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Economic Impact of Epidemics and Covid-19 in East Asia

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Abstract: This article examines the economic effects of epidemics and COVID-19 on four East-Asian nations: China, Mongolia, South Korea, and Japan. Three types of disasters' losses used in this research comprise numbers of fatalities, numbers of people affected, and total damage in U.S. dollars. Epidemic and pandemic data from 1989 to 2018 are from The Emergency Events Database (EM-DAT) website. Data on the macroeconomic variables are available from the World Bank website. We estimate a system of two equations to account for the feedback effects between disasters and the economy. The results show that the epidemics' effects on the primary and secondary sectors are mostly adverse and statistically significant. The impact on the tertiary sector is mostly not statistically significant. We also find that country-specific effects differ for different nations. We then provide a projection of real GDP per capita for each country.

JEL classification: O40, Q54

Keywords: epidemics, disasters, COVID-19, East Asia

1. Introduction

The Lunar New Year in East Asia came with the shocking news of a coronavirus epidemic in Wuhan, China. By the time international researchers roughly experimented with a vaccine, the pandemic had been wreaking havoc throughout the world. Since then, the impacts of epidemics and pandemics (henceforth called epidemics) have gained attention in policy analyses by all agents in world organizations, states, and local governments. East-Asian nations are defined in a narrow sense and comprise China, Mongolia, South Korea, and Japan. We exclude Hong Kong, Macao, North Korea, and Taiwan because their data are not comprehensive. Figure 1 exhibits the location of the four nations discussed in this paper on the East-Asia map.

We investigate epidemic effects on three important sectors of the economy—primary, secondary, and tertiary—instead of overall real GDP. The paper estimates epidemic impacts on foregone production for each of the above sectors using a panel dataset from 1989 to 2018 for these nations. Data for three types of disaster losses are from the EM-DAT website: numbers of people killed, numbers of people affected, and magnitudes of direct damage in U.S. dollars.

Figure 1: The four analyzed nations on the East-Asia map

Source: https://www.freeworldmaps.net/asia/eastasia/eastasia-physical-map

We first analyze the determinants of these costs for East Asia as a group. We then compare the economic costs of epidemics across nations. Finally, we forecast the impact of COVID-19 on real GDP per capita in these four countries.

Section 2 discusses the existing research and outlines our goals in this paper. Section 3 introduces the methodology, while Section 4 analyzes the results. Section 5 concludes and provides the economic implications of the findings.

2. Existing Research

East Asia has increasing exposure to biological disasters such as **infestations of insects or animals or epidemics.** Many researchers of biological disasters focus on epidemics.

Bloom and Mahal (1997) examine the impact of the HIV/AIDS epidemic on economic growth. They find that the impact on the output growth is statistically insignificant. In contrast, Jamison *et al.* (2001) see a 1.7 percent drop in economic welfare and a 2.6 percent fall in the growth rate of wealth when analyzing a slightly different dataset.

Fan (2003) uses the Oxford Economic Forecasting (OEF) Model to perform an *ex-ante* prediction of the effects of the Severe Acute Respiratory Syndrome (SARS) on GDP growth. Guangdong province in southern China was the first region that experienced SARS in November 2002. The epidemic shared 80%

of its genetic code with COVID-19 and ended in July 2003. SARS became a pandemic when it spread to 29 countries and caused 774 deaths globally. The estimation predicts that the growth rate of GDP in these 29 countries will reduce by 0.2-1.8% if SARS persists for a quarter and 1.5-4.0% if SARS lasts for three quarters.

Nonetheless, an *ex-post* study carried out by Hanna (2004) shows that the *ex-ante* prediction by Fan (2003) was higher than the actual GDP loss. The growth rate was predicted at 1.5 percent during the SARS pandemic peak, while the actual fall was at 0.5 percent, although the pandemic did last three quarters. With *ex-post* research, both governmental and private-sector measures' mitigation activities led to less severe consequences than the ones predicted.

In a similar study, Chou (2004) also finds moderate loss from SARS. Using a computable general equilibrium model for 31 sectors and 16 regions in Taiwan, the author estimates the SARS outbreak's macroeconomic consequences. The results show that the fall in Taiwan's output growth was between 0.5 percent and 0.6 percent. The research compares two scenarios with complete disclosure of SARS cases versus a lack of public communication and finds the difference is 1.6% loss of GDP.

Like the above authors, Keogh-Brown (2008) finds that SARS's economic consequences on affected nations turned out to be much smaller than forecast values conducted by contemporary models. These results call for the improvement of forecasting models to estimate epidemics and pandemics' impacts more accurately.

Smith *et al.* (2009) examine the effects of the 2009 H1N1 (Swine Flu) pandemic from January 2009 to August 2010. According to the WHO, the Swine Flu caused over 284,000 deaths. The results predict a GDP reduction of 0.5-1 percent for low fatality and 3.3-4.3 percent for high fatality scenarios. They forecast a more extensive than 4.3 percent GDP loss if the recuperative effects of pre-vaccinations and prophylactic are absent.

A qualitative analysis by Monterrubio (2010) also points out that the inclusion of industry information is quite valuable to locate the above efforts' impact on specific sectors such as tourism in Mexico during the Swine Flu pandemic.

Several papers show that epidemics can have adverse effects on GDP per capita. Karlsson *et al.* (2014) discuss the Spanish flu epidemic, which became a pandemic in 1918 and affected 1/3 of the world's population due to the failure to promptly discover the viruses' source and the timely finding of vaccines. The results find that there is a five percent fall in capita income in Sweden for each one percent rise in mortality rate. No researcher has conducted a study on the aggregate effect of the 1918 Spanish flu worldwide, partly because it lasted close to two years, with roughly 17-50 million deaths, partly because data on the damage caused by this pandemic is not comprehensive.

The World Health Organization (WHO, 2020) received the first reported COVID-19 case from Chinese health authorities on December 31, 2019, and subsequently labeled it a pandemic on **March 11,** 2020. By the time COVID-19 came into existence, the world had endured five diseases caused by a coronavirus. The WHO labeled each of them a type of "flu," including the SARS and 2009 H1N1 mentioned above. However, COVID-19 was rapidly spreading due to its much higher transmission rate than the other five. Also, whether the pandemic will become a permanent endemic remains unknown.

Tashanova *et al.* (2020) point out that the COVID-19 Pandemic has been causing significant losses due to governments' decisions to shut down production plants and businesses.

Aifuwa *et al.* (2020) perform a linear regression of a surveyed dataset from private enterprises in Nigeria through questionnaires administered online. The results show that COVID-19 hurts both the financial and non-financial performance of private enterprises in this country. The authors propose that the Nigerian government include private firms in its stimulus packages to help private sectors run smooth operations once the economy reopens.

Based on the above literature review, an analysis of East Asia's epidemics is a compelling subject: its nations reveal differences in the levels of GDP per capita, infrastructure, and government involvement. On the other hand, they share similarities in cultural characteristics of Confucianism, high literacy rate, export growth policies, and increasing trade openness.

Using national data enables us to analyze the effects of disasters on East-Asian countries as a group. At the same time, it also allows us to compare across nations in the region to find their similarities and disparities based on their specific levels of development and openness. The involvement of all epidemics helps us draw general conclusions in a realistic scenario, which serve as bases for our specific forecast of the COVID-19 pandemic in the later section. Note that the word "epidemics" in this paper refers to pandemics as well.

3. Methodology

This section presents the model and the data used in our estimations and forecasts. We will use the regression model to investigate the aggregate effects first and then examine country effects by adding dummy variables. Finally, we will employ the forecast model to project future scenarios for each of the four countries investigated.

3.1. Regression model

Model (1)contains a system of equations to account for the possible two-way causality:

$$PERCA_{i,t} = \alpha_1 DAM_{i,t} + \Sigma_{k=1}^{K} \alpha_k DAM_{i,t-k} + \beta X_{i,t} + q_i + s_t + \varepsilon_{i,t} \qquad (1.1)$$

$$DAM_{i,t} = \varphi Z_{i,t} + \theta PERCA_{i,t} + \Sigma_{l=1}^{L} \gamma_l Z_{i,t-l} + v_i + w_t + \omega_{i,t} \tag{1.2}$$

where *PERCA* is real output per capita, which is the ratio of each sector's real output to population. *DAM* the ratio of damage caused by disasters to population. We will eliminate *Equation* (1.2) if our preliminary tests show the assumption of the weak exogeneity of the DAM measures used in Skidmore and Toya (2002) holds, implying there is no feedback effect. X and Z are two vectors of potential control variables that might affect the system's dependent variables. The subscript *i* is country index among East-Asian countries, *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 country-specific effect, time-specific effect, and idiosyncratic disturbances.

Emanuel (2005) shows that the damage caused by a hurricane often rises roughly to the cubic power of maximum wind speed when the hurricane makes its landfall on a specific location. From his analysis, the hurricane damage index in a country during time t based on the total damage due to the n = 1, 2,… N hurricanes affected county i during this time when they make landfall in locations j = 1, 2, … J is:

$$DAM_{it} = \Sigma_{n=1}^{N} [\Sigma_{j=1}^{J} (V_{ijt} / J)]^3 \tag{2}$$

where V_{ijt} is the velocity of the wind at location j due to storm n observed in country *i* during time *t*.

In this article, we modify Equation (2) by replacing the wind velocity with the magnitude (M_{it}) of a epidemic measure per capita. Vu and Noy (2015) also show that there are unequal distributions of the national resources in developing countries. They find that locations far away from a large city usually receive much less support from the central government and therefore endure more severe damages from disasters. In other words, the distance between a province and central governments determines the local economy's level of disaster losses.Hence, we further modify System (1) to allow the weight of the distance, d_j, from a province where a disaster occurs to a large city. If more than one city is in the vicinity of a province, we average all distances. With these two modifications, the equation for the damage is:

$$DAM_{it} = \Sigma_{n=1}^{N} [\Sigma_{j=1}^{J} d_j (M_{ijt} / J)]^3 \tag{3}$$

We will use the damage measure in Equation (3) for all three types of disaster losses in this paper.

3.2. Data

Data on the output for three essential sectors of the economy—the primary (PRIM), secondary (SECND), and tertiary (TERT)—employment, trade, Foreign Direct Investment (FDI), infrastructure, human capital, and capital formation are from the World Development Indicators posted on the World

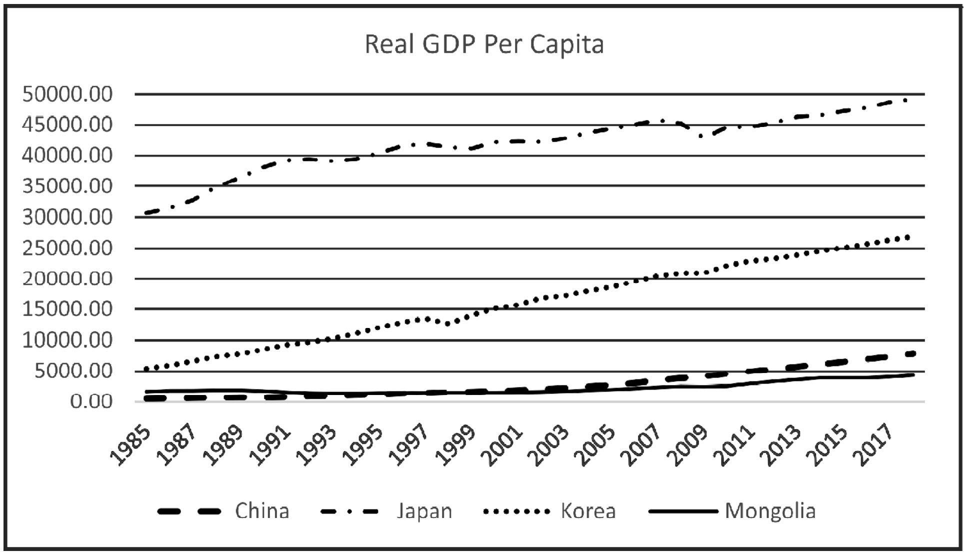

Figure 2: Real GDP per capita

Source: Constructed by Tam Vu based on data from USDA

Bank website. Data on interest rates, exchange rates, GDP deflators, and population are from the U.S. Department of Agriculture (USDA) Website and the International Monetary Fund website. Figure 2 charts the real GDP per capitafor the four countries.

From this figure, we can see the starkly different income levels among these four countries, although they share many cultural characteristics. The chart also shows Japan's real GDP per capita declined sharply in 2007-2009 in addition to the stagnation during 1991-2009. The sharp drop dragged Japan's economy back 5-6 years, to the 2003 level, where it started a new trajectory, which is parallel to the previous trend at a lower level. South Korea and China enjoyed high growth during this period, with South Korea growing faster in real terms. Mongolia's economy did not start its growth until 1999, two years after joining the World Trade Organization (WTO). Note that the figure charts the real GDP per capita instead of the nominal one.

Table 1 shows that the average GDP composition for each country's three essential sectors during 1989-1918 also significantly different among the four countries. This difference makes our study even more enjoyable.

Table 1: GDP composition for the four countries (%)

Country	*Primary*	*Secondary*	*Tertiary*
China	15	45	40
Japan	8	30	62
Mongolia	41	33	25

South Korea	10	39	51

Concerning data on disasters, while the "Country Profile" page on the EM-DAT website only provides data for two types: natural and technological, its "Advanced Search" page adds data for complex disasters. However, EM-DAT's data for complex disasters only comprise famines, animal/insect infestations, and lack of food availability or availability. We hence collect all datapoints presenting epidemics from EM-DATs' "natural-disaster" category to obtain a dataset on epidemic losses. Thus, we construct data from 1989 to 2018 for China, Mongolia, South Korea, and Japan.

Data for our analysis include three types of epidemic damage, and all are in the ratio of each loss to population: mortalities (MORT), people affected (AFFT), and damage in U.S. dollars (DAMA). Their lagged values are MORTL, AFFTL, and DAMAL, whereas the combined effects of current and lagged values are COM-MORT, COM-AFFT, and COM-DAMA, respectively.

3.3. Preliminary tests

We perform downward piecewise regressions to avoid missing variables, starting with all available variables that might explain each of the dependent variables according to the existing literature. We then eliminate variables gradually, using the Variance Inflation Factors (VIF) tests discussed in Kennedy (2008), who recommends that we eliminate any variable with VIF greater than ten.

To detect possible endogeneity for each model, we employ the modified Hausman test called Omitted Variable (OV) variant of the Hausman test in Kennedy (2008). Next, we perform Granger-causality tests, which show that there are two-way causalities between DAM and PERCA. We also carry out preliminary regressions of the system, including both Equations (1.1) and 1.2) using the Three-Stage Least Squares (3SLS) technique. The results confirm the robustness of the Granger-causality test.

We use lagged values as instrumental variables (IVs) for the current values in the 3SLS estimations. To control for lagged dependent variables, we employ the Blundell-Bond System generalized method of moments (SGMM) procedure as described in Blundell and Bond (1998) and Bond (2002). The Blundell-Bond process is a refined application of the Arellano and Bond (1991) and the Arellano and Bover (1995) procedures.

The Akaike (1973) Information Criterion (AIC) and Schwarz (1978) Bayesian Information Criterion (BIC) indicate that the model only needs the first lagged values of DAM and PERCA. The Dickey-Fuller tests discussed in Kennedy (2008) show that the series is stationary. A Hausman test for model specification indicates that a random effect is more appropriate than a fixed-effect model. Thus, the structural equations for System (4) are:

$$PERCA_{i,t} = \alpha_1 DAM_{i,t} + \alpha_2 DAM_{i,t-1} + \beta_1 INT_{i,t} + \beta_2 CAP_{i,t} + \beta_3 INI_{i,t} + s_t + \varepsilon_{i,t} \quad (4.1)$$

$$DAM_{i,t} = \theta_1 PERCA_{i,t} + \lambda_1 HUM_{i,t} + \lambda_2 INF + \lambda_3 EXC + r_i + u_t + e_{i,t} \quad (4.2)$$

where INT denotes real interest rate, CAP physical capital, INI initial output, HUM human capital, INF infrastructure, andEXC the exchange rate. There are missing observations, so we have unbalanced panels, so we use binary dummies to control for missing observations.Note that DAM is used alternatively for three types of damage (MORT, AFFT, and DAMA). PERCA also used alternatively for three sectors (PRIM, SECND, and TERT).

After checking the order and rank conditions for System (4), we have System (5) as the reduced forms so that predicted values from the regression results of System (5) can serve as IVs for System (4):

$$DAM_{i,t-1} = \pi_{11} DAM_{i,t-2} + \pi_{12} INT_{i,t} + \pi_{13} HUM_{i,t} + e_{2i,t} \quad (5.1)$$

$$PERCA_{i,t} = \pi_{21} PERCA_{i,t-1} + \pi_{22} EXC_{i,t} + \pi_{23} INI_{i,t} + \pi_{14} CAP_{i,t} + e_{1i,t} \quad (5.2)$$

Having saved the IVs from estimating System (5), we then estimate System (4) using the random effect 3SLS (RE3SLS) approach.The SGMM procedure is employed again to control for the lagged dependent variables.

3.4. COVID-19

Although Mongolia has only more than 300 cases of COVID-19 with zero death and its second wave is very mildat this moment, Mongolia's GDP still fell sharply in Quarter 2, 2020, sowe keep this country in our analysis. The business and border closedown caused Mongolia's high unemployment and reduced trade volume. Since COVID-19 is an on-going incidence, we will employ a forecast model combined with a time-series estimation.

To see the economic impact of COVID-19, we apply a two-step process:

(1) Project the number of people affected due to COVID-19 in 2020 and 2021 based on the early-2020 data.

(2) Forecast the COVID-19 impact on real income per capita by applying the theoretical framework in Section 3 on this pandemic.

We calculate monthly data on numbers of COVID-19 affected people—measured as the number of confirmed new infections and unemployed—using data from the World Health Organization's Situation Reports.

The current data shows that this number of people affected in each country follows a nonlinear trend. Thus, we use the higher-order exponential smoothing (HOE) model because it adds a nonlinear term to the standard Holt-Winters exponential smoothing (HWE) models' trend equation. The nonlinear term could be in quadratic, cubic, logarithmic, or any other form, depending on the series' curvature. To find out the curvature of the COVID-19 time series, we construct a time series plot. The results reveal that the curve for the number of people affected by the COVID-19 pandemic follows an inverted-U shape. Thus, the forecast model with a quadratic term added is:

$$F_{t+1} = b_1 + b_2\, t - b_3\, t^2 + e_{t+1} \quad (6)$$

Using the above theoretical framework, we project the ratio of COVID-19 affected people to each nation's population. We then forecast the effects of the COVID-19 on realGDP per capitain the four countries.

4. RESULTS

This section discusses the estimation results for epidemic effects and provide projection of the four countries' real GDP per capita.

4.1. Aggerate Effects of Epidemics

Table 2 shows the aggregate results for Model (4). This table reveals that the current effect of epidemics on the primary sector is negative and statistically significant. The lagged and combined effects are also harmful and statistically significant. Specifically, a one percent increase in the ratio of mortalities to population (MORT) in the current period decreases the primary output per person by 2.71 percent, holding other variables constant. The interpretation of other coefficients is in the same manner.Listed below are several remarks:

From panel (2.1) the severities of the disaster losses' effects on the output per person— ranging from the most to the least—are PRIM, SECOND, and TERT. Theseresults make sense, as primary sector workers are often located far from cities and so receive less attention from the governments.

From panel (2.2), the tertiary sector helps reduce the disaster's losses the most among the three sectors. The results are in line with development theory where the higher per capita income sector, the better prepared it is to fight against disaster losses.

The signs of the control variables are as expected. The coefficient of INI in panel (2.1), supporting the convergence theory in development economics. Note that the coefficient of EXC in Panel (2.2) is positive. The result also makes sense, as an increase in exchange rates reduces a company's quantity of exports and revenue, reducing a firm's resources needed to fight against disaster losses. As a result, the disaster impact's severities increase. Similarly, an increase in interest rates reduces a business's ability to borrow funds to cope with disaster losses.

From the results for MORT, we see that the aggregate effects of human losses are the most severe for the four countries as a group. The effects of the number of people affected are the second. The adverse effects of U.S. dollars' total damage are very mild and even favorable for the secondary

Table 2: Aggregate effects of epidemics

Panel (2.1) Dependent variable: Sectoral output per person			
Variable	*Primary*	*Secondary*	*Tertiary*
MORT	-2.71** (.019)	-1.62** (.038)	-0.17** (.021)
MORTL	-0.22** (.041)	-0.07** (.039)	0.04*** (.005)
COM-MORT	-2.93*** (.001)	-1.69** (.022)	-0.13** (.026
AFFT	-1.82** (.042)	-1.41** (.015)	-0.51* (.099)
AFFTL	0.11** (.037)	-0.15* (.069)	0.10 (.162)
COM-AFFT	-1.71** (.021)	-1.56** (.032)	-0.41* (.077)
DAMA	-1.12** (.032)	0.13** (.027)	0.15** (.033)
DAMAL	0.01** (.046)	0.03** (.019)	0.01 (.261)
COM-DAMA	-1.11** (.031)	0.16** (.025)	0.16** (.049)
INT	-0.07** (.042)	-0.08** (.036)	-0.10** (.022)
CAP	0.33*** (.008)	0.31** (.041)	0.35** (.034)
INI	-0.05** (.024)	-0.06** (.049)	-0.07** (.041)
Panel (2.2) Dependent variable: Ratio of damage measure to population			
Variable	*MORT*	*AFFT*	*DAMA*
PRIM	-0.06** (.024)	-0.07** (0.48)	-0.09** (.032)
SECND	-0.10** (.038)	-0.13** (.037)	-0.16*** (.008)
TERT	-0.14*** (.004)	-0.16** (.013)	-0.18** (.024)
HUM	-0.07** (.019)	-0.08** (.031)	-0.09** (.018)
INF	-0.12*** (.003)	-0.15** (.025)	-0.16*** (.005)
EXC	0.05** (.044)	0.04** (.026)	0.06** (.048)
p-value for F-test	0.008	.005	0.006
Average RMSE	0.261	0.202	0.148
p-value for AR (1)	0.203	0.162	0.227
p-value for AR (2)	0.417	0.193	0.248
Chi^2-Sargan	0.248	0.254	0.129
Chi^{2-}Hansen	0.375	0.405	0.361

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.

and tertiary sectors. These results might be due to the sectors' structures, government policies and private sectors' 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.

4.2. Country-specific effects

We use China as the base group and generate dummy variables for the three other countries, with Mongolia as MO, South Korea as KO, and Japan as JA. Table 3exhibits the regression results.

Table 3: Country-specific effect of epidemics

Variable	*Primary*	*Secondary*	*Tertiary*
Panel (3.1) Dependent variable: Sectoral output per person			
Variable	*Primary*	*Secondary*	*Tertiary*
MORT (China)	-2.92** (.026)	-2.51** (.038)	0.63** (.023)
MOMORT	-0.51*** (.002)	-0.47** (.023)	-0.32*** (.002)
KOMORT	1.32** (.019)	1.32** (.044)	0.51** (.037)
JAMORT	1.12** (.016)	0.91**(.012)	0.47** (.018)

contd. table 3

AFFT (China)	-1.62** (.049)	-1.43*** (.003)	0.39** (.024)
MOAFFT	-0.44** (.031)	-0.34** (.028)	-0.29*** (.004)
KOAFFT	1.42*** (.001)	1.32** (.035)	0.62** (.046)
JAAFFT	1.21** (.045)	1.14** (.021)	0.43** (.038)
DAMA (China)	-1.42** (.024)	-1.28** (.016)	0.24** (.018)
MODAMA	-0.51** (.047)	-0.42** (.031)	-0.22** (.034)
KODAMA	0.93** (.036)	0.89** (.022)	0.71** (.032)
JADAMA	0.61** (.026)	0.65** (.029)	0.51** (.027)
Panel (3.2) Dependent variable: Ratio of damage measure to population			
Variable	*MORT*	*AFFT*	*DAMA*
PRIM (China)	-0.05*** (.006)	-0.06** (.026)	-0.08*** (.003)
Mongolia	0.01 **(.032)	0.02** (.045)	0.04** (.033)
South Korea	-0.05** (.017)	-0.06*** (.008)	-0.08** (.031)
Japan	-0.02*** (.007)	-0.04** (.048)	-0.05*** (.002)
SECND (China)	-0.10** (.029)	-0.12** (.034)	-0.14** (.028)
Mongolia	-0.01** (.031)	-0.03** (.026)	0.01* (.067)
South Korea	-0.06** (.034)	-0.04** (.042)	-0.07** (.046)
Japan	-0.05*** (.004)	-0.04** (.041)	-0.05**(.038)
TERT (China)	-0.11** (.045)	-0.13** (.029)	-0.15** (.018)
Mongolia	0.04*** (.026)	0.06** (.036)	0.07*** (.006)
South Korea	-0.06** (.038)	-0.08** (.029)	-0.08*** (.004)
Japan	-0.05** (.016)	-0.07*** (.003)	-0.08** (.021)
p-value for F-test	0.004	0.007	0.002
Average RMSE	0.214	0.312	0.242
p-value for AR (1)	0.283	0.159	0.147
p-value for AR (2)	0.263	0.187	0.254
Chi^2-Sargan	0.421	0.217	0.245
Chi^2-Hansen	0.325	0.193	0.346

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.

The dummies are interacted with the damage variables, so an interaction of Mongolia with mortalities is MOMORT, Japan is JAMORT, and so on. Note that the effects on other countries are comparative to China. For example, the coefficient of mortality for Mongolia (MOMORT) is more negative than that of China and equals – 3.43 (= – 2.92 – 0.51), and so on. Overall, South Korea shows its superb ability to cope with epidemics as the country with the least disaster losses. Japan ranks second, China the third, and Mongolia the least effective in fighting disasters.

One might wonder why Japan ranks second. The answer might come to terms with our period, from 1989 to 2018. From 1991 through 2011, Japan was in two lost decades due to nonperforming bank loans and damaged balance sheets. Japanese authority has tried to lower the real interest rate to stimulate the economy since 1991. However, the low rate has caused the so-called "monetary trap." Thus, the Japanese economy has stagnated for a long time, making it difficult to cope with disasters in general and epidemics specifically.

During this same period, South Korea enjoyed substantial growth, especially in the secondary sector. The South Korean government has also promptly implemented rules and regulations against disasters. Moreover, South Korea is the most disciplined people in embracing large-scale interventions. This phenomenon might have roots in the South Korean experience of rapid industrialization and national development in the past forty years.One detail worth attention in Panel (3.2) is Mongolia's secondary sector, which reduces disasters' losses more than China's.The results might imply the severity of environmental degradation in China as the manufacturers extend their production without appropriate measures against the pollution caused by the careless industrialization.

4.3. COVID-19

This section provides projections of real incomeper capita (RIPC) in East-Asian nations up to the first quarter of 2022. For each country, we chart three series:

Series (1):there is a new vaccine, antiviral drug, orantibody-drug byQuarter 1 of 2021, and the drug helps nations reduce numbers of people affectedby 50 percent,

Series (2): the new drugcomes by the end of Quarter 2 of 2021, and

Series (3): COVID-19 has never occurred (a hypothetical case).

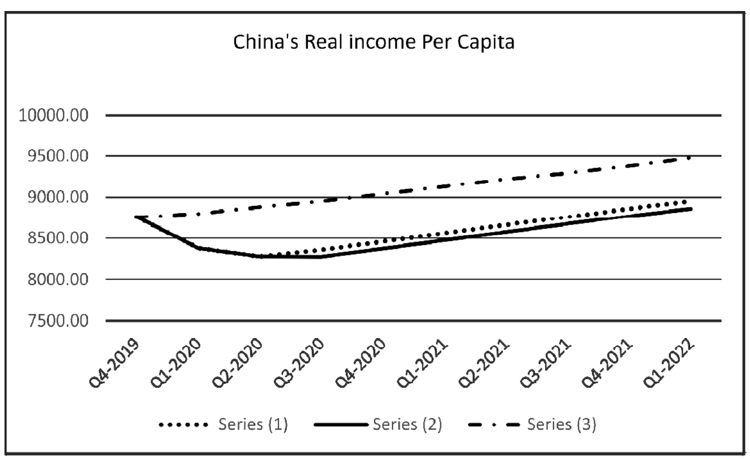

Figure 3: Projection ofreal income per capitain China

Source: Projected by Tam Vu based on the framework in section 3

The antibody-drug is a kind of middle ground between an antiviral and a vaccine. According to Langreth and Berfield (2020), multiple hospitals have been trying antibody-rich plasma from the blood of recovered patients of COVID-19 on newly infected patients and the Remdesivir previously used on Ebola patients. Various pharmaceutical companies have also worked diligently on the antibody-drug.

Figure 3 charts the resultsfor China.

Series 1 (dotted line) of this figure reflects the fact that China's RIPC has already started to rise since the middle of Quarter 2, 2020, and will achieve the post-COVID level by Quarter 3, 2021. Series 2 (solid line) shows that China's real GDP per capita also started to rise in Quarter 2, 2020, but not reaching the post-COVID level until Quarter 4, 2021.

The quick recovery is possible thanks to the mild second wave of COVID-19 in China. When the first wave occurred in November 2020,the Chinese government was hesitating to lockdown the private businesses until December, weeks after the first case had occurred in Wuhan.The government and private sectors have well learned their lessons in coping with the second wave of the pandemic. Series 3 provides a long-term trend of China's economy without the COVID-19, which pulls the economy to a new growth path that is lower than the hypothetical one, implying the permanent harm caused by this pandemic.

Figure 4 charts the results for Japan. The actual datareveals that Japan's RIPC had enjoyed its expected growth path when RIPC started to decrease in Quarter 1, 2020. Series 1 shows that RIPC starts to rise in Quarter 4, 2020, reaching the post-COVID level by Quarter 4, 2021. Series 2 shows that RIPC starts to risein Quarter 4, 2020, but not catching with the post-COVID level

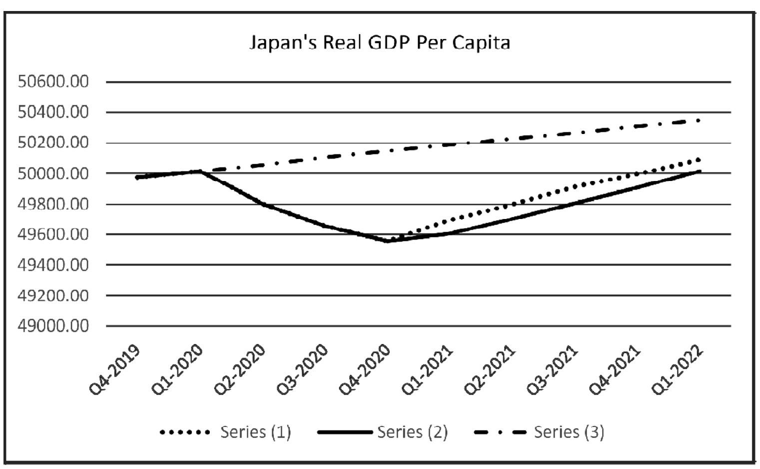

Figure 4: Projection of real income per capita in Japan

Source: Projected by Tam Vu based on the framework in section 3 until Quarter1, 2022.

The long delay to recovery is evident in the chart. The Japanese government is responsible for this severity. The first wave of the pandemic in Japan was milder than that in China.However, the Japanese government was slow in arriving with a counter-disaster policy,and even after issuing a closedown order, was reluctant to shut down some night clubs and bars. The spreading out of the pandemic second wave is also evidence of hesitating actions on the part of the Japanese governmentin implementing measures against the rapid

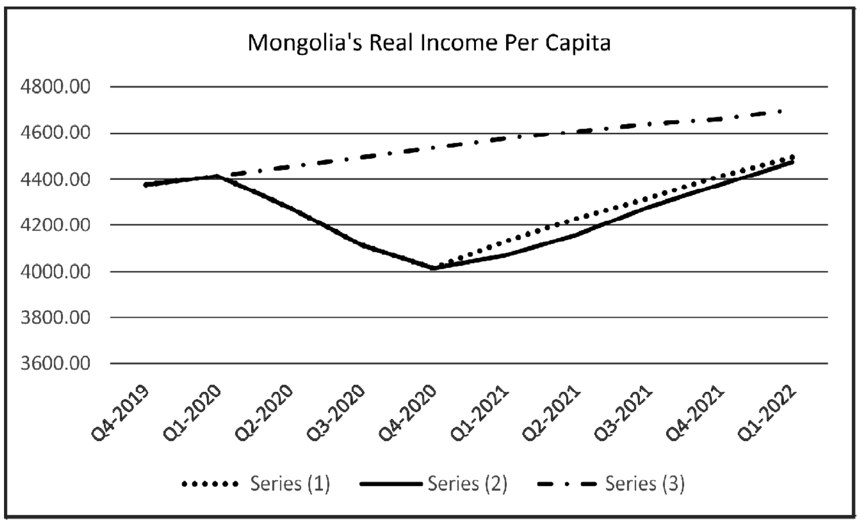

Figure 5: Projection of real income per capita in Mongolia

Source: Projected by Tam Vu based on the framework in section 3

spreading of the disease.

Figure 5 charts the results for Mongolia. In Series 1, Mongolia was enjoying RIPC growth until Quarter 1 when it fell sharply. However, the RIPC starts to rise in Quarter 4, 2020, and will reach the post-COVID level by Quarter 4, 2021. In Series 2, the RIPC will achieve the post-COVID level by the end of Quarter 1, 2022. Note that both series gradually close their gaps with Series 3, reflecting the convergent effects when RIPC falls sharply.

We credit the Mongolian government for its timely and drastic measures to minimize the number of infections. The Mongolian government had ordered the closure of China-Mongolia air and land traffics, educational institutions, and numerous businesses before the pandemic reached the country. The government also canceled all public events such as conferences, sports, and festivals. Mongolian residents were to stop traveling to the countries affected by the outbreak, and any traveler returned from these countries was subjected

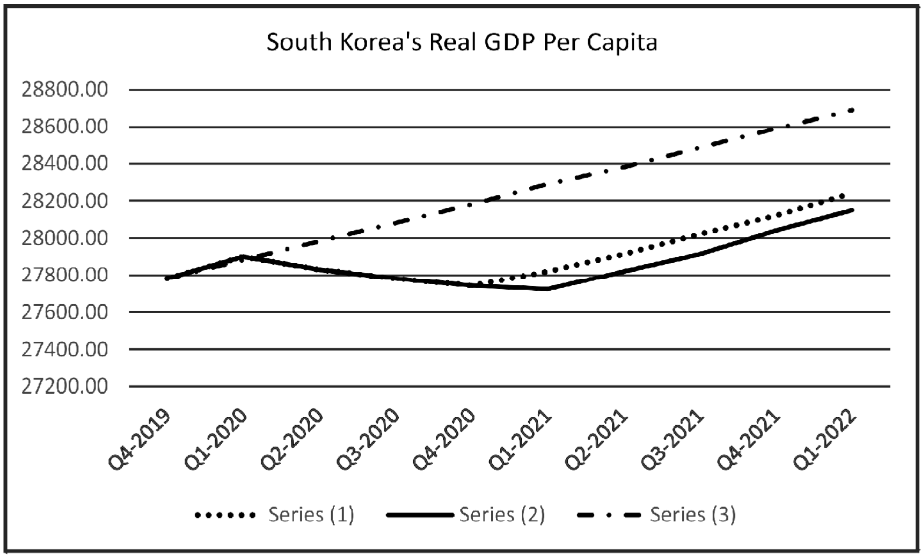

Figure 6: Projection of real income per capita in South Korea

Source: Projected by Tam Vu based on the framework in section 3

to a 14-day quarantine.

Figure 6 charts the results for South Korea. The growth path of South Korea from Quarter 4, 2019, to Quarter 2 2020, was the same as that of Japan. However, Korea's RIPC reached its bottomin Quarter 3, and the economy recovers from the pandemic quicker than Japan, reaching the post-COVID level by Quarter 2, 2021. Korea's RIPC in Series 2 will achieve the post-COVID level by Quarter 3, 2021.

The quick recovery is due to the Korean government's decisive measures and the Korean public's determination to fight the pandemic. The government has performed tests extensively to trace the affected people and practiced quarantines to isolate these from the rest of the population. Korean people have been strictly obedient to the government orders. As a result, the first wave of the pandemic was short-lived, and the second wave has been quite mild without the total closedown of all businesses.

5. Conclusion

The above estimation and forecast results imply the following observations. First, human resource is the most critical factor of production, reflected through the most harmful effects of the disaster mortalities on all three major sectors of the economy. Second, our results support the recent lock-down of business, public communication, and testing to locate and confine the infected areas in the recent pandemic. Third, decreasing consumer confidence caused by COVID-19 will cause less travel, fewer trips to bars or restaurants, and reduced attendances at conferences, reunions, or public events. This new lifestyle mightindirectly raise disaster losses in the tertiary sector more than in the other two sectors. Finally, overall, the availabilities of actual data are crucial in disasterprevention and mitigation.

In sum, this paper has analyzed the effects of epidemics in general and COVID-19, specifically on three major sectors —primary, secondary, and tertiary—in four East Asian countries. The less severe or favorable results from all disasters in South Korea compared with those in Japan resulted from the measures to prevent and mitigate the disaster losses carried out by governments and the public seriousness in fighting against disasters in each country.

There are also new measures enhancing the active positions in fighting the disasters' losses. Additional research can focus on other efforts like public health programs, international assistance, containment policies, and government stimulus plans on various economy sectors during and after a disaster. Nations should strengthen coordination and assistances from foreign organizations and international multilateral institutions in planning to prevent and counter epidemic losses.

This paper only provides the readers with a broad picture of the disaster impact on the East-Asian economy. The inclusion of broken-down sectors, such as exports, imports, and transportation, can also prove extremely valuable. The analyses of various small sectors help us find the most vulnerable sectors and allocate resources accordingly to mitigate disasters' adverse effects. Future researchers should employ this approach when studying one country or a single disaster event.

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