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The Global Economic Impact of the COVID-19 Pandemic: The Second Wave and Policy Implications

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Abstract: *This paper examines the macroeconomic impact of the COVID-19 pandemic through the Computable General Equilibrium model. Due to a second wave and a subsequent delay in economic recovery, the pandemic could lead to a permanent shock in capital accumulation and productivity. This implies that the shock may not merely affect the short-term growth rate but also negatively impact the future economic growth path from its pre-pandemic trend. Through simulations, in the mild scenario, countries lose 0.10% to 0.31% of their future economic growth rates; in the severe scenario, they lose 0.21% to 0.69%.*

Keywords: COVID–19; Computable General Equilibrium; the second wave

JEL Classification: E13, E17, E21, E22, E24

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1. Introduction

Infectious diseases have threatened humankind throughout history, ranging from the 'Spanish flu' in the early 20th century to today's coronavirus. Their detrimental impact is not limited to demographics and health systems but extends to the growth and development of economies (Brainerd and Siegler, 2003; Lee and McKibbin, 2004; Keogh-Brown and Smith, 2008).

The World Health Organization (WHO) has only declared three pandemics – the highest degree of warning, when a disease has spread across more than two continents – since its founding in 1948. COVID-19, which was first reported in December 2019, was declared a pandemic in March 2020, like the 1957 Asian Flu and the 1968 Hong Kong Flu. The COVID-19 pandemic is spreading at an unprecedented pace, thanks partly to globality mobility. Globalisation and economic integration through trade, as well, have meant that its economic impact has been especially detrimental to the global economy.

COVID-19 is thought to be similar to Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS). Infection occurs through the respiratory system, and the absence of a vaccine originally limited the modes of preventing the disease. While SARS and MERS cases were generally limited to China and the Middle East, COVID-19 has spread across all areas of the globe.

As of September 2020, the number of COVID-19-positive patients surpassed 26 million, with the United States, Brazil, and India having the most cases, respectively (European Centre for Disease Control and Prevention 2020). As its spread has continued, many public health experts are warning of a second wave of infections due to the delayed development and deployment of a vaccine, mutations, and lower temperatures. According to Gallagher (2020), 'to say one wave has ended, the virus would have been brought under control and cases [have] fallen substantially…. For a second wave to start, you would need a sustained rise in infections.' In fact, in the Republic of Korea, COVID-19 cases were decreasing until mid-August but spiked again in November 2020 (Korea Disease Control and Prevention Agency 2020).

According to the Organisation for Economic Co-operation and Development (2020), G20 countries' growth rate in the first quarter of 2020 was –3.4%, the lowest figure since records began in 1998. In the second quarter of 2020, the fall deepened to –6.9%, showing that the economic damage was more severe than the –1.5% hit during the 2008 global financial crisis. The United States received a shock of –1.3% in the first quarter of 2020, falling to –9.1% in the second quarter; the United Kingdom witnessed respective declines of –2.2% and –20.4%; and France –5.9% and –13.8. In Asia, India received a shock of 0.7% in the first quarter of 2020 and –25.2% in the second; Korea, –1.3% and –3.2%; Japan, 0.6% and –7.9%; and China, –10.0% and 11.5%. Based on the epidemic and associated restriction measures, the International Monetary Fund (2020) predicted an annual global growth rate of –4.4% for 2020.

A significant factor in the economic recovery is the uncertainty of the continued spread of the disease; hence, an investigation into the economic impact depending on different scenarios is crucial. This study thus aims to contribute to the existing literature in two ways. First, the short- and long-term effects of the COVID-19 pandemic will be distinguished, as a sufficiently large negative shock could lead to both a temporary reduction in growth and a decrease in the growth gradient. Second, although the existing literature has analysed the impact by assuming a shock from the pandemic, this study will also include early epidemiological trends and their economic impact and assume a second wave. Assessing the magnitude and severity of the economic downturn is critical in evaluating the damage and the worst-hit industries, which will then allow governments to develop appropriate mitigating measures.

Section 2 presents the literature review, and Section 3 describes the data and empirical model used to examine the macroeconomic impact of the COVID-19 pandemic. Section 4 reports the results of estimations, and implications are derived in Section 5. Section 6 concludes.

2. Literature Review

The economic impact of pandemics has been continually studied, enhancing direct knowledge of their impact as well as limiting uncertainty and negative confidence shocks that accompany pandemics. Research has also been used to prevent and to prepare for other infectious diseases, highlighting the importance of this field of economics.

The 1918 'Spanish flu' pandemic has served as a starting point in assessing the impact of infectious diseases on economic growth and development. Beach, Clay, and Saavedra (2020) showed through a literature survey that the health effects from this pandemic were large and diffused while the economy shrunk from the negative labour supply shock on prime-aged workers. Barro, Ursúa, and Weng (2020) also assessed 43 countries during 1901–1929 to estimate the macroeconomic effects of this pandemic. They found that it led to about a 2% population loss for the average country, a 6% decline in real gross domestic product (GDP) per capita, and an 8% decline in real consumption per capita on average. However, Brainerd and Siegler (2003) argued that many deaths resulted in higher capital accumulation per capita, which then stimulated economic growth in the following decade – the impact of a V-shaped recovery.

Prior studies assessed the economic impact of other infectious diseases, such as SARS and the H1N1 flu. The Congressional Budget Office (2005) in the United States assessed the impact of an influenza pandemic in two scenarios, mild and severe, estimating that the GDP of the United States would fall by 1.00%–4.25%. Dixon et al. (2010) examined the H1N1 flu in 2010 using the Computable General Equilibrium (CGE) model on each quarter. They found demand-side shocks, such as on tourism, led to a reduction of 1.6% in the GDP. Douglas, Szeto, and Buckle (2006) assessed this flu's impact on the real GDP of New Zealand. In a mild scenario, they found that the GDP would fall 1%–2%; in the severe case, it would decrease 5%–10%.

Keogh-Brown and Smith (2008) assessed the pandemic planning documents of the European Union and the United Kingdom using 2004 data, differentiating the infection rate and fatality rate with school closures and vaccinations. They posited that the GDP fell by 0.5%–1.0%, 3.3%–4.3%, and 6.0%–9.6% in respective

severity scenarios of a pandemic, concluding that school closures increase economic costs while pre-pandemic reactions mitigate negative impacts.

The impact of infectious diseases on China was examined in regard to SARS. SARS reduced China's GDP by 1%–2%, a magnitude of $24.3 billion (Hai, Zhao, Wang, Hou, 2004). In addition, Chou, Kuo, and Pen (2004) used the CGE model to estimate the damage of SARS to be 0.20%–1.80% of the GDP in China and 0.67% in Taiwan.

However, in a pandemic where a disease is not limited to one country, it is more suitable to assess the economic impact on a global scale, taking into account international trade and capital flow. Lee and McKibbin (2004) estimated the impact of SARS on the global economy through their global model, the G-Cubed model. SARS involved not only the medical costs associated with the disease but also economic costs from the reduction in trade and negative demand-side shocks. GDP changes in each country were estimated as 0.13% in Australia, 0.14% in the United States, 0.20% in Korea, 0.95% in Singapore, and 2.42% in China. Cho and Song (2009), in addition, built a multi-regional, multi-industry, fully dynamic model to estimate the impact of the H1N1 spread as a 0.50%–0.12% reduction of global GDP, with a 0.80%–4.60% reduction in GDP in a severe case.

The rapid spread of COVID-19 has incited vast amounts of research into its policy responses and the economic impact. McKibbin and Fernando (2020) expanded the G-Cubed model to COVID-19, analysing the impact on two agendas, one limited to China and another that impacts the whole world. Specifically, they applied the index of medical services to evaluate the impact on global economies as –0.1% to –9.9%. Keogh-Brown, Jensen, Edmunds, and Smith (2020) evaluated the impact of COVID-19 through direct disease effects and those of government restriction policies using the CGE model. They evaluated the impact on the United Kingdom as £40 billion in 2020, with preventative suppression actions including lockdowns imposing unprecedented economic losses.

3. Methodology

COVID-19 has manifested itself into the economy in multiple ways, where both supply-side and demand-side factors are negatively affected. First, the supply-side impact is displayed by a reduction in the labour supply, as there are permanent losses through deaths and temporary disruptions from medical treatments and child care. Further, closed schools and remote schooling may lead to a decrease in human capital formation in the long run, where the impact could be permanent to the economy.[1] A reduction in savings from falling income may lead to less capital accumulation and productivity, impacting the future long-term growth rate.

Demand-side shocks occur largely due to lockdowns and social distancing, which lead to a reduction in aggregate demand and household income. Social distancing impacts socio-economic activity levels, especially industries such as tourism, aviation, and hospitality. The global supply chain is also impacted due to the shutting down of factories and borders, restricting international mobility and disrupting the delivery–production–storage–consumption supply chain.

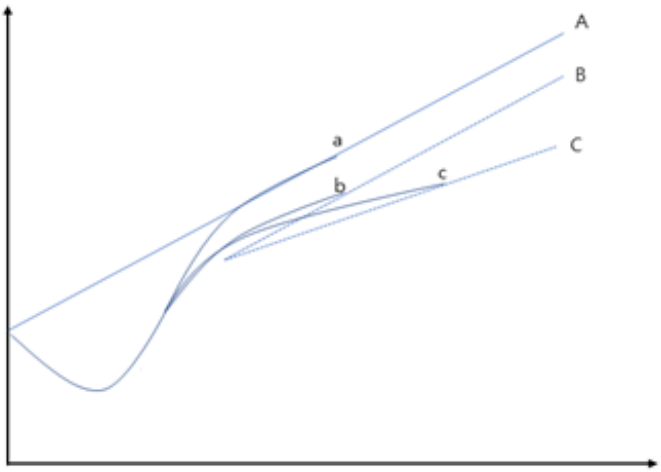
3.1. Level Effect and Growth Effect

While temporary labour shocks and short-term reductions in demand will recover over time from the COVID-19 pandemic, deaths, capital accumulation, and productivity may be permanently damaged in the long-term growth path. As shown in Figure 1, when the impact of shock is small, economies will return to the growth path seen in A, post-temporary GDP loss. However, if the lasting impact is large, this could lead to the growth paths of B and C through the transitory growth paths of b and c. B displays a lower level of income but returns to the former long-term growth path. However, if shock is severe enough that the growth path goes through the transitory growth of c and reaches the long-term rate at C, the long-term growth rate falls, and the growth gradient is lower than pre-pandemic levels. If C is

[1] According to Almond (2006), children during the Spanish flu had lower educational achievements, higher rates of disabilities, lower incomes, and lower socio-economic statuses. Hence, pandemics lead to severe negative impacts on human capital, independent of the deaths directly caused by the disease.

actualised in real-world economies, the pandemic shocks become larger as time progresses, as the lost GDP accumulates over time.

Figure 1: Three Growth Paths after the Economic shock



Source: Cho and Kim (2020).

3.2. Model and Data

Previous research, such as Beutels, Jia, Zhou, and Smith (2008), highlighted the need for general equilibrium models rather than traditional partial equilibrium forms of health economic evaluation to analyse the macroeconomic impact of a pandemic, in view of the multi-faceted and multi-sectoral impact of infectious disease outbreaks. Hence, this study analyses the effect of COVID-19 by setting up the Global CGE model, a dynamic model with neoclassical growth models underpinning trade and capital mobility across multiple regions and sectors.

The Global CGE model can be categorised as the Multiregional and Multisector Fully Dynamic CGE model. It assumes perfect foresight in all economic entities through which all present and future decisions are made. Similar to neoclassical growth models, households decide savings, spending, and leisure to maximise intertemporal utility. Savings lead to investment, which contributes to capital accumulation in the next period.

Although the model is based on an endogenous growth model, endogenous technology improvements are not assumed. The model was initially developed to analyse the economic impact of free trade agreements, but pandemics also impact the economy as well as the international goods and services trade.

3.2.1. Households

Each household in the region acts as a representative consumer, who maximises intertemporal utility under a budget constraint with perfect foresight:

$$maxU_r(Z_{r,t}) = \sum_{t=0} \beta^t \frac{Z_{r,t}^{1-\theta}}{1-\theta} \tag{1}$$

Here, β represents the discount rate, Z represents the final consumption composite good, and $1/\theta$ is the intertemporal elasticity of substitution.

The final composite good is formed for consumption composite good C and leisure, represented by the following constant elasticity of substitution function:

$$Z_{r,t} = \left[\alpha C_{r,t}^{\rho} + (1-\alpha)\left(1 - H_{r,t}\right)^{\rho}\right]^{\frac{1}{\rho}} \tag{2}$$

Here, $H_{r,t}$ represents the time given to a household in region r and time t, and $L_{r,t}$ represents the total labour hours. $1/1–\rho$ represents the elasticity of substitution between consumption and labour, and α is the constant for the proportion of each composite good.

The regional total time budget constraint is as follows:

$$\sum_t p_{c,r,t} C_{r,t} + \sum_t p_{k,r,t} I_{k,r,t} = \sum_t w_{r,t} L_{r,t} + \sum_t r_{r,t} K_{r,t} + \sum_t Tr_{r,t} \tag{3}$$

All prices seen in Equation (3) represent post-tax prices, with the time discount rate applied. At a steady state, $p_{c,r,t}$ is defined as $\frac{1}{(1+r_r^*)^{t-1}} p_{c,r,0}$. Here,

$p_{c,r,0}$ is the price of the composite consumption good in region *r*, and r_r^* is the steady state interest rate. $p_{k,r,t}$ is the post-tax price of investment good in region *r*, $w_{r,t}$ is the post-tax wage rate, and $r_{r,t}$ is the post-tax rate of return on capital. $Tr_{r,t}$ is the discounted value of government-transferred household income.

Total investment in the region is formed from household savings, government savings, and foreign capital inflow:

$$I_{r,t} = S_{h,r,t} + D_{g,r,t} + B_{r,t} \tag{4}$$

Cr,t is a composite good formed from imported and domestic goods as follows:

$$C_{r,t} = \left[\sum_i \alpha_{c,i,r,t} XA_{c,i,r,t}^{\rho}\right]^{\frac{1}{\rho}} \tag{5}$$

Here, *X,Ac,i,r,t* represents Armington composite good *i* consumed by household *c* in region *r*.

3.2.2. Production

Each industry in the region uses production factors and intermediate goods to produce final goods that are sold for domestic final demand or exported as intermediate goods to other regions. Income of industry *i* in region *r* at time *t* is formulated through the use of labour, capital, energy, composite goods, and Armington intermediate goods:

$$Y_{i,r,t} = \left[\alpha KL_{i,r,t}^{\rho} + (1-\alpha) XA_{i,r,t}^{\rho}\right]^{\frac{1}{\rho}} \tag{6}$$

Here, *KLi,r,t* is the composite good formed from capital and labour, and *XAi,r,t* is the Armington composite good formed from foreign and domestic goods. The final good produced is sold domestically or exported. Constant elasticity of transformation is assumed.

$XA_{i,r,t}$ is formed through three steps. First, transport costs depend on the region and good. If there are no alternative services for transport, transport is calculated through the Leontief Production Function. Then, the imported transport service is incorporated into the import composite good form, which in turn forms the Armington composite good through the incomplete substitution effect with the domestic composite good, $XA_{j,r,t}$:

$$XA_{j,r,t} = \left[\alpha XM_{j,r,t}^{\rho} + (1-\alpha)Y_{j,r,t}^{\rho}\right]^{\frac{1}{\rho}} \tag{7}$$

$XM_{j,r,t}$ is the formed import composite good from the imperfect substitution between import j from each region:

$$XM_{j,r,t} = \left[\sum_{s} \alpha_{j,s,r} YT_{j,s,r,t}^{\rho}\right]^{\frac{1}{\rho}} \tag{8}$$

$YT_{j,s,r}$ is the composite good formed from the transport cost $T_{j,s,r}$ incurred from importing good $Y_{j,s,r}$ from region r to region s. The transport service cost is fixed according to the region and the good. In other words, there is a fixed payment for importing good j from region r to region s:

$$YT_{j,s,r,t} = Y_{j,s,r,t} + T_{j,s,r,t} \tag{9}$$

The above formed Armington composite good is distributed as follows. It is divided into intermediate good $XA_{i,t}$, household consumption good $XA_{c,t}$, government consumption good $XA_{g,t}$, and investment good XA_{cgdmt}:

$$XA_{j,t} = XA_{i,t} + XA_{c,t} + XA_{g,t} + XA_{cgd,t} \tag{10}$$

The capital–labour–composite good is then formed through the following constant elasticity of substitution function:

$$KL_{i,r,t} = \left[\alpha K_{i,t}^{\rho} + (1-\alpha)L_{i,t}^{\rho}\right]^{\frac{1}{\rho}} \tag{11}$$

Here, *Ki,t* and *Li,t* represent the capital and labour used in region *r*, industry *i*. The capital in *t+1* in region *r* is then formed through the following:

$$K_{r,t+1} = (1 - \delta)K_{r,t} + I_{r,t} \tag{12}$$

$I_{r,t}$ is the total investment determined in Equation 4. Moreover, assuming there is an installation cost to convert the investment into capital, the quadratic adjustment cost proposed by Uzawa (1969) is applied:

$$I_{r,t} = J_{r,t}\left(1 + \emptyset\frac{J_{r,t}}{2K_{r,t}}\right) \tag{13}$$

Here, $J_{r,t}$ is the net investment, and $\emptyset$ is the adjustment speed. This implies that the higher the speed at which the investment is converted to capital, the higher the cost of conversion.[2] If $\emptyset$ is 0, there are no adjustment costs, meaning that the net investment is equal to the total investment.[3]

3.2.3. Population and Labour

By using the regional labour income available from the Global Trade Analysis Project 10 (Aguiar et al., 2019), the income per capita is estimated, and the loss of income from deaths, COVID-19 cases, and labour lost are calculated. The model uses involuntary unemployment to calculate the effect of COVID-19 on the labour market. Involuntary labour is often modelled through matching theory, efficiency wage theory, and migration theory.[4] All three theories summarise the relationship between wages and unemployment through the wage curve:

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[2] When the cost of installation incurs, the price of capital and the rate of returns to capital to sustain the equilibrium state of capital stock, investment, and returns to capital are as follows. If there are no installation costs, the price of capital is Pk* = (1+r)P*. If P* is normalised to 1, then it becomes Pk* = (1+r). If the price of installation is added, the marginal price of installation is Pk*= (1+r)(1+$\emptyset(\delta + g)$). If there are no installation costs, the rate of return to capital is Rk* = ($\delta + g$). If there are installation costs, excluding the pre-installed capital premium, the rate of return to capital is Rk* = Pk*(δ+r)/(1+r) – $\emptyset(\delta + g)2/2$.

[3] $\emptyset$ is set at 0.3 across all regions.

[4] Matching theory assumes that unemployment occurs through trade unions setting a higher wage than the market clearing wage level. Solow (1956) and Shapiro and Stiglitz (1984) used efficiency wage theory, where firms pay higher wages to employees to increase their productivity, setting

$$\frac{W_{r,t}}{P_{r,t}} = \left(\frac{ur_{r,t}}{ur_0}\right)^{\beta} \quad (14)$$

The left side of Equation (14) is the real income level determined in the model. The right side, ur_0, is the regional rate of unemployment. $ur_{r,t}$ is the rate of unemployment determined in the model, and β is the elasticity of labour according to wages. From the empirical works of Blanchflower and Oswald (1995), the elasticity is set to –0.1:

$$ur_{r,t} \leq a \quad (15)$$

The unemployment rate is limited to α since the entire population cannot be unemployed in reality.

3.2.4. Government

The government gains its revenue from labour income tax, capital income tax, consumption tax, import tax, and export tax, and expends it through government consumption and household transfers. The difference between revenue and expenditure is defined as a deficit or surplus. The government revenue $\Phi_{r,t}$ from region *r* is as follows:

$$\Phi_{r,t} + D_{g,r,t} = \sum_i \tau_{k,i,r,t} R_r K_{i,r,t} + \sum_i \tau_{l,i,r,t} W_r L_{i,r,t} + \sum_i \tau_{i,r,t} P + \sum_i \tau_{m,i,s,r,t} P_{m,i,s,r,t} XM_{i,s,r,t} + \sum_i \tau_{e,i,r,s,t} P_{e,i,r,s,t} XE_{i,r,s,t} \quad (16)$$

$D_{g,r,t}$ is the government revenue imbalance. $\tau_{k,i,r,t}$ is the tax rate for capital income, while R_r is the pre-tax rate of return on capital. $\tau_{l,i,r,t}$ is the tax rate on labour income from sector *i*, while W_r is the pre-tax wage rate. $\tau_{i,r,t}$ is the consumption tax rate from good *i*, and $P_{i,r,t}$ is the pre-tax price of the final product.

higher wages than the market equilibrium. Harris and Todaro (1970) used migration theory to suggest that workers migrate to higher-wage regions, causing unemployment.

$\tau_{m,i,r,s}$ is the tax rate on imported goods from region *r* to region *s* on good *i*, and $P_{m,i,s,r}$ is the pre-tax price of imports. $\tau_{e,i,r,s,t}$ is the tax rate on exported goods from region *r* to region *s* on good *i*, while $P_{e,i,s,r,t}$ is the pre-tax price of exports.

Government expenditure $\Gamma_{r,t}$ is defined as follows:

$$\Gamma_{r,t} = \sum_{i} p_{xa,r,t} XA_{g,i,r,t} + Tr_{r,t} \tag{17}$$

$p_{xa,r,t}$ is the post-tax price of Armington good $XA_{g,i,r,t}$. $Tr_{r,t}$ is the transferred household income from the government.

3.2.5. Trade

Assuming that the movement of capital is unrestricted, the trade deficit imbalance is adjusted by the transfer of capital as follows:

$$\sum_{i} \sum_{s} P_{xe,i,r,s,t} XE_{i,r,s,t} - \sum_{i} \sum_{s} P_{xm,i,s,r} XM_{i,s,r,t} = B_{r,t} \tag{18}$$

Here, $P_{xe,i,r,s,t}$ and $XE_{i,r,s,t}$ are the price and quantity of exported good *i* at time *t* from region *r* to region *s*. Respectively, $P_{xm,i,s,r}$ and $XM_{i,s,r,t}$ are the price and quantity of imported good *i* at time *t* from region *r* to region *s*. $B_{r,t}$ is the net export from subtracting imports from exports.

While there can be regional imbalance in imports and exports, in terms of the entire globe, there are no imbalances. Since this is a zero-sum phenomenon, the following equation is satisfied:

$$\sum_{r} B_{r,t} = 0 \tag{19}$$

3.2.6. Regions

For this study, regions of interest are divided into Korea, the United States, Japan, China, the European Union and the United Kingdom, Asia including Association of Southeast Asian Nations (ASEAN) Member States, and rest of world (Table 1).

Table 1: Regions of Interest

Region	Countries
KOR	Korea
USA	United States
JPN	Japan
CHN	China
EUUK	Austria, Belgium, Bulgaria, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom
ASIA	Bangladesh, Hong Kong, India, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, Viet Nam, Rest of South–East Asia, Rest of South Asia
ROW	Rest of the World

Source: Authors.

Industries of interest are divided into agriculture, manufacturing, construction, wholesale and retail, hospitality and food, transport, medical, and the rest. Baseline data were collected from the Organisation of Economic Co-operation and Development and International Monetary Fund, and the quarterly growth rates are assumed to be one-fourth of the annual growth rate (Table 2). The period of analysis is 40 quarters starting from the first quarter of 2020. The data used are from the Global Trade Analysis Project 2014; hence, production capabilities are adjusted upwards for 2019 levels.

Table 2: Base Gross Domestic Product and Growth Rate

	Gross Domestic Product, 2019 ($ billion)	Growth Rate (%)	
		Annual	Quarterly
KOR	1,642.4	2.6	0.64
USA	21,427.7	2.5	0.62
JPN	5,081.8	1.2	0.30
CHN	14,342.9	6.1	1.52
EUUK	19,526.3	1.2	0.31
ASIA	6,389.4	5.1	1.28
ROW	16,889.2	3.0	0.75
World	85,299.7	3.2	0.79

Sources: World Bank (2020) and authors' calculations.

3.2.7. Scenarios and Assumptions

It is assumed that the COVID-19 pandemic lasts for eight quarters. For the first three quarters, intermediate–goods trade and the demand shock index are adjusted to calibrate the regional growth rate, as well as model estimates based on the actual growth rates of regions for those quarters. Two scenarios are set, varying the number of cases from the fourth quarter, to illustrate the possibility and severity of a second wave. The fatality rate and leave rate are assumed to be the same as the actual rates in the first three quarters; however, the supply shocks are expanded from the fourth quarter following these scenarios:

(i) S1 (Low) presumes that in quarter 4, the number of cases stays the same as in quarter 3 and gradually diminishes from quarter 5 before being completely eradicated in quarter 10; and

(ii) S2 (High) presumes that in quarter 4, the number of cases rise from that in quarter 3 by 50%, gradually diminishing from quarter 5 before being completely eradicated in quarter 11.

Table 3: Number of COVID-19 Cases for Scenarios, Low and High

Scenarios	Q1–Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
Low	Actual	Actual (Base)	1.00	0.75	0.50	0.25	0.10	0.05	0.00	0.00
High			1.50	1.25	1.00	0.75	0.50	0.25	0.10	0.00

Q = quarter.
Note: The figures are indexed to the actual figures of the third quarter.
Source: Authors' assumptions.

Table 4: COVID–19 Actual Cases and Deaths

(number of persons)

	Total Cases			Deaths		
	Q1	**Q2**	**Q3**	**Q1**	**Q2**	**Q3**
KOR	9,787	3,015	11,012	163	119	131
USA	164,621	2,425,933	4,600,509	3,170	122,970	79,858
JPN	1,954	16,641	64,417	56	916	592
CHN	82,215	2,540	5,748	3,309	1,332	98
EUUK	430,931	1,127,154	1,804,696	27,852	147,435	16,417
ASIA	10,496	861,092	6,461,860	299	22,685	96,543
ROW	108,941	5,044,735	10,539,341	3,878	167,934	313,345
WORLD	808,945	9,481,110	23,487,583	38,727	463,391	506,984

Q = quarter.
Source: Authors' calculations from Johns Hopkins University (2020).

Those infected are assumed to exit the labour market on average for 4 weeks due to treatment and quarantine. Those who die are completely removed from the labour market. The number of working days per year is 220, and the percentage of parents/guardians needing to take time off work if schools are closed is estimated. Following Sadique, Adams, and Edmunds (2006) and Smith, Keogh-Brown, Barnett, and Tait (2009), the loss of labour due to care of family is calculated as 16.1%, and 46.0% for those who do not have alternative sources for care. School closures in the first scenario are set at 8 weeks, and 12 weeks for the high scenario.

Demand-side shocks are set from previous studies conducted by the Congressional Budget Office (2005) and Cho and Song (2009) (Table 5). These shocks are then calibrated according to the actual regional growth rate in the first three quarters. Subsequent quarters are adjusted with the number of cases in

respective scenarios. Supply-side shocks are set from the supply chain of imported and domestic goods, where they are assumed to be one-tenth of the demand-side shocks. Compared to the previous literature, more realistic outcomes can be estimated regarding parameters of infection rates and case fatality rates by employing actual index and data in the first three quarters.

Table 5: Degree of Impact by Industry

(%)

Industry	Degree of Impact
Agriculture	3.0
Manufacturing	3.0
Construction	3.0
Retail	3.0
Accommodations and Food Services	20.0
Transport	17.0
Recreational, Cultural, and Sports	20.0
Health	–4.0
Other services	1.0

Sources: Authors' assumptions based on the Congressional Budget Office (2005) and Cho and Song (2009).

4. Results

The economic impact of the COVID–19 pandemic can be separated into short- and long-term. These negative shocks affect global supply and demand, including the level of global trade. This phenomenon is not only limited to today's global economies but also those into the future. While the short-term impact decays over time, permanent long-term negative effects exist to the income level and growth gradient.

4.1. Growth Rate

Table 6 shows the change in the economic growth rate in the low scenario, representing gradually decreasing infected cases. In all economies, a recovery is obvious from the third quarter. The magnitude of this recovery is proportional to the size of the dip in the second quarter, except for China, which has a positive growth rate. If the number of cases are assumed to be the same in the fourth quarter as the third quarter, the growth rate is expected to be lower. For there to be a growth rate greater than that in the previous quarter, COVID-19 should be less severe in the following quarter. In 2021, when the number of infected cases is assumed to fall for all countries, they are expected to have growth rates higher than the baseline growth rate. In particular, the United States will have the highest growth rate of 8.97%. Asia will have a relatively low growth rate in 2021 due to the base effect from the relatively high growth rate in 2020. All economies are expected to have a lower growth rate than their business-as-usual growth rate by quarter 10.

Table 6: Quarterly Growth Rate, Low Scenario

(%)

Q	KOR	USA	JPN	CHN	EUUK	ASIA	ROW	WLD
1	–1.33	–1.31	–0.63	–10.11	–3.64	0.58	–2.34	–3.24
2	–3.12	–9.50	–5.91	11.55	–12.15	–5.84	–8.64	–6.46
3	2.14	7.42	5.28	2.71	8.91	12.53	8.82	7.48
4	0.58	0.44	0.23	1.56	0.14	1.35	0.65	0.66
5	1.51	2.32	0.67	1.78	2.20	0.34	1.52	1.75
6	1.92	3.12	0.88	1.88	3.05	–0.25	1.93	2.21
7	1.57	2.40	0.73	1.79	2.23	0.06	1.61	1.79
8	0.91	1.14	0.41	1.61	0.83	0.88	0.98	1.04
9	0.65	0.66	0.27	1.53	0.32	1.20	0.73	0.76
10	0.62	0.61	0.26	1.51	0.27	1.24	0.70	0.73
11	0.62	0.61	0.27	1.50	0.27	1.23	0.70	0.73
12	0.62	0.61	0.27	1.50	0.27	1.23	0.70	0.73
13	0.65	0.64	0.29	1.51	0.29	1.24	0.72	0.75
14	0.62	0.61	0.27	1.49	0.27	1.22	0.70	0.73
15	0.62	0.61	0.27	1.48	0.28	1.21	0.70	0.73

16	0.62	0.60	0.28	1.47	0.28	1.21	0.70	0.73
17	0.62	0.60	0.28	1.47	0.28	1.20	0.70	0.73
18	0.62	0.60	0.28	1.46	0.28	1.20	0.70	0.73
19	0.62	0.60	0.28	1.46	0.28	1.19	0.70	0.73
20	0.62	0.60	0.28	1.45	0.28	1.19	0.70	0.73
40	0.61	0.54	0.29	1.42	0.26	1.14	0.66	0.73
2020	–1.73	–2.95	–1.02	5.70	–6.73	8.63	–1.50	–1.56
2021	5.90	8.97	2.69	7.06	8.32	1.03	6.04	6.79

Q = quarter.
Source: Authors' calculations.

In the high scenario of the second wave, the rise in cases is assumed to continue into the fourth quarter, hence lowering the growth rate across all regions except for China and Asia (Table 7). In particular, the growth rate of the European Union and United Kingdom is estimated to fall to –4.28% in the fourth quarter. The United States dips to –3.60%, and Korea is expected to have a growth rate of –1.36%. Asia behaves differently, as demand increases in the first three quarters despite the rise in cases. If such behaviour continues, it is expected to have a positive growth rate in the fourth quarter. The growth rate of all regions are expected to be negative in 2020 and positive in 2021 with the base effect.

Table 7: Quarterly Growth Rate, High Scenario

(%)

Q	KOR	USA	JPN	CHN	EUUK	ASIA	ROW	WLD
1	–1.33	–1.31	–0.63	–10.11	–3.64	0.58	–2.34	–3.24
2	–3.12	–9.50	–5.91	11.55	–12.15	–5.84	–8.64	–6.46
3	2.14	7.42	5.28	2.71	8.91	12.53	8.82	7.48
4	–1.36	–3.60	–0.67	1.06	–4.28	3.23	–1.17	–1.70
5	–1.02	–3.19	–0.48	1.15	–3.77	2.68	–0.82	–1.37
6	0.52	0.22	0.21	1.51	–0.01	1.31	0.57	0.56
7	2.50	4.78	1.09	1.97	4.94	–0.38	2.35	3.05
8	3.24	6.10	1.48	2.16	6.33	–1.41	3.10	3.84
9	2.41	4.14	1.13	1.96	4.14	–0.97	2.38	2.76
10	1.12	1.58	0.50	1.62	1.31	0.48	1.16	1.28
11	0.66	0.71	0.28	1.49	0.36	1.09	0.71	0.76
12	0.60	0.60	0.25	1.47	0.24	1.16	0.66	0.70
13	0.64	0.65	0.28	1.49	0.27	1.18	0.68	0.73
14	0.60	0.60	0.25	1.46	0.24	1.15	0.65	0.70
15	0.60	0.60	0.26	1.45	0.25	1.14	0.65	0.70
16	0.60	0.59	0.26	1.45	0.25	1.14	0.65	0.70
17	0.60	0.59	0.26	1.44	0.25	1.14	0.65	0.70
18	0.60	0.59	0.26	1.44	0.25	1.13	0.65	0.70
19	0.60	0.58	0.26	1.43	0.25	1.13	0.64	0.69
20	0.60	0.58	0.26	1.43	0.25	1.12	0.64	0.69
40	0.57	0.44	0.27	1.39	0.17	1.04	0.54	0.64
2020	–3.67	–6.99	–1.93	5.20	–11.16	10.50	–3.32	–3.92
2021	5.25	7.90	2.30	6.79	7.49	2.21	5.20	6.09

Q = quarter.
Source: Authors' calculations.

As the growth rate of the United States fell to –2.5% during the 2008 global financial crisis and to –12.9% during the Great Depression, the impact of COVID-19 could be disastrous to the economic conditions in the following quarters. A graphical illustration of such growth rates is in Figure 2.

Figure 2: Quarterly Growth Rate

(%)

Source: Authors' calculations.

4.2. Gross Domestic Product Change

In Table 8, GDP change in the low scenario compared to the baseline case meaning the growth rate of 2019 is provided. While the growth rate can become higher than that in the baseline scenario due to a V-shaped recovery, the scale of the GDP remains below the baseline GDP. The most severe shock to GDP is in the European Union and United Kingdom, where they have a –8.1% GDP change. However, from the aforementioned behaviour of Asia, the GDP is expected to increase in Asia. A V-shaped recovery to the economy is expected in 2021 as business and/or consumer confidence rejuvenates, and various government stimuli are implemented. In 2021, the shrinkage is largely alleviated, but the GDP still decreases across all regions.

Table 8: Changes in Gross Domestic Product Relative to Business as Usual, Low Scenario

(%)

Q	KOR	USA	JPN	CHN	EUUK	ASIA	ROW	WLD
1	–1.82	–1.92	–0.88	–11.44	–3.95	–0.66	–3.07	–3.95
2	–5.49	–11.78	–6.97	–2.78	–15.83	–7.71	–12.08	–10.81
3	–4.08	–5.81	–2.30	–1.71	–8.57	2.48	–5.03	–4.84
4	–3.84	–6.54	–2.04	–1.41	–8.05	3.51	–4.23	–4.53
5	–3.01	–4.95	–1.64	–1.21	–6.28	2.50	–3.49	–3.58
6	–1.78	–2.59	–1.03	–0.90	–3.68	0.92	–2.34	–2.17
7	–0.87	–0.86	–0.58	–0.67	–1.80	–0.33	–1.50	–1.15
8	–0.61	–0.34	–0.45	–0.60	–1.26	–0.74	–1.27	–0.86
9	–0.60	–0.29	–0.45	–0.61	–1.22	–0.83	–1.27	–0.85
10	–0.62	–0.30	–0.46	–0.63	–1.24	–0.88	–1.31	–0.87
11	–0.64	–0.30	–0.48	–0.64	–1.26	–0.93	–1.35	–0.90
12	–0.66	–0.31	–0.49	–0.66	–1.29	–0.98	–1.38	–0.92
13	–0.65	–0.28	–0.49	–0.65	–1.29	–1.01	–1.41	–0.92
14	–0.67	–0.29	–0.50	–0.67	–1.32	–1.06	–1.45	–0.95
15	–0.69	–0.30	–0.52	–0.69	–1.34	–1.11	–1.49	–0.97
16	–0.71	–0.31	–0.53	–0.70	–1.37	–1.15	–1.53	–1.00
17	–0.73	–0.32	–0.55	–0.72	–1.40	–1.20	–1.57	–1.02

18	–0.75	–0.33	–0.56	–0.74	–1.43	–1.25	–1.61	–1.05
19	–0.77	–0.34	–0.58	–0.75	–1.46	–1.30	–1.66	–1.08
20	–0.79	–0.36	–0.59	–0.77	–1.49	–1.34	–1.70	–1.11
40	–1.27	–1.10	–0.96	–1.16	–2.48	–2.46	–3.00	–1.97
2020	–3.60	–6.89	–2.84	–4.06	–8.65	0.11	–5.50	–5.76
2021	–1.56	–2.17	–0.92	–0.84	–3.25	0.57	–2.14	–1.93

Q = quarter.
Source: Authors' calculations.

The high case GDP loss can be seen in Table 9, where this is proportional to the magnitude of the pandemic, except in Asia. The GDP in Asia is simulated to increase in 2021, since Asia displays a behaviour where demand increases as COVID-19 worsens. The GDP of all regions except for Asia is expected to permanently reduce by a proportion.

The graphical illustration is in Figure 3.

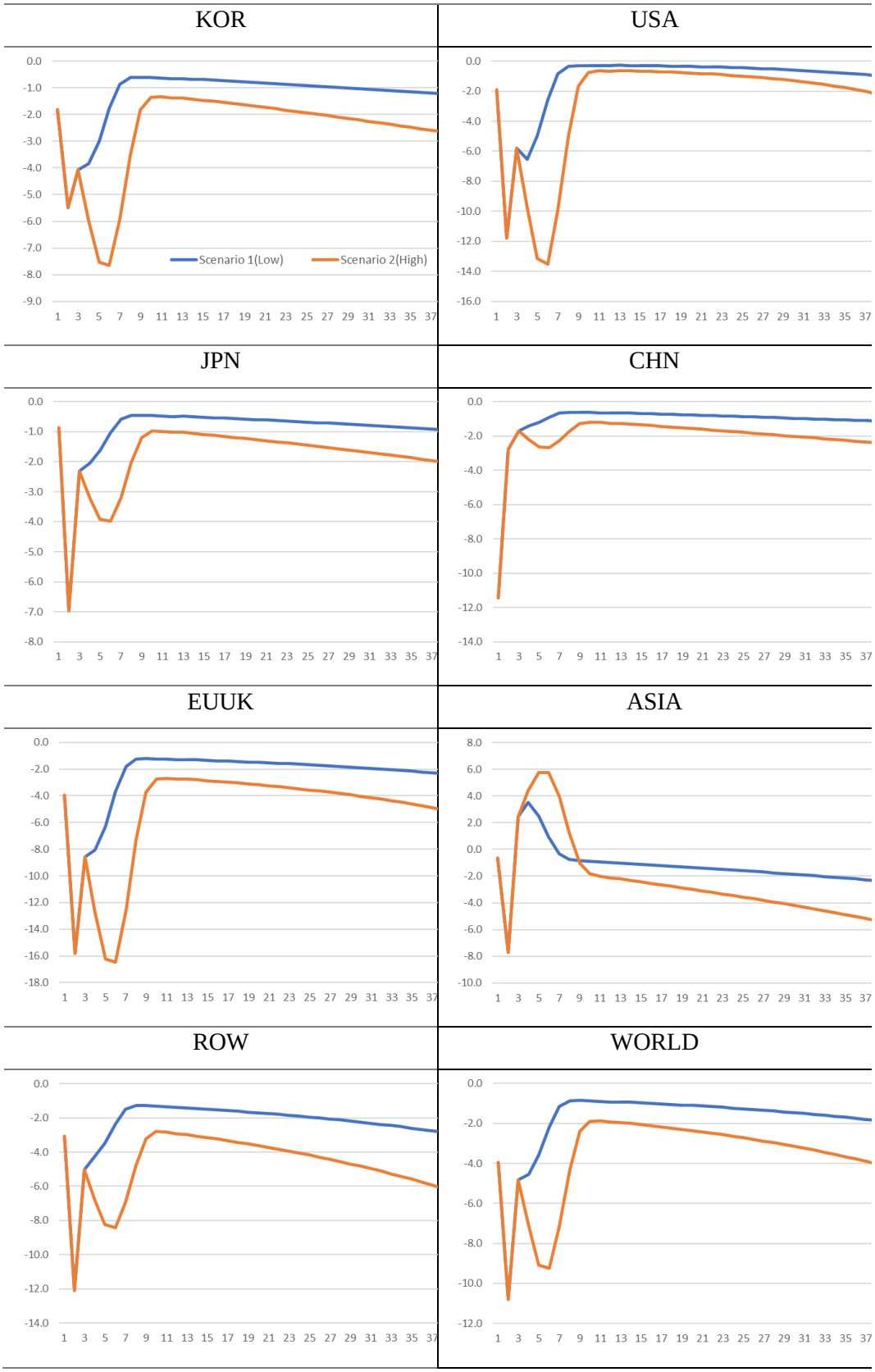
Table 9: Changes in Gross Domestic Product Relative to Business as Usual, High Scenario

(%)

Q	KOR	USA	JPN	CHN	EUUK	ASIA	ROW	WLD
1	–1.82	–1.92	–0.88	–11.44	–3.95	–0.66	–3.07	–3.95
2	–5.49	–11.78	–6.97	–2.78	–15.83	–7.71	–12.08	–10.81
3	–4.08	–5.81	–2.30	–1.71	–8.57	2.48	–5.03	–4.84
4	–5.99	–9.75	–3.21	–2.22	–12.71	4.39	–6.82	–7.14
5	–7.53	–13.16	–3.93	–2.62	–16.22	5.78	–8.26	–9.09
6	–7.64	–13.51	–3.98	–2.67	–16.46	5.77	–8.41	–9.25
7	–5.94	–9.93	–3.20	–2.28	–12.57	4.01	–6.94	–7.17
8	–3.51	–5.01	–2.04	–1.68	–7.29	1.23	–4.76	–4.31
9	–1.81	–1.69	–1.20	–1.27	–3.73	–1.03	–3.21	–2.40
10	–1.35	–0.74	–0.98	–1.18	–2.74	–1.82	–2.81	–1.89
11	–1.33	–0.65	–0.98	–1.21	–2.68	–2.01	–2.84	–1.88
12	–1.37	–0.66	–1.02	–1.25	–2.73	–2.12	–2.92	–1.93
13	–1.38	–0.62	–1.02	–1.26	–2.75	–2.21	–2.98	–1.95
14	–1.42	–0.64	–1.05	–1.30	–2.81	–2.32	–3.06	–2.00
15	–1.46	–0.66	–1.09	–1.35	–2.86	–2.43	–3.15	–2.05
16	–1.51	–0.68	–1.12	–1.39	–2.92	–2.54	–3.24	–2.11
17	–1.55	–0.70	–1.15	–1.43	–2.98	–2.66	–3.33	–2.17
18	–1.59	–0.73	–1.19	–1.47	–3.04	–2.77	–3.43	–2.23
19	–1.64	–0.76	–1.22	–1.52	–3.11	–2.88	–3.53	–2.29
20	–1.69	–0.79	–1.26	–1.56	–3.17	–2.99	–3.63	–2.36
40	–2.75	–2.45	–2.09	–2.49	–5.32	–5.65	–6.49	–4.29
2020	–4.35	–7.33	–3.34	–4.48	–10.27	–0.34	–6.75	–6.69
2021	–6.14	–10.38	–3.29	–2.31	–13.12	4.17	–7.08	–7.44

Q = quarter.
Source: Authors' calculations.

Figure 3: Changes in Gross Domestic Product Relative to Business as Usual (%)



Source: Authors' calculations.

4.3. Scale Effect and Growth Effect

As with Figure 1, how COVID-19 diverts the growth path in terms of slope and level of economies is explored. Table 10 shows the GDP change in scale in the low scenario. In 2021, except for Asia, there is GDP loss in every country, and the world economy is expected to decrease by $1,676.8 billion in 2021.

Table 10: Decline in Gross Domestic Product Relative to Business as Usual, Low Scenario

($ billion)

Q	KOR	USA	JPN	CHN	EUUK	ASIA	ROW	WLD
1	–7.52	–103.42	–11.17	–416.36	–193.33	–10.68	–130.52	–872.99
2	–22.79	–638.81	–88.95	–102.66	–777.40	–126.40	–517.81	–2,274.81
3	–17.05	–317.19	–29.47	–64.26	–421.67	41.11	–216.93	–1,025.46
4	–16.14	–358.97	–26.12	–53.66	–397.35	59.16	–184.08	–977.15
5	–12.74	–273.52	–21.06	–46.71	–310.52	42.70	–152.66	–774.51
6	–7.58	–143.80	–13.32	–35.36	–182.33	15.89	–103.34	–469.84
7	–3.75	–48.12	–7.48	–26.68	–89.51	–5.71	–66.58	–247.82
8	–2.64	–19.28	–5.78	–24.47	–62.69	–13.09	–56.69	–184.65
9	–2.61	–16.65	–5.80	–25.16	–61.02	–14.87	–57.48	–183.59
10	–2.70	–16.88	–6.00	–26.17	–62.15	–16.01	–59.49	–189.39
11	–2.80	–17.34	–6.21	–27.22	–63.48	–17.13	–61.62	–195.80
12	–2.91	–17.86	–6.43	–28.32	–64.87	–18.27	–63.82	–202.46
13	–2.90	–16.27	–6.38	–28.62	–65.34	–19.08	–65.35	–203.93
14	–3.00	–16.80	–6.59	–29.74	–66.81	–20.24	–67.66	–210.85
15	–3.11	–17.40	–6.81	–30.91	–68.34	–21.42	–70.04	–218.03
16	–3.22	–18.07	–7.03	–32.12	–69.93	–22.62	–72.51	–225.51
17	–3.33	–18.82	–7.26	–33.37	–71.59	–23.85	–75.07	–233.29
18	–3.45	–19.64	–7.49	–34.66	–73.31	–25.11	–77.72	–241.38
19	–3.57	–20.54	–7.73	–36.00	–75.11	–26.40	–80.46	–249.80
20	–3.69	–21.53	–7.96	–37.38	–76.99	–27.72	–83.31	–258.58
21	–3.81	–22.61	–8.21	–38.81	–78.94	–29.08	–86.26	–267.72
22	–3.94	–23.79	–8.46	–40.28	–80.98	–30.47	–89.32	–277.25
23	–4.07	–25.08	–8.71	–41.81	–83.11	–31.91	–92.50	–287.18
24	–4.21	–26.48	–8.97	–43.38	–85.32	–33.38	–95.80	–297.53
25	–4.35	–28.00	–9.23	–45.00	–87.63	–34.90	–99.22	–308.33

26	–4.49	–29.66	–9.50	–46.66	–90.04	–36.47	–102.78	–319.58
27	–4.63	–31.46	–9.77	–48.38	–92.55	–38.08	–106.48	–331.35
28	–4.78	–33.41	–10.05	–50.15	–95.17	–39.74	–110.33	–343.63
29	–4.93	–35.53	–10.33	–51.96	–97.90	–41.46	–114.33	–356.45
30	–5.08	–37.83	–10.61	–53.83	–100.75	–43.24	–118.49	–369.85
31	–5.24	–40.33	–10.90	–55.74	–103.72	–45.07	–122.82	–383.83
32	–5.40	–43.05	–11.20	–57.70	–106.82	–46.97	–127.33	–398.45
33	–5.56	–46.00	–11.50	–59.72	–110.05	–48.93	–132.01	–413.75
34	–5.72	–49.20	–11.80	–61.77	–113.42	–50.96	–136.89	–429.75
35	–5.89	–52.68	–12.11	–63.87	–116.93	–53.06	–141.97	–446.50
36	–6.05	–56.46	–12.43	–66.01	–120.60	–55.23	–147.25	–464.03
37	–6.22	–60.58	–12.74	–68.20	–124.43	–57.48	–152.75	–482.38
38	–6.39	–65.05	–13.06	–70.42	–128.42	–59.81	–158.48	–501.63
39	–6.56	–69.92	–13.38	–72.67	–132.59	–62.23	–164.45	–521.78
40	–6.73	–75.23	–13.71	–74.95	–136.93	–64.73	–170.65	–542.93
2020	–63.50	–1,418.38	–155.72	–636.93	–1,789.75	–36.80	–1,049.34	–5,150.42
2021	–26.70	–484.72	–47.64	–133.22	–645.05	39.79	–379.27	–1,676.81

Q = quarter.
Source: Authors' calculations.

As Table 11 illustrates, GDP loss is more drastic in the high scenario, amassing to $5,709.5 billion in 2020 and $6,528.2 billion in 2021. This GDP loss is permanent, and the gap between the baseline path and estimated path widens.

Table 11: Decline in Gross Domestic Product Relative to Business as Usual, High Scenario

($ billion)

Q	KOR	USA	JPN	CHN	EUUK	ASIA	ROW	WLD
1	–7.52	–103.42	–11.17	–416.36	–193.33	–10.68	–130.52	–872.99
2	–22.79	–638.81	–88.95	–102.66	–777.40	–126.40	–517.81	–2,274.81
3	–17.05	–317.19	–29.47	–64.26	–421.67	41.11	–216.93	–1,025.46
4	–25.18	–535.39	–41.23	–84.58	–627.25	73.84	–296.44	–1,536.22
5	–31.89	–727.11	–50.55	–101.63	–802.66	98.56	–361.61	–1,976.90
6	–32.56	–750.60	–51.40	–105.28	–816.55	99.74	–371.08	–2,027.71
7	–25.46	–555.08	–41.41	–90.99	–625.40	70.23	–308.58	–1,576.68
8	–15.12	–281.95	–26.40	–68.28	–363.84	21.80	–213.07	–946.87
9	–7.86	–95.40	–15.62	–52.47	–186.62	–18.56	–144.69	–521.22
10	–5.89	–42.28	–12.75	–49.47	–137.68	–33.10	–127.61	–408.77

11	–5.86	–37.21	–12.84	–51.35	–134.77	–37.03	–129.82	–408.88
12	–6.08	–38.26	–13.31	–53.91	–137.68	–39.63	–134.59	–423.45
13	–6.14	–36.20	–13.39	–55.30	–139.29	–41.77	–138.40	–430.47
14	–6.37	–37.36	–13.87	–57.94	–142.40	–44.43	–143.43	–445.79
15	–6.60	–38.67	–14.35	–60.68	–145.65	–47.15	–148.63	–461.72
16	–6.84	–40.13	–14.85	–63.49	–149.04	–49.93	–154.01	–478.29
17	–7.08	–41.77	–15.35	–66.40	–152.58	–52.77	–159.58	–495.52
18	–7.33	–43.58	–15.86	–69.39	–156.27	–55.68	–165.35	–513.46
19	–7.59	–45.57	–16.39	–72.48	–160.12	–58.66	–171.34	–532.14
20	–7.86	–47.76	–16.92	–75.67	–164.14	–61.71	–177.54	–551.59
21	–8.13	–50.15	–17.46	–78.95	–168.34	–64.85	–183.97	–571.86
22	–8.42	–52.77	–18.02	–82.33	–172.71	–68.08	–190.65	–592.98
23	–8.70	–55.63	–18.59	–85.81	–177.28	–71.40	–197.58	–615.01
24	–9.00	–58.75	–19.16	–89.40	–182.05	–74.82	–204.78	–637.95
25	–9.30	–62.14	–19.75	–93.09	–187.02	–78.34	–212.27	–661.90
26	–9.61	–65.83	–20.35	–96.88	–192.21	–81.97	–220.04	–686.90
27	–9.93	–69.84	–20.96	–100.79	–197.63	–85.72	–228.12	–713.00
28	–10.25	–74.20	–21.58	–104.80	–203.28	–89.60	–236.53	–740.25
29	–10.58	–78.94	–22.21	–108.92	–209.18	–93.60	–245.27	–768.70
30	–10.92	–84.08	–22.86	–113.14	–215.34	–97.74	–254.36	–798.43
31	–11.26	–89.67	–23.51	–117.47	–221.76	–102.02	–263.83	–829.50
32	–11.61	–95.73	–24.18	–121.91	–228.47	–106.46	–273.68	–862.03
33	–11.97	–102.33	–24.85	–126.44	–235.46	–111.05	–283.93	–896.03
34	–12.32	–109.50	–25.54	–131.08	–242.76	–115.81	–294.60	–931.60
35	–12.69	–117.29	–26.23	–135.82	–250.38	–120.74	–305.71	–968.88
36	–13.05	–125.76	–26.94	–140.65	–258.33	–125.86	–317.28	–1,077.88
37	–13.43	–134.99	–27.65	–145.57	–266.63	–131.16	–329.34	–1,048.75
38	–13.80	–145.02	–28.37	–150.57	–275.30	–136.67	–341.89	–1,091.60
39	–14.17	–155.95	–29.10	–155.64	–284.34	–142.38	–354.97	–1,136.53
40	–14.54	–167.85	–29.84	–160.78	–293.77	–148.31	–368.59	–1,183.68
2020	–72.54	–1,594.79	–170.83	–667.86	–2,019.64	–22.13	–1,161.70	–5,709.49
2021	–105.04	–2,314.74	–169.75	–366.17	–2,068.45	290.34	–1,254.34	–6,258.16

Q = quarter.
Source: Authors' calculations.

Table 12 illustrates the annual average loss of GDP compared to the business-as-usual scenario, after quarter 13 when the economies are expected to return to the long-term equilibrium growth path. For Korea, in the low scenario, this leads to an annual average loss of $18.6 billion and $39.9 billion in the high scenario, for example.

Table 12: Scale Effect and Growth Effect

	KOR	USA	JPN	CHN	EUUK	ASIA	ROW	WLD
A. Scale Effect ($ billion)								
BAU	1,945.30	25,226.47	5,482.03	21,462.29	21,141.63	8,968.27	20,585.38	104,811.37
Low	–18.62	–143.06	–39.13	–196.30	–379.10	–155.66	–437.46	–1,369.3
High	–39.93	–318.20	–84.02	–408.76	–810.24	–351.24	–937.95	–2,950.3
B. Growth Effect (%)								
SGR	2.6	2.5	1.2	6.1	1.2	5.1	3.0	3.2
Low	–0.13	–0.11	–0.10	–0.12	–0.25	–0.26	–0.31	–0.19
High	–0.29	–0.25	–0.21	–0.27	–0.55	–0.61	–0.69	–0.43

BAU = business as usual, SGR = difference between the baseline and the annual average growth rate.
Source: Authors' calculations.

The growth effect is calculated as the difference between the baseline (i.e. the growth rate of 2019) and the annual average growth rate in each scenario. The long-term growth gradient of the world economy is expected to fall by 0.19%. In the case of the high scenario, the growth rate of the world economy is reduced by 0.43%. Such scale effect and growth effect lead to a widening of the gap and a lowering of the growth gradient as time passes.

4.4. Trade

As with the GDP change, except for Asia, trade decreases in all regions compared to the equilibrium (Table 13). In the low scenario, the value of trade decreases by 0.8% in Asia, 3.4% in Japan, 3.5% in Korea, 4.2% in China, 5.2% in the rest of the world, 6.9% in the United States, and 8.1% in the European Union and United Kingdom. Global trade is expected to decrease by 5.7%. In 2021, when COVID-19 is assumed to ameliorate, global trade will decrease by –1.8% relative to the baseline scenario.

Table 11: Changes in Trade Relative to Business as Usual, Low Scenario

(%)

Q	KOR	USA	JPN	CHN	EUUK	ASIA	ROW	WLD
1	–2.60	–2.54	–2.33	–6.43	–3.29	–1.18	–2.88	–3.18
2	–5.47	–12.50	–7.37	–6.16	–14.97	–7.57	–11.02	–11.28
3	–2.90	–5.76	–2.11	–2.32	–7.50	1.29	–4.21	–4.56
4	–2.96	–6.25	–2.01	–2.19	–7.40	2.09	–3.87	–4.38
5	–2.31	–4.86	–1.54	–1.75	–5.72	1.56	–3.11	–3.42
6	–1.32	–2.76	–0.85	–1.11	–3.25	0.65	–1.97	–2.03
7	–0.60	–1.21	–0.36	–0.66	–1.49	–0.11	–1.14	–1.05
8	–0.40	–0.72	–0.23	–0.54	–0.98	–0.40	–0.93	–0.77
9	–0.41	–0.65	–0.25	–0.55	–0.95	–0.49	–0.95	–0.77
10	–0.43	–0.63	–0.28	–0.58	–0.97	–0.56	–0.99	–0.80
11	–0.46	–0.61	–0.31	–0.61	–0.99	–0.63	–1.04	–0.83
12	–0.48	–0.60	–0.34	–0.63	–1.02	–0.70	–1.08	–0.86
13	–0.49	–0.55	–0.35	–0.64	–1.02	–0.75	–1.11	–0.87
14	–0.51	–0.54	–0.38	–0.66	–1.05	–0.81	–1.15	–0.90
15	–0.54	–0.53	–0.41	–0.69	–1.07	–0.87	–1.20	–0.93
16	–0.57	–0.53	–0.44	–0.72	–1.10	–0.93	–1.24	–0.97
17	–0.59	–0.53	–0.47	–0.75	–1.13	–1.00	–1.29	–1.00
18	–0.62	–0.53	–0.50	–0.78	–1.16	–1.06	–1.33	–1.03
19	–0.65	–0.54	–0.54	–0.81	–1.19	–1.11	–1.38	–1.07
20	–0.68	–0.55	–0.57	–0.84	–1.22	–1.17	–1.42	–1.10
40	–1.41	–1.42	–1.38	–1.66	–2.20	–2.39	–2.63	–2.12
2020	–3.46	–6.94	–3.37	–4.15	–8.13	–0.83	–5.20	–5.67
2021	–1.15	–2.38	–0.74	–1.01	–2.86	0.42	–1.78	–1.81

Q = quarter.
Source: Authors' calculations.

Table 14 shows that in the high scenario, the decrease in trade is higher. Global trade is expected to decrease by 6.5% in 2020 and 7.3% in 2021, as the number of COVID-19 cases are assumed to rise continuously into the fourth quarter.

Table 14: Changes in Trade Relative to Business as Usual, High Scenario

(%)

Q	KOR	USA	JPN	CHN	EUUK	ASIA	ROW	WLD
1	–2.60	–2.54	–2.33	–6.43	–3.29	–1.18	–2.88	–3.18
2	–5.47	–12.50	–7.37	–6.16	–14.97	–7.57	–11.02	–11.28
3	–2.90	–5.76	–2.11	–2.32	–7.50	1.29	–4.21	–4.56
4	–4.63	–9.36	–3.24	–3.42	–11.59	2.34	–6.15	–6.94
5	–6.09	–12.55	–4.17	–4.37	–15.11	3.06	–7.77	–8.98
6	–6.28	–12.97	–4.22	–4.46	–15.40	3.12	–7.95	–9.16
7	–4.84	–9.78	–3.18	–3.45	–11.63	2.33	–6.33	–7.00
8	–2.80	–5.37	–1.76	–2.09	–6.54	0.85	–4.04	–4.11
9	–1.42	–2.38	–0.83	–1.23	–3.15	–0.52	–2.49	–2.23
10	–1.06	–1.50	–0.61	–1.04	–2.23	–1.07	–2.12	–1.75
11	–1.06	–1.37	–0.65	–1.09	–2.17	–1.28	–2.17	–1.75
12	–1.11	–1.33	–0.72	–1.16	–2.22	–1.44	–2.27	–1.82
13	–1.12	–1.25	–0.75	–1.20	–2.23	–1.56	–2.33	–1.86
14	–1.17	–1.23	–0.81	–1.27	–2.29	–1.71	–2.43	–1.92
15	–1.22	–1.21	–0.88	–1.34	–2.34	–1.86	–2.53	–2.00
16	–1.27	–1.21	–0.95	–1.41	–2.40	–2.00	–2.63	–2.07
17	–1.32	–1.21	–1.02	–1.49	–2.46	–2.14	–2.73	–2.14
18	–1.38	–1.21	–1.09	–1.56	–2.52	–2.28	–2.83	–2.22
19	–1.43	–1.23	–1.16	–1.64	–2.58	–2.42	–2.93	–2.29
20	–1.49	–1.25	–1.23	–1.71	–2.65	–2.56	–3.03	–2.37
40	–3.05	–3.19	–3.02	–3.66	–4.73	–5.39	–5.68	–4.63
2020	–3.90	–7.55	–3.76	–4.56	–9.34	–1.25	–6.07	–6.50
2021	–4.99	–10.15	–3.33	–3.58	–12.16	2.33	–6.51	–7.30

Q = quarter.
Source: Authors' calculations.

4.5. Unemployment

Unemployment is expected to rise as COVID-19 spreads. Table 15 shows that in the low scenario, the unemployment rate in Korea is expected to rise by 0.81% in 2020 and 0.33% in 2021. The most severe case of unemployment is seen in the European Union and United Kingdom, amounting to 4.68% in 2020 and 1.01% in

2021, probably due to the large services sector and tourism industry that is expected to be heavily damaged from the pandemic and mitigation measures in place such as social distancing.

Table 15: Changes in Unemployment Rate Relative to Business as Usual, Low Scenario

(% of population)

Q	KOR	USA	JPN	CHN	EUUK	ASIA	ROW	WLD
1	–0.03	1.58	–0.08	9.84	0.84	–1.66	–0.10	2.18
2	0.96	7.61	1.11	0.03	9.82	1.92	5.96	3.58
3	1.10	3.34	0.19	0.06	3.57	–3.13	0.81	–0.12
4	1.14	3.22	0.22	0.29	3.83	–2.82	1.23	0.16
5	0.81	2.34	0.16	0.22	2.62	–2.32	0.84	0.02
6	0.38	1.20	0.07	0.12	1.14	–1.44	0.29	–0.12
7	0.10	0.48	0.01	0.05	0.25	–0.65	–0.08	–0.14
8	0.03	0.28	–0.01	0.04	0.02	–0.37	–0.17	–0.13
9	0.02	0.25	–0.01	0.04	0.00	–0.33	–0.18	–0.12
10	0.02	0.24	–0.01	0.05	0.00	–0.31	–0.17	–0.11
11	0.03	0.22	–0.01	0.05	0.00	–0.30	–0.17	–0.11
12	0.03	0.21	–0.01	0.05	0.00	–0.28	–0.16	–0.10
13	0.03	0.21	–0.01	0.07	0.01	–0.26	–0.14	–0.08
14	0.03	0.20	–0.01	0.08	0.02	–0.24	–0.14	–0.08
15	0.04	0.20	–0.01	0.08	0.02	–0.23	–0.13	–0.07
16	0.04	0.19	0.00	0.08	0.02	–0.22	–0.13	–0.07
17	0.04	0.18	0.00	0.09	0.02	–0.21	–0.12	–0.06
18	0.04	0.17	0.00	0.09	0.02	–0.20	–0.11	–0.06
19	0.04	0.17	0.00	0.09	0.03	–0.19	–0.11	–0.05
20	0.04	0.16	0.00	0.10	0.03	–0.17	–0.10	–0.04
40	0.06	0.17	0.02	0.16	0.11	0.02	0.04	0.08
2020	0.81	3.79	0.39	2.77	4.68	–1.08	2.34	0.00
2021	0.33	1.08	0.06	0.11	1.01	–1.20	0.22	0.00

Q = quarter.
Source: Authors' calculations.

Table 16 demonstrates that unemployment worsens in the high scenario. In Korea, unemployment rises by 0.99% in 2020 and 2.03% in 2021. Unemployment in the European Union and United Kingdom and the United States is expected to rise by 6.19% and 7.65%, respectively.

Table 16: Changes in Unemployment Rate Relative to Business as Usual, High Scenario

(% of population)

Q	KOR	USA	JPN	CHN	EUUK	ASIA	ROW	WLD
1	–0.03	1.58	–0.08	9.84	0.84	–1.66	–0.10	2.18
2	0.96	7.61	1.11	0.03	9.82	1.92	5.96	3.58
3	1.10	3.34	0.19	0.06	3.57	–3.13	0.81	–0.12
4	1.93	5.75	0.33	0.23	6.94	–3.85	1.70	0.40
5	2.72	8.24	0.45	0.36	10.64	–4.26	2.48	1.00
6	2.76	8.39	0.46	0.38	10.84	–4.23	2.53	1.05
7	1.84	5.57	0.33	0.27	6.63	–3.64	1.65	0.42
8	0.80	2.57	0.14	0.09	2.50	–2.48	0.52	–0.16
9	0.22	0.98	0.01	–0.04	0.52	–1.27	–0.19	–0.32
10	0.08	0.57	–0.03	–0.07	0.05	–0.80	–0.38	–0.32
11	0.06	0.50	–0.03	–0.06	0.01	–0.72	–0.39	–0.31
12	0.07	0.48	–0.03	–0.04	0.01	–0.69	–0.37	–0.29
13	0.08	0.47	–0.02	–0.01	0.03	–0.64	–0.35	–0.26
14	0.08	0.44	–0.02	0.01	0.03	–0.61	–0.33	–0.24
15	0.08	0.43	–0.02	0.02	0.04	–0.58	–0.32	–0.23
16	0.08	0.41	–0.02	0.03	0.04	–0.55	–0.31	–0.21
17	0.09	0.39	–0.01	0.04	0.05	–0.53	–0.29	–0.20
18	0.09	0.38	–0.01	0.06	0.05	–0.50	–0.28	–0.19
19	0.09	0.37	–0.01	0.07	0.06	–0.47	–0.27	–0.17
20	0.09	0.35	–0.01	0.08	0.06	–0.45	–0.25	–0.16
40	0.14	0.36	0.03	0.28	0.23	0.02	0.07	0.14
2020	0.99	4.57	0.39	2.54	5.29	–1.68	2.09	0.00
2021	2.03	6.19	0.35	0.28	7.65	–3.65	1.80	0.00

Q = quarter.
Source: Authors' calculations.

5. Implications

This study uses a dynamic CGE model to evaluate the temporary and permanent shocks of the COVID-19 pandemic. Its international impact spans across all industries and their respective factors of production, particularly in intertemporal resource allocation. The effect size of intertemporal resource allocation is determined through the household utility maximisation mechanism. If the end of the pandemic could be predicted, intertemporal borrowing and savings could increase the utility of the current period. As the permanent income hypothesis dictates, if temporary shocks reduce current income and consumption, households will undergo consumption smoothing through borrowing from future income. However, this will be limited by liquidity constraints, restricting the utility gain from such processes. Governments should thus deploy direct assistance to lower-income groups, whose borrowing is severely limited precisely due to that reason.

Deaths of workers and the temporary educational vacuum from school closures could lead to a reduction in labour supply, impacting productivity and ultimately lowering the long-term growth path. Thus, strengthening public health systems to minimise deaths and to prevent the qualitative decline of education are crucial to preserving human capital. In addition, technology bias should not spill over to education, requiring governments to aid low-income students and countries in establishing internet and periphery infrastructure internationally.

A balance of policies is key to prevent a health crisis setting off a chain reaction to a financial crisis. Although lives are of the utmost importance, there needs to be an agreement between the prevention of epidemics and the preservation of the economy.

In the long-term, the COVID-19 pandemic should help establish counterstrategies for future pandemics, especially in information sharing and research on data and issues. In the post-COVID-19 era, industrial changes are expected to hit their stride. There needs to be alternatives to revitalise the dynamism of the private sector to boost the economy. In addition, the transition to a contact-free economy and digitalisation are being accelerated in the manufacturing sector, where there is ongoing productional and structural change.

Better inter-state cooperation would also alleviate the challenges of the present and the future. International collaboration is particularly important for ASEAN and East Asian countries who have a significant degree of interdependence in the global supply chain due to regional proximity.

6. Conclusions

This paper analysed the economic impact of the COVID-19 pandemic through the CGE model. Due to a second wave and a subsequent delay in economic recovery, a permanent shock to capital accumulation and productivity could occur. This implies that the shock may not be a short-term growth rate decrease but instead an actual change in the growth path of the economy. Study results suggest that a second wave of infections needs to be prevented, and government actions in disease control and international cooperation are essential.

The impact of COVID-19 is not restricted to future levels of GDP but is also associated with a reduction in the GDP growth rate. In the short term, it is important to aid the most precarious low-income workers, who are often the most prone to economic downturns; the impact of the COVID-19 pandemic is comparable to the most severe recessions. Furthermore, due to the negative impact on the growth gradient, long-term economic policies are needed to promote growth in the post-pandemic era, requiring institutional reforms in labour regulations and corporate taxes to promote favourable investment environments. Extended periods of low growth must be prevented, and consumer confidence and business must be boosted.

This paper employed a neoclassical growth model to estimate the impact of the COVID-19 pandemic on the global economy. However, alternative models, such as the endogenous growth model used in Brainerd and Siegler (2003), could yield different results. In addition, this paper assumes a situation where a vaccine is not developed; hence, further studies should incorporate the differing circumstances post-vaccine. Widening research agendas are expected, such as cross–country variations, in the timing of vaccinations and a more complete evaluation of the impact of COVID–19 in the future.

References

Aguiar, A., M. Chepeliev, E. Corong, R. McDougall, and D. van der Mensbrugghe (2019), 'The GTAP Data Base: Version 10,' *Journal of Global Economic Analysis*, 4(1), pp.1–27.

Almond, R.J. (1996), 'Is the 1918 Influenza Pandemic Over? Long-Term Effects of In Utero Influenza Exposure in the Post-1940 U.S. Population', *Journal of Political Economy*, 114(4), pp.672–712.

Barro, R.J., J.F. Ursúa, and J. Weng (2020), 'The Coronavirus and the Great Influenza Pandemic: Lessons from the "Spanish Flu" for the Coronavirus's Potential Effects on Mortality and Economic Activity', *NBER Working Paper Series*, No. 26866. Washington, DC: National Bureau of Economic Research.

Beach, B., K. Clay, and M. Saavedra (2020), 'The 1918 Influenza Pandemic and Its Lessons for COVID–19', *NBER Working Paper Series*, No. 27673. Washington, DC: National Bureau of Economic Research.

Beutels, P., N. Jia, Q. Zhou, and R.D. Smith (2008), 'Partially Wrong? Partial Equilibrium and the Economic Analysis of Public Health Emergencies of International Concern', *Health Economics*, 17(11), pp.1317–22.

Blanchflower, D.G. and A.J. Oswald (1995), 'An Introduction to the Wage Curve', *Journal of Economic Perspectives*, 9(3), pp.153–67.

Brainerd, E. and M. Siegler (2003), 'The Economic Effects of the 1918 Influenza Epidemic', *CEPR Discussion Papers*, No 3791. https://EconPapers.repec.org/RePEc:cpr:ceprdp:3791 (accessed 1 February 2021).

Cho, G.L. and W.G. Song (2009), 'The Economic Impact of the H1N1 in Korea', *KERI Research Paper*. Seoul: Korea Economic Research Institute.

———. (2020), 'Effects of COVID-19 Pandemic', *KERI Research Paper*. Seoul: Korea Economic Research Institute.

Chou, J., N. Kuo, and N. Pen (2004), 'Potential Impacts of the SARS Outbreak on Taiwan's Economy*', Asian Economic Papers*, 3(1), pp.84–112.

Congressional Budget Office (2005), *A Potential Influenza Pandemic: Possible Macroeconomic Effects and Policy Issues*. Washington, DC.

Dixon, P.B., B. Lee, T. Muehlenbeck, M.T. Rimmer, A. Rose, and G. Verikios (2010), 'Effects on the U.S. of an H1N1 Epidemic: Analysis with a Quarterly CGE Model', *Journal of Homeland Security and Emergency Management*, 7(1).

Douglas, J., K. Szeto, and B. Buckle (2006), *Impacts of a Potential Influenza Pandemic on New Zealand's Macroeconomy.* Wellington: The Treasury.

European Centre for Disease Control and Prevention (2020), 'Download Historical Data (to 14 December 2020) on the Daily Number of New Reported COVID–19 Cases and Deaths Worldwide', *COVID–19.* https://www.ecdc.europa.eu/en/publications–data/download–todays–data–geographic–distribution–covid–19–cases–worldwide (accessed 1 February 2021).

Gallagher, J. (2020), 'Coronavirus: What Is a Second Wave and Is One Coming?', *BBC*, 24 June, https://www.bbc.com/news/health-53113785 (accessed 1 Feb 2021).

Goulder, L.W. and S.H. Schneider (1999), 'Induced Technological Change and the Attractiveness of CO_2 Abatement Policies', *Resource and Energy Economics*, 21, pp.211–53.

Harris, J.R. and M.P. Todaro (1970), 'Migration, Unemployment and Development: A Two–Sector Analysis', *The American Economic Review*, 60(1), pp.126–42.

Health Protection Agency (2006), *Pandemic Influenza Contingency Plan*. London.

International Monetary Fund (IMF) (2020), *World Economic Outlook,* https://www.imf.org/en/Publications/WEO/Issues/2020/09/30/world-economic-outlook-october-2020 (accessed 1 February 2021)

Johns Hopkins University (2020*), COVID-19 Data Repository by Center for Systems Science*, https://github.com/CSSEGISandData/COVID-19. (accessed 1 February 2021)

Keogh–Brown, M.R. and R.D. Smith (2008), 'The Economic Impact of SARS: How Does the Reality Match the Predictions', *Health Policy* 88(1), pp.110–20.

Keogh–Brown, M.R., H.T. Jensen, W.J. Edmunds, and R.D. Smith (2020), 'The Impact of Covid–19, Associated Behaviours and Policies on the UK Economy: A Computable General Equilibrium Model', *SSM Population Health*, 12(100651).

Korea Disease Control and Prevention Agency (2020), 'Domestic Infectious Disease Occurrence', *Archives.* http://www.kdca.go.kr/board/board.es?mid=a30502000000&bid=0032 (accessed 1 February 2021).

Lee, J. and W.J. McKibbin (2004), 'Globalization and Disease: The Case of SARS*', Asian Economic Papers*, 3(1), pp.113–31.

McKibbin, W.J. and R. Fernando (2020), 'The Global Macroeconomic Impacts of COVID–19: Seven Scenarios', *Brookings.* https://www.brookings.edu/research/the–global–macroeconomic–impacts–of–covid–19–seven–scenarios/ (accessed 1 February 2021).

Organisation for Economic Co–operation and Development (OECD) (2020), 'Strengthening the Recovery: The Need for Speed', *COVID–19.* https://www.oecd.org/economic–outlook/ (accessed 1 February 2021).

Sadique M.Z., E. Adams, and W. Edmunds (2008), 'Estimating the Costs of School Closure for Mitigating an Influenza Pandemic', *BMC Public Health*, 8. Article 135.

Shapiro, C. and J.E. Stiglitz (1984), 'Equilibrium Unemployment as a Worker Discipline Device', *The American Economic Review*, 74(3), pp.433–44.

Smith, R.D., M.R. Keogh-Brown, T. Barnett, and J. Tait (2009), 'The Economy-Wide Impact of Pandemic Influenza on the UK: A Computable General Equilibrium Modelling Experiment ,' *BMJ*, 339, b4571.

Solow, R.M. (1956), 'A Contribution to the Theory of Economic Growth', *Quarterly Journal of Economics*, 70(1), pp.65–94.

Uzawa, H. (1969), 'Time Preference and the Penrose Effect in a Two–Class Model of Economic Growth', *Journal of Political Economy*, 77, pp.628–52.

World Bank (2020), *World Development Indicators*, https://databank.worldbank.org/source/world-development-indicators (accessed 1 February 2021).

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