



A Method to Estimate the Economic Consequences of COVID-19

Wenrui Zhang^(✉) 

Faculty of Economic Sciences, HSE University, Moscow, Russia
vchzhan_2@edu.hse.ru

Abstract. The study proposes an instructive economic consequences estimation method to calculate the economic losses of COVID-19 on the global economy and some countries in 2020 and 2021. The economic consequences do not refer to the impact, but to the result despite the efforts of governments to control it. There are two parts: the actual economic consequences are reflected in GDP falling short of expectations, and the potential economic consequences are reflected in the value of the years of life lost. According to calculations, COVID-19 caused \$3.162 trillion in actual losses and \$2.005 trillion in potential losses on a global scale in 2020 and 2021, totaling \$5.168 trillion. Combining the two losses, COVID-19 caused \$6.319 trillion in global losses in 2020, but in 2021 due to economic recovery and so on, the global economy was backfilled with \$1.151 trillion. The estimation method can be generalized to other epidemics. Several schemes are also proposed that can help improve estimation accuracy.

Keywords: COVID-19 · economic consequences · estimation method · years of life lost · value of statistical life year

1 Introduction

Almost all major epidemics in history have seriously affected economic activities. Although their negative effects are often more noticeable, their incidental positive benefits do exist, such as promoting scientific and technological progress and social governance systems [1]. Effectively estimating the economic consequences of the epidemic is critical for policy decisions. Because it can help gauge how effective governments are in fighting COVID-19. More importantly, it allows us to more intuitively understand the impact of COVID-19 on economic development.

United Nations (May 2020) predicts that COVID-19 will cause cumulative output losses of approximately \$8.5 trillion in 2020 and 2021 [2]. This figure is only for direct losses and does not capture the potential future value of those who have died from COVID-19, which is usually considered the value of life. Therefore, the weakening of GDP by the epidemic can be defined as actual economic consequences, and the value of years of life lost due to the epidemic can be defined as potential economic consequences. The sum of the two is the economic consequences; the positive value is economic gain, and the negative value is economic loss.

2 Literature Review

International Monetary Fund (Oct 2021) expected the global economy to grow by 5.9% in 2021 and 4.9% in 2022, which means that the decline in 2020 seems to be smoothed out [3]. Jordà et al. analyzed the long-run economic consequences of pandemics and used historical data to provide empirical evidence for the case [4]. The Black Death induced labor scarcity in Europe and pushed real wages up. More crucially, the response of real GDP per capita is relatively positive in the next 40 years. Compared with wars, the government is more capable of pursuing aggressive stimulating fiscal policies to counter the shock during epidemics. This suggests that economies may be more resilient to pandemics than we think, at least in the long run.

Hence the actual economic consequences we predict caused by epidemics are often worse than real ones, owing to ignoring or underestimating the economic resilience. You can find out later that the $-\$3.162$ trillion estimated by the new method is much smaller than the $-\$8.5$ trillion forecast by the United Nations in May 2020 [2] and the $-\$9$ trillion forecast by IMF in April 2020 [5]. And this may also be the gap between economic consequences and economic impact. The former considers the mitigation effect of policies launched by the government, while the latter does not.

However, we also underestimate or ignore potential losses, the statistical value of life lost of the deceased as a result of the epidemic. The value of potential losses can be roughly considered as years of life lost multiplied by the average annual value of life. The average annual value of life is a very controversial matter, especially when applied simultaneously in different countries [6]. Cost-effectiveness analysis based on this is often used in public health decision-making [7], therefore, we can borrow its estimation elements such as setting the average annual value of life to several times the annual GDP per capita.

World Health Organization (WHO) recommends thresholds of 1.0 and 3.0 for cost-effectiveness analyses [8], they are used extensively. Robinson et al. pointed out that the one and three times GDP per capita currently used as thresholds for avoiding costs per disability-adjusted life years have not been strictly deduced and demonstrated [9], so the thresholds should be determined according to the needs. However, there is no doubt that the threshold of 1.0 is the lowest value that can be used to calculate the lowest potential loss, which is in line with the connotation of GDP per capita.

Likewise, quantifying years of life lost from COVID-19 is diverse. Years of potential life lost (YPLL) is the sum of the years of life lost annually by persons who suffered early deaths, which does not take into account the damage of those who were sick but recovered, while the disability-adjusted life year (DALY) does. However, the current research on the sequelae of COVID-19 is not clear, so DALY is not used in this study. But as research progresses in this field, DALY is a better choice in the future due to its higher accuracy. Tamás Ferenci provided a variety of methods, such as using the life table and individual patient-level data on comorbidities [10].

But many estimation methods in the above literature are not available or inconvenient, since most governments do not have detailed statistics or publish detailed data on the deaths. The method to be introduced is biased towards computability, which can be relatively simple to obtain data and calculate.

3 Methods and Results

The economic consequences (EC) of the epidemic are the sum of actual economic consequences (AEC) and potential economic consequences (PEC), also known as economic gains (positive value) or economic losses (negative value), see formula (1).

The actual economic consequences are actual GDP (AGDP) minus projected GDP before the shock (PGDP), see formula (2). The potential economic consequence of an individual's death is the years of life loss (YLL) multiplied by the value of a statistical life year (VSLY), and the sum of the potential economic consequences of all individual deaths is PEC, see formula (3) and i is each deceased individual.

$$EC = AEC + PEC \quad (1)$$

$$AEC = AGDP - PGDP \quad (2)$$

$$PEC = - \sum_i (YLL_i \times VSLY_i) \quad (3)$$

3.1 Actual Economic Consequences

The calculation of actual economic consequences uses actual GDP (provided by World Bank) and the forecasted value of GDP for 2020 and 2021 published before the epidemic spread on a large scale [11]. The results of AEC are shown in Table 1.

We can find that COVID-19 reduces world output by \$5.638 trillion in 2020, but increases world output by \$2.476 trillion in 2021, which may be due to the rapid recovery of some economies from the impact of the epidemic. Combining the results of two years, China's Mainland ranks first in the world with actual economic gains of \$1270.34 billion, some European countries such as Germany and France also achieved positive values, which is in line with EU forecasts [12].

3.2 Potential Economic Consequences

The estimation of PEC has two important elements, namely YLL and VSLY. In this study, we equate VSLY to the annual GDP per capita, which means we use a threshold of 1.0 in the cost-effectiveness analysis. The calculation of YLL is more complicated and requires the use of the distribution of deaths by age and gender and the life tables. We need to find the expected lifespan of each deceased individual on the life table according to their sex and age. For those countries that do not publish the distribution of deaths or the statistics lack credibility, we use the distribution of data sources such as the CDC in the US [13] after the weighted average instead. The life table for each country or region can be found in the World Health Organization [14].

Table 1. Actual Economic Consequences (in US\$ billions)

	AGDP		PGDP		AEC		
	2020	2021	2020	2021	2020	2021	2020 + 2021
US	20893.74	22996.1	21800.02	22170.62	-906.28	825.48	-80.8
Germany	3846.41	4223.12	3931.1	3986.13	-84.68	236.98	152.3
France	2630.32	2937.47	2764.35	2800.28	-134.03	137.19	3.16
Italy	1892.57	2099.88	2021.34	2035.49	-128.77	64.39	-64.38
Spain	1281.48	1425.28	1415.33	1437.98	-133.85	-12.7	-146.55
Japan	5040.11	4937.42	5159.18	5184.98	-119.07	-247.56	-366.63
UK	2756.9	3186.86	2918.98	2962.76	-162.08	224.1	62.02
Canada	1645.42	1990.76	1773.37	1805.29	-127.95	185.47	57.52
China's Mainland	14687.67	17734.06	15136.73	16014.66	-449.06	1719.4	1270.34
India	2667.69	3173.4	2995.78	3190.51	-328.09	-17.11	-345.2
Russia	1488.32	1775.8	1725.28	1759.79	-236.96	16.01	-220.95
Brazil	1448.57	1608.98	1914.5	1958.53	-465.93	-349.55	-815.49
Mexico	1087.12	1293.04	1282.1	1302.61	-194.98	-9.57	-204.55
Saudi Arabia	703.37	833.54	818.88	836.9	-115.52	-3.36	-118.88
Nigeria	432.29	440.78	459.32	470.81	-27.03	-30.03	-57.06
South Africa	335.44	419.95	391.04	394.95	-55.6	25	-30.6
World	84906.81	96100.09	90545.41	93623.95	-5638.59	2476.14	-3162.45

After obtaining YLL and VSLY, use the formula (3) to calculate, and the results are shown in Table 2. Among all countries, the US ranks first in the world with potential economic consequences of US\$922.42 trillion and accounts for 46% of the world's. This stems from its large number of deaths and high GDP per capita. COVID-19 claimed 26.443 million life years globally in 2020 and 60.625 million life years in 2021, for a total of 87.068 million life years (8,469,333 deaths [15]).

Table 2. Potential Economic Consequences

	2020			2021			2020 + 2021
	GDP Per capita	YLL	PEC	GDP Per capita	YLL	PEC	PEC
World	10936	26443	-679.92	12263	60625	-1325.24	-2005.17
US	63028	5552	-349.95	69288	8262	-572.48	-922.42
Germany	46253	513	-23.74	50802	1484	-75.4	-99.14
France	39037	999	-38.99	43519	1098	-47.77	-86.76
Italy	31835	1123	-35.74	35551	1198	-42.58	-78.32
Spain	27056	789	-21.34	30116	744	-22.4	-43.74
Japan	39918	57	-2.26	39285	299	-11.73	-13.99
UK	41098	1399	-57.5	47334	1516	-71.77	-129.26
Canada	43258	246	-10.66	52051	282	-14.7	-25.36
China's Mainland	10409	59	-0.61	12556	2	-0.03	-0.65
India	1933	1755	-3.39	2277	4906	-11.17	-14.56
Russia	10162	684	-6.95	12173	3722	-45.3	-52.25
Brazil	6815	2624	-17.88	7519	7117	-53.51	-71.39
Mexico	8432	1730	-14.59	9926	2950	-29.28	-43.87
Saudi Arabia	20204	77	-1.56	23586	41	-0.98	-2.54
Nigeria	2097	15	-0.03	2085	25	-0.05	-0.08
South Africa	5656	329	-1.86	6994	902	-6.31	-8.17
Others	10936	8492	-92.87	12263	26077	-319.78	-412.65

Note. GDP Per capita in US dollars, YLL in millennia, and PEC in billions of dollars.

3.3 Economic Consequences

The calculation of economic consequences is the sum of actual and potential economic consequences, and the results are shown in Table 3.

Table 3. Economic Consequences (in US\$ billions)

	EC				EC		
	2020	2021	2020 + 2021		2020	2021	2020 + 2021
US	-1256.23	253	-1003.23	China's Mainland	-449.67	1719.37	1269.69
Germany	-108.43	161.58	53.15	India	-331.49	-28.28	-359.77
France	-173.02	89.42	-83.59	Russia	-243.91	-29.29	-273.2
Italy	-164.51	21.81	-142.7	Brazil	-483.81	-403.06	-886.88
Spain	-155.19	-35.11	-190.3	Mexico	-209.57	-38.86	-248.43
Japan	-121.33	-259.29	-380.62	Saudi Arabia	-117.08	-4.33	-121.42
UK	-219.57	152.33	-67.24	Nigeria	-27.06	-30.08	-57.14
Canada	-138.61	170.77	32.16	South Africa	-57.46	18.69	-38.77
World	-6318.52	1150.89	-5167.62	Others	-2061.58	-607.78	-2669.36

4 Conclusions and Prospects

The paper proposes a new method to estimate the economic consequences of epidemics. The AEC of the epidemic as a result of worse-than-expected economic conditions is reflected by subtracting forecasted GDP from actual GDP. COVID-19 caused global actual losses of \$5.638 trillion in 2020, and global actual gains of \$2.476 trillion in 2021, a total of \$3.162 trillion in actual losses within two years.

Potential economic consequences are calculated using years of life loss and the value of a statistical life year. The calculation results show that COVID-19 caused potential losses of \$679.92 billion worldwide in 2020, \$1325.24 billion in 2021 (roughly double that of 2020), and \$2.005 trillion within two years.

However, both estimation elements in PEC can be further improved. The years of life loss does not take into account other diseases that the deceased may have, nor does it consider the possible sequelae of the infected. On the premise of obtaining more detailed individual data, you can try to change it to the disability-adjusted life years or others. In this study, the value of a statistical life year is used for one time of per capita GDP (that is, the threshold of 1.0), which is used to estimate the minimum potential losses. It is not advisable to use a threshold of 1.0 when using cost-effectiveness analysis to demonstrate the necessity of epidemic prevention policies (at least a threshold of 3.0 should be used). Because even in extremely poor areas, the estimated threshold is well above 3.0, ranging from 3.5 to 33.5 [16].

The accuracy of PEC estimation using the method depends on the availability of detailed data on deceased individuals, which is difficult to obtain. Therefore, the popularization of big data technology and information management technology is the key to solving this problem.

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