines three main sectors: primary, secondary, and tertiary. The results show that Mongolia suffers the most damages, China the second, whereas Japan and South Korea take a turn in the third and the fourth place depending on the sectors.

## 1. Introduction

If a country's GDP represents its global power, then the People's Republic of China (henceforth called China) is currently the most critical nation globally with its highest GDP. China also has the highest potential for development in the future. China has recently replaced the U.S. as the largest trading partner of nearly every major nation.

Nevertheless, disasters have wreaked havoc on China like the Sichuan (Wenchuan) earthquake of 2008 and its high numbers of deaths, people affected, and property damages. With the inception of the COVID-19, research on disasters has become a hot topic worldwide, especially in China, where the pandemics started. China is also an intriguing case due to its high literacy rates and a high degree of government involvement in its economy.

Reading the existing literature, we find that most current research has focused on one type, such as natural or technological disaster. Few scholars spend time studying the combined effect of all disasters. We also notice that very few papers perform a comparative study either among China's regions or among nations of East Asia, of which China belongs. The lack of a comprehensive study on this topic inspires us to write this paper.

Figure 1 exhibits the six administrative regions in China.


**Figure 1: Six Administrative Regions in China**

*Source: https://www.bing.com/images*

We estimate disaster impact in terms of foregone production caused by disasterdamages on human resources and the reverse effect of human capital investment on disaster damages in these six regions. The article first compares the effects among six administrative regions in China. We consider two types of disaster damages to human resources: the number of deaths (mortalities) and the number of people affected (affected people).

We then compare disaster effects in China with those in the other three East Asian countries of Japan, Mongolia, and South Korea. Our paper examines disaster impacts on three main sectors, namely primary, secondary, and tertiary, in these four nations. We compare the effects on human resources across sectors and nations and finally provide the findings' economic implications.

Section 2 discusses the existing research. Section 3 introduces the model and the data. Section 4 analyzes the results, and Section 5 concludes.

## 2. Review of Empirical Studies

Paxson (1992), Townsend (1994), and Udry (1994) study the impact of disasters, financial crises, and dramatic changes in trade policies, specifically on rural communities. The research mainly focuses on the correlation between insurance purchases and a family's expected income and financial capabilities.

Borensztein *et al.* (2008) also discuss insurance needs, specifically regarding the Belizean government regarding disaster losses. The research concludes with recommendations to establish a public savings program, issue catastrophe bonds, and garner more importance to measuring fiscal costs to reduce the risk of emergency-related damages.

Utilizing a Vector Auto-Regression (VAR) analysis, Raddatz (2007) analyzes the effects of various shocks in the short and long run on GDP volatility. The author uses a panel dataset for developing countries to determine severe GDP instabilities in the short-run but does not show long-term impact.

Noy (2009) is one of the authors to compare the various short-run impact of various disasters using a nationwide dataset. The author discusses the correlation between disasters and economic damages and various factors that strengthened or weakened the impact. The author points to factors like better educational resources, higher levels of government spending, higher literacy rates, freer trade, and more foreign exchange reserves when comparing countries' initial disaster shocks and mitigate economic after-shocks.

When looking at countries' budget issues, there has only been qualitative research on the impact of various disasters on tax and other government revenue sources. Noy and Nualsri (2011) also provided a global look at various effects and concluded that the stimulus policies differ significantly among the governments. The research results show that pre-existing conditions of government revenues and preparation highly determine country-specific macroeconomic dynamics after an external disaster.

Anbarci *et al.* (2005), Kahn (2004), Raschky (2008), and Toya and Skidmore (2007) discuss various institutional and structural factors that impact disaster costs related to the immediate aftermath following a disaster. Cavallo and Noy (2009) look at economic development in various nations after a disaster. The research found that nations' recovery differed significantly, most related to the initial level of government policy and economic development.

When looking at disaster research that focused specifically on the Northeast Asian region, Chang (2010) investigates the link between high temperatures and the increasing frequency of hurricanes. Michaels *et al.* (2006) provided the significant 28.25 degrees Celsius as the nexus threshold when looking at the correlation between high temperatures and the rising frequency of hurricanes. Chang (2010) also looks explicitly at Hurricane Vamsi in Malaysia, December 2006, which brought heavy rainfall resulting from rising temperatures.

Mendelsohn *et al.* (2012) also analyze the significant correlation between disaster frequency and climate change. Regions with unpredictable climate patterns also saw high-intensity hurricane frequency.Estrada *et al.* (2015) also discuss the correlation between natural disaster frequency and climate change, specifically looking at the United States. Even with the United States' more well-prepared government and businesses, there was still significant economic loss with the maximum damage amount at 14 billion.

Vu *et al.* (2017) further dive into the relationship between climate change, the disastrous weather it brings, and growth/decline in sustainable tourism in Northeast Asia. By analyzing the Tropical Best Track Tables and the Annual Tropical Cyclone Reports by the US National Climate Center, the authors discovered a two-way causality between hurricanes and sustainable tourism. Tourism bureaus and organizations can use this two-way causality to push forward sustainable tourism efforts, framing the idea that continued tourism efforts without consideration of the environment might lead to no tourism industry at all.

Tashanova *et al.* (2020) provide updated research regarding the Covid-19 pandemic, which has created a substantial economic loss in almost every country globally. Aifuwa et al. (2020) look specifically at Covid-19's impact on Nigeria using various quantitative and qualitative measures.

We looked at various research sources on China's disaster management efforts for natural disasters, technological disturbances, and diseases. Zhang *et al.* (2018) create a dynamic stochastic general equilibrium (DSGE) model to analyze the impact of energy price, technology, and disaster shocks on China's Energy-Environment-Economy (3E) System. The final result showed that both technology and energy price shock increase the ratio of the environment to GDP, improvements like reduction in CO2 pollution and improving economic structures.

Thompson (2003) looks at the handling of HIV/AIDS in China from government officials, and the impact globalization has on China's handling of HIV/AIDS, utilizing statistical methods to provide potential infection rates without government intervention.

Yin *et al.* (2013) look specifically at typhoon's impact on China's coastal regions. The typhoon indicator system includes two aspects of hazard and vulnerability indicators, with each criterion weighted to create the composite risk assessment model. Although only 6.30% of coastal areas were at high risk, the affected areas had low topography combined with the most-developed economy and a very dense population.

Peijun (2009) discusses the number of natural disasters in China every year and government construction projects formed to circumvent the damage from said natural disasters. Lixin *et al.* (2011) break down China's disaster management system, including their formalized national emergency system. The research also explores future improvements to China's disaster management system to become less of a segmented model.

Wai-fong Ting *et al.* (2012) discuss the relationship between China's economic growth model and disaster recovery efforts in the Sichuan region. The author shows how the evolution of China's relentless desire for GDP growth relates to their redevelopment efforts post-natural disasters. There are also recommendations of different models that focus on renewing interpersonal relationships among villagers and the relationship between urban and rural consumers and economic growth.

Gao (2016) looks explicitly at the snow and freezing disasters' impact on China's economic development. The research first investigates the long-term occurrences of snow and freezing in China. Then, spatial analysis is applied to understand losses in different hazard-affected bodies, including livelihood, the economy, and agriculture. The research also proposes an index for estimating agricultural risk and provides a risk map for disaster management.

In this new paper, we use an regression approach that enables us to better estimate the disaster impacts while emphasizing the regional differences in China and compare disaster effects in China with those in the other three countries.

## 3. Research Instruments and Data Collection

### *3.1. The model*

Model (1) contains a system of equations to account for the possiblefeedback effects among the variables:

$$PERCA_{i,t} = \alpha_1 DAM_{i,t} + \alpha_2 DAM_{i,t-1} + \beta X_{i,t} + f_i + ?_t + \varepsilon_{i,t} \quad (1.1)$$

$$DAM_{i,t} = \lambda_1 PERCA_{i,t} + \gamma_f Y_{i,t-l} + r_i + g_t + e_{i,t} \quad (1.2)$$

$$HUM_{i,t} = \kappa_1\, DAM_{i,t} + \kappa_2\, DAM_{i,t-1} + \gamma_1\, Z_{i,t-l} + o_i + z + \omega_{i,t} \qquad (1.3)$$

where *PERCA* is per capita GDP, *DAM* the ratio of disaster damages by to population, and HUM human capital proxied by education. X, Y, and Z are three vectors of potential control variables that might affect the system's dependent variables. The subscript *i* is either regional index or country index depending on comparative studies, *t* is the time index measured in years, *k* and *l* are the numbers of lagged periods. The last three variables in each equation are individual-specific effect, time-specific effect, and idiosyncratic disturbances.

Preliminary testsfor the model on the regional effect in China show that PERCA does not Granger cause DAM and so lead to the following empirical system:

$$PERCA_{i,t} = \alpha_1\, DAM_{i,t} + \alpha_2\, DAM_{i,t-1} + \beta_1\, CAP_{i,t} + \beta_2\, INI_{i,t} + f_i + h_t + \varepsilon_{i,t} \qquad (2.1)$$

$$HUM_{i,t} = \kappa_1\, DAM_{i,t} + \kappa_2\, DAM_{i,t-1} + \varphi_1\, INT_{i,t} + \varphi_2\, EXC_{i,t} + o_i + z + \omega_{i,t} \qquad (2.2)$$

where CAP is physical capital, INF is infrastructure, INT is real interest rate, and EXC is real exchange rate.

Another set of preliminary tests lead to the following empirical system for the cross-country comparative study:

$$PERCA_{i,t} = \alpha_1\, DAM_{i,t} + \alpha_2\, DAM_{i,t-1} + \beta_1 CAP_{i,t} + \beta_2 + INI_{i,t} + f_i + h_t + \varepsilon_{i,t} \qquad (3.1)$$

$$DAM_{i,t} = \lambda_1\, PERCA_{i,t} + \lambda_2\, HUM_{i,t-1} + \lambda_3\, INF_{i,t} + r_i + g_t + e_{i,t} \qquad (3.2)$$

$$HUM_{i,t} = \kappa_1\, DAM_{i,t} + \kappa_2\, DAM_{i,t-1} + \varphi_1\, INT_{i,t} + \varphi_2\, EXE_{i,t} + o_i + z + \omega_{i,t} \qquad (3.3)$$

where INF is infrastructures. The satisfaction of the necessary and sufficient conditions yields the reduced forms shown in System (4):

$$PERCA_{i,t} = \pi_{11}\, PERCA_{i,t-1} + \pi_{12}\, CAP_{i,t} + \pi_{13}\, INI_{i,t} + e_{1i,t} \qquad (4.1)$$

$$HUM_{i,t} = \pi_{21}\, HUM_{i,t-1} + \pi_{22}\, EXC_{i,t} + \pi_{23}\, EXC_{i,t} + e_{3i,t} \qquad (4.2)$$

$$DAM_{i,t-p} = \pi_{31}\, DAM_{i,t-2} + \pi_{32}\, HUM_{i,t-1} + \pi_{33}\, INF_{i,t} + e_{2i,t} \qquad (4.3)$$

The Hausman tests for the model specification shows that the fixed-effect (FE) technique is more appropriate than the random-effect (RE) for both models. Hence, we must employ the FE2SLS approach for on Systems (2) and FE3SLS approachon System (3).

## *3.2. The Data*

Data on disasters are from The Emergency Events Database (EM-DAT) website. The damages to human resources comprise the number of mortalities and the number of people affected. We sum the three datasets on damage measures for each type of disaster—natural, technological, and complex—to obtain a composite dataset on the impact of disaster damages to human resources by all disasters.

Figure 2 sketches the frequency of disasters in addition to these two variables (denoted "mortalities" and "affected people" in the graph) in China from 1995 to 2019. Our graph excludes the 2008 earthquake in Sichuan, which is an outliner in the whole period. The figure reveals that disaster frequency was rising from 1995 until 2005, then tapering off. Without the 2008 earthquake, the number of deaths peaked in 2004, whereas the number of people affected peaked in 2005. If we included this earthquake, it would cause a sharp rise in each series and significantly distort the estimation results. Hence, we eliminate this outlier.

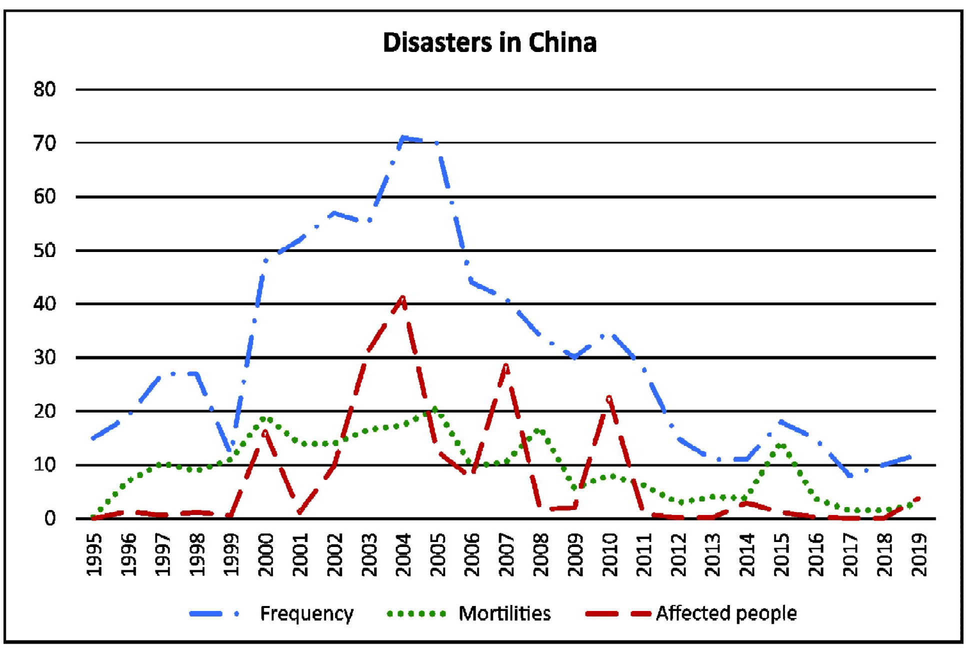


**Figure 2: Disasters in China**

*Source:* Tam Vu constructs based on EM-DAT data

Data on China's economy are from the National Bureau of Statistics of China (NBSC) and the World Bank website. The NBSC provides provincial data used in China's region-comparative study, whereas the World Bank website provides sectoral data used in the country-comparative study. Data for Mongolia, South Korea, and Japan are available from the World Bank website.

## 4. Results and Discussions

This section discusses the estimation results for Systems(2) and (3) after estimatingtherespective equations in System (4) to obtain required instrumental variables.

### *4.1. Comparative Study of Regional Effects in China*

Weuse the North region as the basegenerate and generate five dummies for the other five regions to comparethe effects of disaster damages on China's economy. Table 1 reports the results for the GDP per capital in China's six regions.The odd-numbered columns show the comparative value of each dummy to the base-dummy (North region); while the even-numbered column reports the absolute value (the magnitude) of each measure by summing the comparative value with the base value.

High mortalities appear to have the most intense impact on economic activity (per capita income) in the Northeast, followed by the South-Central region in columns (1)-(2).These regions are poorer and less connected to the central government in Beijing than the North and Eastern regions, that are the most prosperous and well connected.

**Table 1: Effects of disaster damages on GDP per capital.**

| *Damage variable* | *Mortalities* | | *Affected People* | |
|---|---|---|---|---|
| | *1* | *2* | *3* | *4* |
| | *Comparative Value* | *Absolute Value* | *Comparative Value* | *Absolute value* |
| North | -1.03** | -1.03** | 0.35** | 0.35** |
| | (0.04) | (0.04) | (0.05) | (0.05) |
| Northeast | -2.12** | -3.25** | 0.05* | 0.40** |
| | (0.05) | (0.01) | (0.08) | (0.05) |
| East | -0.21 | -1.24** | 0.04 | 0.39** |
| | (0.23) | (0.04) | (0.59) | (0.05) |

*contd. table 1*

| *Damage variable* | *Mortalities* | | *Affected People* | |
|---|---|---|---|---|
| | *1* | *2* | *3* | *4* |
| | *Comparative Value* | *Absolute Value* | *Comparative Value* | *Absolute value* |
| South Central | -1.01** | -2.26** | -0.02** | 0.37** |
| | (0.08) | (0.06) | (0.06) | (0.09) |
| Southwest | -0.13** | -1.55** | -0.05** | 0.40** |
| | (0.04) | (0.05) | (0.02) | (0.04) |
| Northwest | -0.16 | -1.19** | 0.08 | 0.43** |
| | (0.61) | (0.04) | (0.39) | (0.05) |
| CAP | | 0.038*** | | 0.035** |
| | | (0.001) | | (0.004) |
| INI | | -0.012** | | -0.009*** |
| | | (0.03) | | (0.003) |
| p-value F-test | 0.00 | | 0.00 | |
| p-value AR(1) | 0.39 | | 0.81 | |
| p-value for AR(2) | 0.42 | | 0.53 | |
| $Chi^2$-Sargan test | 0.56 | | 0.73 | |
| $Chi^2$-Hasen test | 0.91 | | 0.64 | |

*Note:* The p-values for coefficients equal to zero (no effect) are provided in parentheses. *, **, and *** denote 10%, 5%, and 1% statistical significance, respectively. The p-values for AR(1) and AR(2) are from Arellano-Bond test in first differences and second differences, respectively. Sample size is 584.

When disaster magnitudes are measured by how many people were affected, the impact on per capita income does not appear to be different across China's regions. In all cases, we still obtain the optimistic conclusion that in the short-term it appears that when disasters do not include high mortality (but rather by how many people are affected or by the extent of monetary damages), they seem to have a benign effect on per capita incomes across all regions. The results for the control variables are as expected.

Table 2 reports the results for the human capital in China's six regions. The results we obtain for capital-human investment are not very different from the results for per capita incomes. Again, the odd-numbered columns show the comparative value to the base-dummy, while the even-numbered column reports the magnitude of each measure by summing the comparative value with the base value (and calculating the relevant goodness-of-fit statistic).

Columns (1)-(2) of this table show that once again, the Northeast is especially vulnerable to the indirect economic impact of disasters (whenmeasured by the mortality they cause). In this case, it is the impact on investment. In contrast with table 6, the second region that seems especially vulnerable is the Southwest, and not South-Central. The east, the wealthiest region in China, always appears to be the least vulnerable to the economic aftermath of significant natural disasters.

**Table 2: Effects of disaster damages on human capital**

| *Damage variable* | *Mortalities* | | *Affected People* | |
|---|---|---|---|---|
| | *1* | *2* | *3* | *4* |
| | *Comparative Value* | *Absolute value* | *Comparative Value* | *Absolute value* |
| North | -1.01** (0.043) | -1.01** (0.02) | 0.39** (0.04) | 0.39** (0.03) |
| Northeast | -2.01** (0.04) | -3.02** (0.01) | 0.00 (0.19) | 0.39** (0.04) |
| East | -0.23 (0.23) | -1.26** (0.04) | 0.01 (0.58) | 0.40** (0.04) |
| South Central | -1.06** (0.02) | -2.03*** (0.003) | -0.02** (0.03) | 0.41*** (0.001) |
| Southwest | -0.12** (0.04) | -1.13** (0.05) | -0.04** (0.02) | 0.35** (0.04) |
| Northwest | -0.12 (0.69) | -1.14** (0.02) | 0.01 (0.32) | 0.40** (0.04) |
| INT | | -0.03** (0.02) | | -0.04** (0.02) |
| EXC | | -0.04** (0.05) | | -0.03** (0.04) |
| p-value F-test | 0.00 | | 0.00 | |
| p-value AR(1) | 0.45 | | 0.78 | |
| p-value for AR(2) | 0.62 | | 0.67 | |
| $Chi^2$-Sargan test | 0.87 | | 0.81 | |
| $Chi^2$-Hasen test | 0.69 | | 0.54 | |

*Note:* The p-values for coefficients equal to zero (no effect) are provided in parentheses. *, **, and *** denote 10%, 5%, and 1% statistical significance, respectively. The p-values for AR(1) and AR(2) are from Arellano-Bond test in first differences and second differences, respectively. Sample size is 584.

## *4.2. Comparative Study of Cross-Country Effects in East Asia*

Table 3 reports the benchmark variables for the country-specific effects of the four nations in East Asia. Wee keep China as the base variable and denote the mortalities as MORT. We then generate the interaction of Japan with MORT (JAMORT), Korea with MORT (KOMORT), and Mongolia with MORT (MOMORT). Similar interactive variables of affected people (AFFT) with these three countries are JAAFFT, KOAFFT, and MOAFFT.

From Panel (3.1), the effects of MORT and AFFT on primary and secondary sectors are adverse for all countries. In contrast, those on tertiary sectors are negative for China and Mongolia but positive for South Korea and Japan.

**Table 3: Country-specific effects of disaster damages**

| *Panel (3.1) Dependent variable: Sectoral output per person* | | | |
|---|---|---|---|
| *Variable* | *Primary* | *Secondary* | *Tertiary* |
| MORT (China) | -4.27** (.046) | -3.84** (.031) | -0.54* (.072) |
| MOMORT | -0.83** (.021) | -0.67** (.022) | -0.52** (.035) |
| KOMORT | 1.59** (.019) | 1.44** (.042) | 0.68** (.031) |
| JAMORT | 1.45** (.028) | 1.23**(.037) | 0.58** (.032) |
| AFFT (China) | -2.75** (.033) | -1.98** (.031) | -0.11** (.039) |
| MOAFT | -0.49** (.027) | -0.67** (.026) | -0.15** (.037) |
| KOAFFT | 1.62** (.034) | 1.51** (.048) | 0.79** (.028) |
| JAAFFT | 1.45** (.047) | 1.36** (.021) | 0.63** (.032) |

| *Panel (3.2) Dependent variable: Ratio of damage measure to population* | | |
|---|---|---|
| *Variable* | *Mortalities* | *Affected People* |
| PRIM (China) | -0.09** (.034) | -0.07** (.025) |
| Mongolia | 0.03 **(.031) | 0.04** (.050) |
| South Korea | -0.05** (.019) | -0.04** (.022) |
| Japan | -0.04** (.032) | -0.05** (.048) |
| SECND (China) | -0.14** (.024) | -0.15** (.027) |
| Mongolia | 0.03** (.031) | 0.04** (.045) |
| South Korea | -0.07** (.025) | -0.06** (.049) |
| Japan | -0.05** (.046) | -0.06*** (.004) |
| TERT (China) | -0.11** (.045) | -0.12** (.024) |
| Mongolia | 0.04*** (.028) | 0.05** (.043) |
| South Korea | -0.06** (.038) | -0.07** (.024) |
| Japan | -0.05** (.019) | -0.06** (.026) |

| *Panel (3.3) Dependent variable: Ratio of human capital to population* | | | |
|---|---|---|---|
| *Variable* | *PRICAP* | *SECCAP* | *TERCAP* |
| MORT (China) | -0.09** (.018) | -0.07** (.038) | -0.05** (.043) |
| MOMORT | -0.02** (.042) | -0.04** (.023) | -0.03** (.035) |
| KOMORT | 0.09*** (.006) | 0.8** (.047) | 0.08** (.024) |
| JAMORT | 0.10** (.028) | 0.07***(.008) | 0.07** (.025) |
| AFFT (China) | -0.12** (.037) | -0.09** (.036) | 0.04** (.041) |
| MOAFT | -0.02** (.026) | -0.03** (.031) | -0.02** (.027) |
| KOAFFT | 0.23** (.025) | 0.29** (.042) | 0.24*** (.004) |
| JAAFFT | 0.16** (.037) | 0.18** (.39) | 0.22** (.026) |

*Notes:* ***, **, * indicate the significant level at 1, 5, and 10 percent, respectively, with p-values in parentheses. The p-value for AR(1) and p-value for AR(2) are from Arellano-Bond test for AR(1) and AR(2) in first differences and second differences, respectively.Sample size is 201.

Panel (3.2) reveals that the increases in output per person in all sectors help countries mitigate the disasters' losses. Tertiary is still the best sector in recovery from disasters.

The ranking of the countries' capabilities remains the same as those in the previous tables, except for two cases:

The secondary and tertiary sectors in Japan and South Korea are equally effective in fighting the losses when the damage measures are the number of people affected and the total damages in U.S. dollars.

From Panel (3.3), the effects of MORT on capital formation in the primary and secondary sectors are adverse and significant at five percent for China and Mongolia. Those for South Korea and Japan are statistically different from China but not statistically different from zero. MORT's coefficient estimates for the tertiary sectors are negative and significant at five percent for China and Mongolia but positive and significant at one percent and five percent for South Korea and Japan.

Regarding the effects of AFFT on capital formation in the primary and secondary sectors, they are adverse and significant at five percent for China and Mongolia. The remaining coefficient estimates are optimistic and at least significant at five percent. The results reflect the economy's struggle to counter disaster losses.

## 5. Conclusion

From the above estimation results, the following lessons are crucial to mitigate the disaster losses. For all disasters, government and private researchers must have better cost-benefit evaluations of preventive and mitigation programs followed by accurate estimates of the likely financial costs of a disaster. Currently, policies are somewhat ad-hoc instead of based on the economic principle of maximizing public benefits or minimizing all costs.

For recent COVID-19, there is a collective agreement among researchers that the world economy will change due to the unprecedented closure of businesses and national borders due to this pandemic. Decreasing consumer confidence will cause less travel, fewer trips to bars or restaurants, and reduced attendance at conferences, reunions, or public events. This new lifestyle will indirectly raise disaster losses in the tertiary sector than in the other two sectors.

In brief, this paper has analyzed the effects of disasters and those of a composite measure on three important sectors —primary, secondary, and tertiary—in China. We find that the effects of human losses are the most severe for all four countries. The number of people affected is the second, depending on the level of development, government policies, and private sector efforts. The results reveal the importance of tracking each disaster by the governmental agencies and refinancing private sectors for replenishing lost capital due to any disaster.

Additional research can focus on other efforts like public health programs, international assistance, containment policies, government stimulus plans on various sectors of the economy during and after a disaster. Nations should strengthen coordination and assistance from foreign organizations and international multilateral institutions in planning to prevent a human-made or hybrid disaster, forecast the coming and magnitude of a natural disaster, and prevent or mitigate any disaster loss.

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