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Coronavirus: Widespread Disease, but Drug Pipeline Progress

Minimal long-term economic impact; forecast low fatality rate implies overstated threat to the economy.

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Contents

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Coronavirus Hit to 2020 Should Be Significant, but Low Fatalities Would Allow Quick Recovery

COVID-19, the disease caused by SARS-CoV-2 ("coronavirus"), is spreading across the globe, leading to sharp market corrections and fears of triggering a global recession. Risks relating to the fallout from the spread of coronavirus pushed the Federal Reserve to cut the target rate by 50 basis points on March 3, to the 1%-1.25% range, and President Trump signed an $8.3 billion spending bill to fight the coronavirus on March 6. The virus emerged in China, where the government quickly weighed the economic and human costs of the rapidly transmitting new coronavirus (in the same family as the much more deadly SARS and MERS viruses) and in January decided to focus on stopping the spread of the disease, regardless of the short-term economic hit. While responses beyond China will likely be more measured, we expect to see school closures and recommended telecommuting as precautionary measures in the U.S., given the recent rapid spread of the disease.

Key Takeaways

- Overall, we see a weighted average hit of 1.5% to 2020 global GDP and 0.2% to long-run global GDP. We forecast a muted long-term impact because damage to productive capacity will be small, plus economic confidence should quickly return once the virus subsides.
- Our long-term China GDP forecast is unchanged. We have lowered our 2020 China GDP forecast by 250 basis points, but we expect catch-up growth in following years.
- We assume a global fatality rate in our base case of 0.5% among those infected, higher than seasonal flu and recent pandemics like the 2009 swine flu, but much lower than levels reported to date (as diagnosis improves). We expect even lower fatality rates for developed countries (more ICU beds per capita, best practices) and the working age population (the disease is most severe in the elderly).
- We see reason for optimism surrounding vaccines and treatments. We should see initial data from Gilead's remdesivir by April; this could be a strong defense for patients with severe disease, and we raised our Gilead fair value estimate slightly to $85 per share. Among vaccines, Moderna is most advanced, but we don't expect use until 2021. See page 18 for a summary of the COVID-19 pipeline.

Morningstar Scenario Analysis: COVID-19 Health and Economic Hit

	Fatalities	World GDP Impact:		
Scenario	**(% of World Pop)**	**2020**	**Long Run**	**Probability**
Bear	0.2%	-5.00%	-0.6%	15%
Base	0.1%	-1.25%	-0.2%	60%
Bull	0.01%	-0.10%	0.0%	25%
Avg	**0.10%**	**-1.5%**	**-0.2%**	

Source: Morningstar.

Morningstar's Coronavirus Analysis: Epidemiology and Society's Response

In this first coronavirus deep dive, we discuss the potential duration and severity of impact on health and the economy at a higher level, with background on the disease characteristics as well as the burgeoning pipeline of vaccines and treatments.

We Expect Coronavirus to Resemble a Severe but Manageable Flu, Treatments Available Soon

In our base case, we see treatments like Gilead's remdesivir becoming available before a potential second wave in the fall, which should alleviate capacity constraints at hospitals. We include a placeholder for remdesivir in our model, however, we do not assume sustainable long-term sales, as we would expect the disease to either become more mild with time (like flu pandemics) or see no recurrences after the 2020 impact. If this does become a moderate to severe annual threat, we assume vaccines will be available by the 2021-22 virus season.

Pandemics: Novel, Widespread Outbreaks With Key Similarities (and Differences) From the Flu

A pandemic is defined as a disease that can infect and sicken humans, can transmit easily from one human to another, and has spread worldwide. Viral pandemics—which historically have been influenza pandemics—are more contagious than seasonal flu. Pandemics occur when a new form of virus emerges (either a mutated version or a combination with another variation) and is capable of transmitting from person to person. While the World Health Organization has not officially deemed coronavirus a pandemic, it is likely moving in that direction.

What makes pandemics particularly dangerous is that the population generally does not have immunity to the disease, and this can cause outbreaks beyond the traditional winter flu season.[1] Flu pandemics have decreased in severity with time, perhaps partly due to viral preference for diseases that are very transmissible but not lethal.[2] Despite some similarities between seasonal and pandemic flu, there are also key differences, as shown in Exhibit 1. While seasonal flu is every year, pandemics can have multiple waves; Spanish flu came in three waves, and the 2009 swine flu had two waves.

As shown in Exhibit 3, past pandemics have varied substantially in their lethality. For example, the 1957 Asian flu, considered a moderate pandemic, emerged in China in February 1957, reached the U.S. by June, and spread very rapidly in the fall in the U.S. and Europe, with the return to school seen as a significant driver for starting new community epidemics during that pandemic. With mitigation efforts focused on a vaccine (which was developed too late and was not more than 60% effective), most schools remained open and no travel restrictions or restrictions on social gatherings were undertaken, and 25% of the U.S. population was infected.[3]

1 Influenza virus infections in humans October 2018, World Health Organization

2 Morens, David M, Jefferey K Taubenberger, and Anthony S Fauci, The Persistent Legacy of the 1918 Influenza Virus. New England Journal of Medicine, July 16 2009

3 D. A. Henderson, Brooke Courtney, Thomas V. Inglesby, Eric Toner, and Jennifer B. Nuzzo; Public Health and Medical Responses to the 1957-58 Influenza Pandemic

The 1968 Hong Kong flu was milder but more widespread (estimated at almost 40% of the U.S. population infected[4]). The death rate may have been significantly lower than Asian flu because patients had some pre-existing immunity.

Exhibit 1 How a Pandemic Compares With Seasonal Flu

	Typical Pandemic	Seasonal Flu
Seasonality	Varies	December to March (winter months)
Timeline	6-8 week outbreaks, with multiple 2-3 month waves, seasonal potential in future	Roughly 4 months
Immunity	Typically lower	Varies
Infected	20-40% of population	3-11%*
Target	Spanish flu hit young adults hardest, 2009 spared elderly, but typically young or old	Young and old, chronically ill
Incubation period	Typically similar to seasonal	2 days
Contagious prior to symptoms	Roughly one day	Roughly one day

Source: Morningstar, HHS Pandemic Influenza Plan, 2017.
*Seasonal Incidence of Symptomatic Influenza in the United States

Coronavirus 101: A New Virus Related to SARS and MERS

On Jan. 7, a new coronavirus was identified as the cause of several cases of pneumonia in Wuhan, China. COVID-19 is the disease caused by SARS-CoV-2, one of a family of coronaviruses, with this particular strain new to humans. Most coronaviruses spread between animals, although the common cold is often caused by a coronavirus. Like more serious coronaviruses SARS and MERS, SARS-CoV-2 is believed to have jumped to humans by first moving from one species known to carry these diseases to another species capable of transmitting the disease to humans. In the case of SARS-CoV-2, this is likely to have been bats and pangolins (scaly anteaters). Like SARS-CoV and MERS, it is believed to be mostly spread through respiratory droplets, often from a patient's cough (58% of SARS cases and 70% of MERS cases were tied to nosocomial transmission[5]). The virus uses the spike (S) protein to enter cells of its hosts, binding to the ACE-2 receptor as SARS-CoV did (these receptors are present on cells deep in the lungs, hence the link to lower respiratory disease).[6] However, antibodies against the receptor binding domain of SARS-CoV do not work against SARS-CoV-2.[7]

How to Estimate Severity in a Viral Outbreak: The Intersection of Fatality and Transmissibility

A comparison with other outbreaks is one of the easiest ways to think about the potential spread of the coronavirus, although every disease has slightly different characteristics that limit the accuracy of this analysis. The intersection of the fatality rate (the percentage of infected patients who succumb to the

4 Community Mitigation Guidelines to Prevent Pandemic Influenza, United States, CDC, 2017

5 Munster, Vincent J. et al. A Novel Coronavirus Emerging in China-Key Questions for Impact Assessment. New England Journal of Medicine, Jan 24, 2020

6 https://www.the-scientist.com/news-opinion/why-some-covid-19-cases-are-worse-than-others-67160

7 Del Rio, Carlos, Preeti N. Malani. COVID-19-New Insights on a Rapidly Changing Epidemic. JAMA. Feb 28,2020

disease) and how contagious it is, if left unchecked, is a simple way to begin to outline the potential impact versus past pandemics. Epidemiologists measure how contagious a disease is using a reproduction number, termed R0, reflecting how many people an infected person can typically infect. Generally speaking, an R0 of greater than 1 is a threshold for a disease being able to expand into an epidemic[8], and a virus with an R0 above 1.9 is considered highly transmissible.[9] In addition, a higher R0 means a sharper rise and fall of infection rates with a shorter duration of the outbreak.[10] An R0 of 1.9 could imply duration of an outbreak of months, with a two-month peak in infections, as seen with the 1957 and 1968 pandemics.[11]

Diseases are generally the most dangerous if they are both very deadly and very contagious (high R0), but most diseases tend to be more one than the other, as the self-interest of viruses would favor evolution toward diseases that don't kill their victims (spread is limited if victims are not ambulatory). For example, Ebola and rabies have very high fatality rates but are tougher to transmit. At the opposite end of the spectrum is the common cold, which is fairly easy to transmit but almost never fatal. Smallpox was one of the most destructive diseases, as it was both very contagious and very deadly. Also, the Spanish flu of 1918-19 caused more than 50 million deaths worldwide and killed nearly 3% of the population. However, the spread of a disease is more than these numbers—significant efforts to contain SARS have eradicated the disease, even though it is more easily transmissible than the standard flu (which is very widespread every year).

Coronavirus Looks Like a Severe Flu, but Realistic Scenarios Create a Range of Outcomes

Even though death rates have been falling gradually for flu pandemics since the 1918 pandemic, the coronavirus pandemics are a newer phenomenon and don't have an established trend. Fatality rates are already being estimated, but this is very difficult to do accurately at the start of any pandemic. As of March 7, 2020, data from Johns Hopkins, 105,820 people have been infected by the coronavirus, with a death rate of 3.4% (likely skewed high due to non-reporting of mild cases, particularly at the start of a new pandemic).[12] A comprehensive analysis of more than 70,000 cases using data released by the China CDC puts the fatality rate at 2.3%, but 8% for patients in their 70s and almost 15% for patients older than 80.[13] Exhibit 2 details more of the data from the China CDC release. While roughly 80% of the confirmed 44,672 cases were mild (either no or mild pneumonia), 5% of cases were critical, with half of these critical patients dying.

8 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4368036/#!po=25.0000

9 https://www.pnas.org/content/pnas/103/15/5935.full.pdf

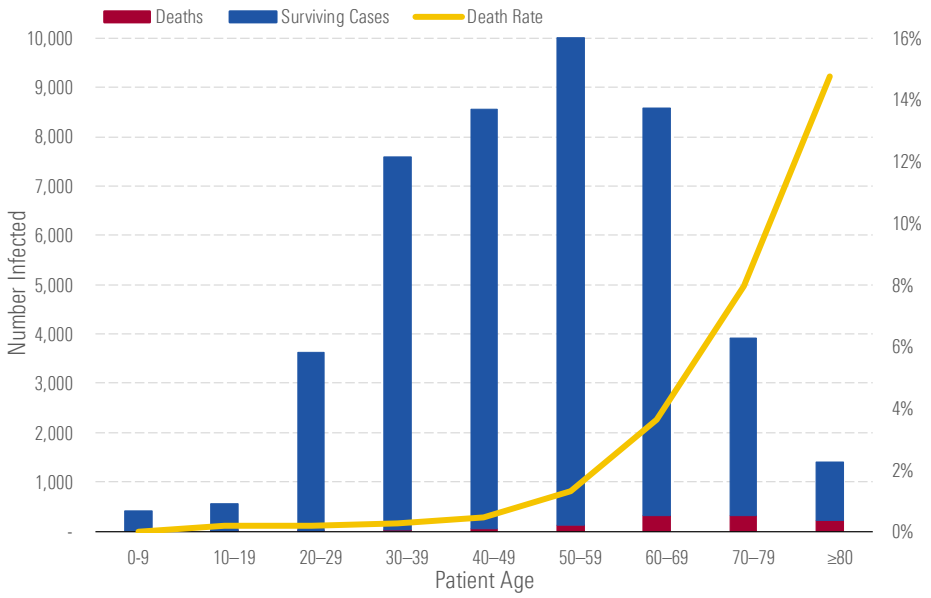
10 Interim Pre-pandemic Planning Guidance: Community Strategy for Pandemic Influenza Mitigation in the United States, Feb 2007. DHHS/CDC

11 https://www.pnas.org/content/pnas/103/15/5935.full.pdf

12 https://www.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6

13 Wu, Zunyou, and Jennifer M McGoogan, Characteristics of and Important Lessons from the Coronavirus Disease 2019 (COVID-19) Outbreak in China. JAMA, Feb 24, 2020

Exhibit 2 Demographics of Coronavirus Cases by Age and Death Rate, China CDC Report



Sources: Morningstar, China CDC.
http://weekly.chinacdc.cn/en/article/id/e53946e2-c6c4-41e9-9a9b-fea8db1a8f51

Researchers have also cited a range of lower fatality rates ranging as high as 2% (deaths with pneumonia diagnosis) to 1.4% (among 1,099 lab-confirmed cases in China, with a range of severity[14]) to potentially less than 1% assuming a high proportion of asymptomatic cases.[15] A fatality rate between 0.1% and 0.8% would put the coronavirus in a position of being more severe than a typical flu (which has a 0.1% fatality rate, on average) but less severe than the Spanish flu (statistics put this closer to a 10% fatality rate).[16] This is the range we use in our scenario analysis. Potential deaths globally and in the U.S. for these scenarios are listed in Exhibit 3, along with historical frame of reference for seasonal flu and past pandemics.

14 Guan W. et al. Clinical Characteristics of Coronavirus Disease 2019 in China, New England Journal of Medicine, Feb 28 2020
15 Fauci, Anthony S. et al. Covid-19-Navigating the Uncharted. New England Journal of Medicine, Feb 28, 2020
16 Gates, Bill. Responding to Covid-19—A Once-in-a-Century Pandemic? New England Journal of Medicine, Feb 28, 2020

Exhibit 3 Global and U.S. Death Rates, for Seasonal Flu, Pandemic Flu, and Coronaviruses
Including Our COVID-19 Scenarios (in Blue)

	Global Deaths	% of Population	U.S. Deaths	% of Population
Seasonal flu (annual)	290,000-650,000	.004%-.008%	12,000-61,000	.004%-.02%
Pandemic flu				
Spanish flu (1918-19)	>50,000,000	>2.8%	500,000-675,000	0.5%-0.7%
Asian flu (1957)	1,500,000-2,000,000	.05-.07%	116,000	0.07%
Hong Kong flu (1968)	1,000,000	0.03%	100,000	0.05%
Swine flu (2009)	300,000	0.004%	12,469	0.004%
Coronaviruses				
MERS (2012-)	811	NM	-	0.00%
SARS (2002-2003)	2,990	NM	-	0.00%
SARS-CoV-2 (2019-) estimate, base case	7,700,000	0.10%	206,010	0.06%
SARS-CoV-2 (2019-) estimate, bull case	770,000	0.01%	29,430	0.01%
SARS-CoV-2 (2019-) estimate, bear case	18,480,000	0.24%	662,175	0.20%

Source: Morningstar, CDC.

We think the bull case is slightly more likely than the bear case, as fatality rates outside of Hubei province (the site of the initial outbreak) have been lower, and the 2009 pandemic was estimated to have fatality rates of 10%-20% initially before these rates faded dramatically,[17] well below 0.1% using U.S. infection data.[18] This can happen due to the fact that only the sickest patients are diagnosed early in an outbreak, distorting the initial data. Exhibit 4 plots the recent data on global infections and death rates, highlighting the differences in death rates for Hubei province and the rest of the world.

Exhibit 4 Coronavirus Infection and Death Rate Statistics

Date	Total Infected	Total Deaths	Total Recovered	Overall Death Rate*	China Infected	China as % of Infected	Hubei infected	Hubei deaths	Death rate, Hubei	Death rate, ex Hubei
March 1	87,464	2,990	42,670	3.4%	79,826	91.3%				
March 3	92,807	3,159	48,201	3.4%	80,151	86.4%	67,217	2,835	4.2%	1.3%
March 4	94,251	3,214	51,039	3.4%	80,270	85.2%	67,332	2,871	4.3%	1.3%
March 5	97,841	3,347	53,786	3.4%	80,422	82.2%	67,466	2,902	4.3%	1.5%
March 7	105,820	3,558	58,354	3.4%	80,652	76.2%	67,666	2,959	4.4%	1.6%

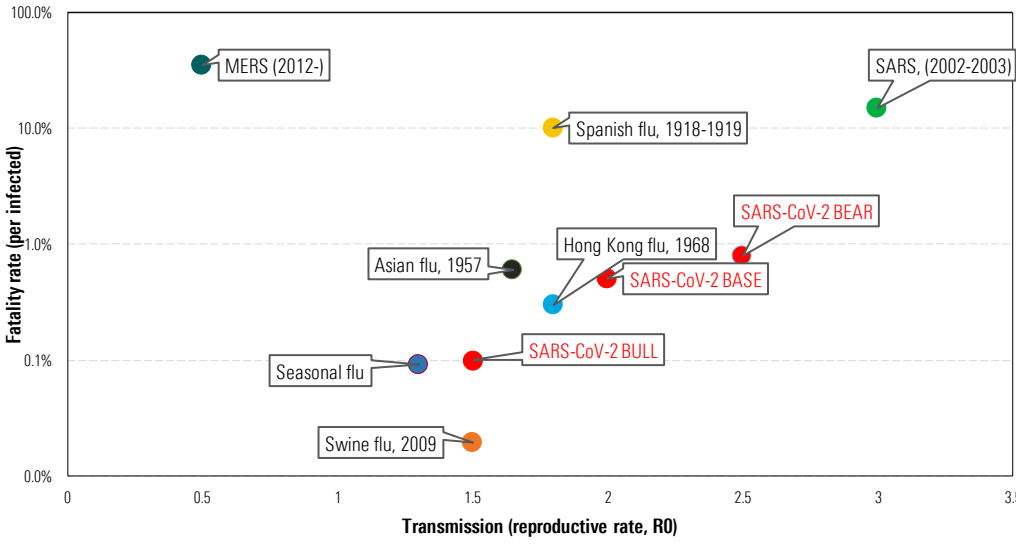
Sources: Morningstar, Johns Hopkins.
Coronavirus COVID-19 Global Cases by Johns Hopkins CSSE

17 https://www.who.int/docs/default-source/coronaviruse/transcripts/who-audio-emergencies-coronavirus-full-press-conference-18feb2020-final.pdf?sfvrsn=5209d6c3_2

18 https://www.cdc.gov/flu/pandemic-resources/2009-h1n1-pandemic.html

Transmissibility is also difficult to estimate during a pandemic, but Bill Gates noted that this virus has already infected 10 times the number of total SARS cases, and in only a quarter of the time, indicating it is much more transmissible than SARS, with a likely R0 for COVID-19 between 2 and 3.[19] Fauci and colleagues cited an R0 of 2.2 for the coronavirus, with containment efforts needed to get this below 1 to begin to contain the virus.[20] Also, the high level of viral shedding early in the disease and among patients who have very mild disease (in contrast with SARS, which was more contagious among symptomatic patients) is concerning, and could hamper efforts to lower this rate significantly. We assume a range from 1.5 (similar to the typical flu) in our bull case to 2.5 in our bear case. Together, we've plotted these assumptions on a graphic, along with statistics on other pandemics over the past century, in Exhibit 5.

Exhibit 5 Transmissibility and Fatality for SARS-CoV-2 ("Coronavirus") in Three Morningstar Scenarios
With a backdrop of historical viral outbreaks



Note: Scale of Y axis is logarithmic
Sources: Morningstar,
Gates, Bill. Responding to Covid-19—A Once-in-a-Century Pandemic? New England Journal of Medicine, Feb 28, 2020
Taubenberger, Jeffery K, and David M Morens, 1918 Influenza: the Mother of All Pandemics
Pandemic Influenza Plan, 2017 Update, Department of Health and Human Services
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4169819/#!po=12.9630
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2862331/#!po=2.08333
https://bmcinfectdis.biomedcentral.com/track/pdf/10.1186/1471-2334-14-480
https://www.sciencedirect.com/science/article/pii/S120197121401491X
https://www.who.int/csr/sars/en/WHOconsensus.pdf
https://www.cdc.gov/flu/about/burden/preliminary-in-season-estimates.htm
https://www.cdc.gov/flu/pandemic-resources/1968-pandemic.html
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3291398/
https://www.thelancet.com/cms/10.1016/S1473-3099(12)70121-4/attachment/b2b46a2a-852d-4367-9855-8ab36057f898/mmc1.pdf
https://www.who.int/en/news-room/fact-sheets/detail/middle-east-respiratory-syndrome-coronavirus-(mers-cov)
https://www.who.int/csr/sars/en/WHOconsensus.pdf
https://www.cdc.gov/flu/pandemic-resources/2009-h1n1-pandemic.html
https://www.sinobiological.com/1968-influenza-pandemic-hong-kong-flu-a-5754.html

19 Gates, Bill. Responding to Covid-19—A Once-in-a-Century Pandemic? New England Journal of Medicine, Feb 28, 2020
20 Fauci, Anthony S. et al. Covid-19-Navigating the Uncharted. New England Journal of Medicine, Feb 28, 2020

While higher fatality rates and higher transmissibility are generally indicators of how severe a pandemic could be, SARS (what has been eradicated) is the highest on both measures among the outbreaks listed in this graphic. Containment efforts were solid for SARS, and patients were most contagious when they were highly ill (viral loads for SARS peaked 10 days after symptom onset, making it less likely patients would be mobile and able to spread to others[21]). In addition, Chinese citizens traveled within China much less extensively in 2003, limiting the spread, while today, 3,500 fly out of Wuhan each day, and the Belt and Road Initiative has led to a high number of domestic and international migrant workers.[22] For COVID-19, viral shedding is more like the flu, with higher loads seen soon after symptoms and also in asymptomatic patients.

Coronavirus Is Likely to Be a Mild Pandemic, With Minimal Long-Term Economic Effect

In a severe pandemic, infrastructure can be disrupted at a national level, such as healthcare (lack of capacity to treat patients sick from other causes, shortages of ventilators), transportation (public transport closures), commerce (trade disruption, healthy citizens avoiding retail outlets), and utilities (in a worst case).[23] This is partly due to risk mitigation measures, but partly due to potential higher rates of patients on sick leave, or employees taking care of children or other family members, or just general population anxiety about gathering in public places.

The direct and indirect U.S. healthcare costs of a moderate pandemic, like those in the 1950s and 1960s, were estimated at roughly $180 billion in 2005 by the U.S. Department of Health and Human Services, assuming no intervention, but this does not include potential for commerce disruption.[24] According to the Congressional Budget Office, a pandemic could cost the U.S. more than 4% of GDP in a severe situation (similar to the Spanish flu of 1918) or 1% of GDP (if the pandemic is more mild, similar to 1957 and 1968 pandemics).[25]

Overall, we think costs of the coronavirus will mirror those of a milder pandemic. As we assume a lower death rate that primarily focuses on patients over the age of 65, we think there could be a significant short-term hit (1.5% of 2020 GDP) but minimal hits beyond, as the economy should be in position to rebound quickly. See page 26 for our detailed analysis on economic costs, both short term and long term, in each of our scenarios.

21 https://www.nytimes.com/interactive/2020/world/asia/china-coronavirus-contain.html
22 https://www.nytimes.com/interactive/2020/world/asia/china-coronavirus-contain.html
23 Pandemic Influenza Plan, 2017 Update, Department of Health and Human Services
24 Pandemic Influenza Plan, 2017 Update, Department of Health and Human Service
25 https://www.cbo.gov/system/files/2018-10/05-22-avian-flu.pdf

Exhibit 6 Comparing the Impact of Viral Pandemics on Global GDP: Coronavirus Likely to Be a Mild Pandemic

Virus	Transmission (reproductive rate)	Fatality rate (per infected)	Global GDP hit (short-term)
Seasonal flu	1.3	0.1%	NA
Spanish flu (1918-19)	1.8	10%	-4.8%*
Asian flu (1957)	1.7	0.6%	-2.0%*
Hong Kong flu (1968)	1.8	0.3%	-0.7%*
Swine flu (2009)	1.5	0.02%	-0.5%-1.5%
MERS (2012-)	0.5	35%	NM (well below SARS)
SARS (2002-2003)	3.0	15%	$33 billion (-.08%)
Coronavirus: base case	2.0	0.5%	-1.25%
Coronavirus: bull case	1.5	0.1%	-0.1%
Coronavirus: bear case	2.5	0.8%	-5.0%

Note: *predicted impact of pandemic similar to these historical pandemics,
Source: http://documents.worldbank.org/curated/en/977141468158986545/pdf/474170WP0Evalu101PUBLIC10Box334133B.pdf
Other sources: Morningstar,
https://www.ncbi.nlm.nih.gov/books/NBK92473/
https://www.economist.com/news/2009/07/27/the-cost-of-swine-flu
https://www.worldbank.org/content/dam/Worldbank/document/HDN/Health/WDR14_bp_Pandemic_Risk_Jonas.pdf

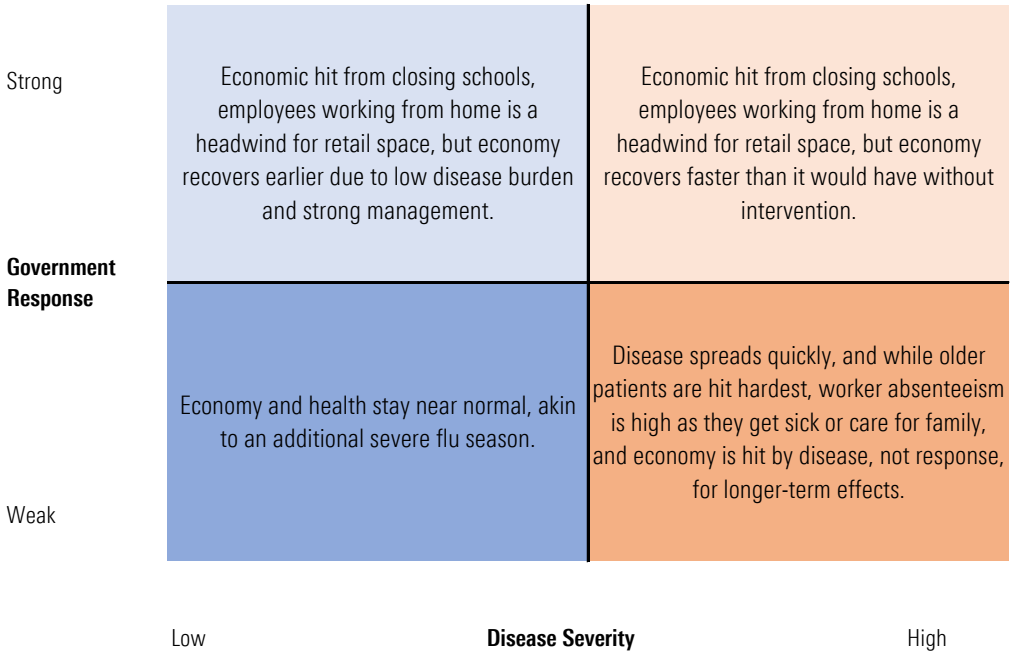
Government Response to a Pandemic Involves Multiple Stages

Initially, efforts to contain a virus include isolation of suspected or confirmed infected patients, once an accurate diagnostic is developed, and quarantine for two weeks of those who were exposed to these patients. However, at a certain point these efforts are less effective due to the wide spread of the disease, at which time mitigation measures like social distancing become the main way to slow transmission, buying time that alleviates some pressure on hospitals (fewer new cases per week) and allows for potential development of best treatment practices (and a potential targeted therapy or vaccine). Mitigation measures are key to reducing transmission and impact on global health and economy. Social distancing takes many forms, like school closures, canceling large gatherings, telecommuting when possible, and travel restrictions (like limiting long-distance travel). Layering of these efforts is even more effective (see Exhibit 8). However, the negative effects of these efforts on the economy have to be considered, so deciding on the timing of implementation is tricky.

For example, the U.K. released a coronavirus action plan in early March[26], planning for potential "no-go" zones, bans on mass gatherings, working from home for at least three months, and other measures if the stage of the action plan moves from "contain" (current stage, which is essentially isolation and quarantine) to "delay" (second stage), and we appear to be heading to the second stage.

We think that most economic commentary on coronavirus has focused on the concern that we will have a strong government response with a disease that winds up being less dangerous than we thought, which creates unnecessary harm to the economy. However, we argue that such a scenario would have only short-term impact on the economy, and that the most concerning scenario is one in which not enough of a government response is seen, but the disease spreads widely.

Exhibit 7 Government Response and Disease Severity: Strong Response Minimizes Long-Term Economic Effects



Source: Morningstar, CDC.

Mitigation can significantly reduce the spread of a disease, although the percentage of a population infected is still closely tied to R0, or the reproduction number (how contagious the disease actually is), which is very difficult to isolate after an outbreak, let alone during an evolving one. However, Exhibit 8 lays out an analysis of the effects that mitigation efforts can have on reducing infection rates in a population. The researchers noted that school closure may be burdensome, but it is likely to be an effective form of social distancing.[27]

26 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/869827/Coronavirus_action_plan_-_a_guide_to_what_you_can_expect_across_the_UK.pdf
27 https://www.pnas.org/content/pnas/103/15/5935.full.pdf

Studies based on the 2009 swine flu also indicate that school closures were effective, with 45%-72% reduction in illness in houses with school-aged children in Texas, where school closures were implemented (0.7% of urban schools and 3.3% of rural schools were closed from August to December 2009).[28]

Exhibit 8 Simulation of Percentage of the Population Infected by Pandemic, Varying With R0 (Transmissibility): School closures particularly effective, but layering is likely necessary without vaccines and targeted antivirals

Intervention	R0=1.6	R0=1.9	R0=2.1	R0=2.4
No Intervention	32.6	43.5	48.5	53.7
School closure*	1	29.3	37.9	46.4
Local social distancing*	25.1	39.2	44.6	50.3
Travel restrictions^	32.8	44	48.9	54.1
Local social distancing and travel restrictions*^	19.6	39.3	44.7	50.5

Note: Blue shading represents most likely R0 for SARS-CoV-2 (we assume 2.0 in our base case)
*7 days after pandemic alert
^ 10% of normal long-distance travel
Source: Germann, Timothy C, et al, Mitigation strategies for pandemic influenza in the United States, PNAS April 11, 2006.

While the situation is changing daily, we have seen mitigation efforts already emerging in various countries beyond China, although responses are generally more measured. Japan, Iran, Italy, and New Delhi have already closed all schools. We're also seeing fewer large gatherings (events canceled in France, Switzerland, the U.S., and other countries), and recommendations for flexible workers to telecommute, but businesses and transportation remaining open. School closures in a Seattle suburb are so far the most extensive in the U.S. The CDC is recommending against cruise ship travel for all Americans, but particularly for those at elevated risk, and it also recommends that those at highest risk avoid crowds and non-essential travel.[29] However, Italy has put 16 million people on lockdown, a more extreme measure akin to that in China, and some argue for this sort of extreme measure in other developed nations like the U.S.[30] We think the U.S. would be unlikely to go this direction unless this were a much more severe pandemic, with death rates closer to SARS or MERS.

China's Rapid and Aggressive Efforts to Contain the Disease Look Successful for Now; Western Approaches Will Be More Moderate but Also Mitigate Impact

As no drugs or vaccines are available for this novel coronavirus, China's rapid and aggressive response to the spread of a novel virus focused on basic mitigation measures, with successful outcomes so far, despite criticism for initial missteps and secrecy.[31] China's first cases of COVID-19 likely began by early December, although no cases were officially diagnosed until January. Within a week of identifying the

28 Community Mitigation Guidelines to Prevent Pandemic Influenza, United States, CDC, 2017.

29 https://wwwnc.cdc.gov/travel/page/covid-19-cruise-ship

30 https://www.thelancet.com/action/showPdf?pii=S0140-6736%2820%2930522-5

31 https://www.wsj.com/articles/how-it-all-started-chinas-early-coronavirus-missteps-11583508932?emailToken=a203e6d0563440aeacdee0360c94ddb5SjclfcC7rnMtk5tQ0zfUvUilFk2fWoY6Yr/Zc+Bxs1pN00eKRZSqRLdbY6sHrZ8zJZZwbkVosrZ3mtH21ntf0N9s2Rb1YfspK0SS95w2dxMCOI4cNd3aT0T8HhcKJP5z&reflink=article_email_share

new virus on Jan. 7, China had released the virus genetic sequences publicly (allowing researchers across the globe to study and target the virus) and created a diagnostic test kit.

On Jan. 20, COVID-19 became a Class B notifiable disease, triggering a more comprehensive approach to containing the virus including quarantines and temperature checks. On Jan. 23-24, Wuhan and 15 other cities were effectively shut down. With the Lunar New Year holiday directly following this, and a mandatory nationwide extended holiday beginning directly after the holiday, China has made incredible strides in containing a very contagious new virus, likely buying the rest of the world a few weeks before spreading significantly beyond China, according to WHO.[32] However, it is still unclear if it has contained or simply suppressed the virus, as Wuhan remains under lockdown, and businesses outside of Hubei have lower alert levels, but workers and students are still in the process of returning to work and school, meaning there could be a resurgence.[33]

Significant social distancing (closing schools, canceling large gatherings like Lunar New Year celebrations), quarantines, and travel restrictions were put in place in China, to the consternation of infectious disease experts (who see these more severe measures as potentially more destructive than helpful), but it now seems these efforts may have been successful, but WHO sees the recent decline in cases is real, with any future resurgence potentially manageable. Offices began to reopen in early March after a month-long break to slow the spread of the virus. Exhibit 9 details the restrictions based on the rate of infections in a given area. In mid-February, at the height of the outbreak, more than half the population were under some form of lockdown in their homes, ranging from checkpoints to forbidding citizens to leave their homes.[34]

Exhibit 9 China's Four Types of COVID-19 Locations, by Epidemiology

Area	Action
No cases	quarantines at transport hubs, temperature checks--preventing disease and ensuring normal activity is maintained
Sporadic cases	focus on reducing importation, stopping transmission, and providing treatment
Community clusters	focus on reducing importation, stopping exportation, and improving treatment
Community transmission	very strict controls, such as stopping entry and exit of citizens

Sources: Morningstar, WHO.
https://www.who.int/docs/default-source/coronaviruse/who-china-joint-mission-on-covid-19-final-report.pdf

32 https://www.statnews.com/2020/02/21/coronavirus-wuhan-quarantine-bought-world-time-to-prepare/
33 https://www.nytimes.com/2020/03/07/world/asia/china-coronavirus-cost.html?referringSource=articleShare
34 https://www.nytimes.com/2020/02/15/business/china-coronavirus-lockdown.html

Today, China is using smartphone software to determine whether citizens should self-quarantine or not, using an unknown method to determine their contagion risk. This can result in a range of actions from unrestricted to a mandatory two-week quarantine.[35]

With the SARS outbreak in 2002, China and Hong Kong comprised the vast majority of cases (7,000 out of roughly 8,000 globally), and the disease was identified in November and officially eradicated by July 2003, with no recurrences.[36] The COVID-19 outbreak, beginning in December 2019, has already spread much more widely than SARS, perhaps because patients are contagious when they are experiencing few symptoms. Given the widespread nature of COVID-19 at this point, we think eradication looks unlikely.

U.S. Mitigation Measures Hampered by Diagnostics Delays

While the U.S. benefits from both China's aggressive efforts to contain COVID-19, the initial response has been slow and disorganized. Trump held a press conference on the coronavirus on Feb. 26, appointing vice president Pence to lead the national effort to defend against the virus. However, the next day, the first case of possible community spread (infection from an unknown source) was identified in California, followed by several cases on Feb. 28, indicating that the virus had likely already been in the U.S. for weeks. While China has multiple commercial tests on the market and can test up to 1.6 million patients a week, the U.S. declined access to the World Health Organization diagnostic,[37] and diagnostics advancements in the U.S. have lagged other countries. The CDC had only tested 459 patients as of Feb. 28, using a test approved by the FDA in early February, for SARS-CoV-2, and testing is still ramping up as the disease spreads to many states, with more cases in Washington and California.

In 2007, the U.S. CDC introduced a Pandemic Severity Index to help determine the measures to take and the length of time they should be implemented, with the goal of mitigating the impact of the disease on overall health and the economy.[38] The system assumed that pandemics could affect 30% of the population, and used case fatality ratios (percentage of infected patients who die) as a measure of the severity of a potential pandemic, with CFRs greater than 1% putting a pandemic into a category of 4 or 5 and leading to a number of recommended mitigation steps or nonpharmaceutical interventions, from more basic measures (voluntary quarantine of sick patients and their families) to social distancing measures (school/daycare closings up to 12 weeks, encouraging teleconferences and working from home, and canceling public gatherings). The goal is to delay the growth curve and buy time for vaccines and treatments.

An updated document from 2017[39] replaces this plan with a Pandemic Severity Assessment Framework that doesn't just rely on CFR for disease severity (as this can be distorted by testing levels, particularly early in a pandemic), but also hospitalization/death ratios, and transmissibility is defined by attack rates

35 https://www.nytimes.com/2020/03/01/business/china-coronavirus-surveillance.html?referringSource=articleShare

36 Wu, Zunyou, and Jennifer M McGoogan, Characteristics of and Important Lessons from the Coronavirus Disease 2019 (COVID-19) Outbreak in China. JAMA, Feb 24, 2020

37 https://www.politico.com/news/2020/03/06/coronavirus-testing-failure-123166

38 Interim Pre-pandemic Planning Guidance: Community Strategy for Pandemic Influenza Mitigation in the United States, Feb 2007. DHHS/CDC

39 Community Mitigation Guidelines to Prevent Pandemic Influenza, United States, CDC, 2017

in different community settings. The CDC will make a recommendation for action when a pandemic begins, which could take weeks to refine, and the effectiveness can be improved by layering several of these mitigation strategies together, as we discussed in Exhibit 8.

Therefore, the U.S. healthcare system has made significant effort to prepare for pandemics, and these plans were activated as recently as 2009 with the swine flu pandemic, meaning that hospitals should be prepared for current COVID-19 planning, with efforts focused on isolating suspected patients and protecting workers.

That said, diagnostics efforts, which should lead our response in a pandemic threat, have been disappointing. Distribution of tests to state and local labs was hampered by test inaccuracies.[40] In addition, criteria for testing for the virus have been strict, delaying earlier diagnoses. We do expect rapid improvement on these fronts, as restrictions on testing were lifted as of March 3, and CLIA-certified labs (large labs such as those in medical centers) are now allowed to create and run their own tests. Commercial diagnostic makers are also working to get FDA approval for their tests, and while this is technically required before running tests in a public health emergency, the FDA is letting Quest and LabCorp launch tests ahead of approval, given the strong need. In addition, Bill Gates has funded an effort that should result in at-home testing kits becoming available in Seattle, and these tests can be sent for analysis with results in one to two days, although ultimate supply and processing is still uncertain.[41] While a million tests could now be conducted each week, according to FDA head Stephen Hahn, this could overwhelm processing capabilities initially.[42]

U.S. Measures Unlikely to Mirror China's, Making Containment More Difficult

In the U.S., restrictions and quarantines were among the first steps to slow the spread of the virus. For example, the U.S. halted flights between the U.S. and China in early February (barred foreign nationals who had been to China from entering the U.S.) and is now screening all travelers on flights from Iran, Italy, and South Korea. Current school closures aren't widespread, with 12 closures in Washington state and fewer in other states, although as of March 6 189 U.S. schools were closed,[43] and Chicago is closing its first school the week of March 9.[44] While ideally we could learn more about the fatality rate (which is lower outside of Hubei province, where the disease started, and which provided the data for China to make its initial decisions) and weigh this against the potential economic hit from long-term closures of schools, public transportation, and office buildings, the disease is spreading rapidly and doesn't allow time for lengthy analysis. We expect to see school closures and recommended telecommuting in the U.S. as the next precautionary measures, as other than household transmission, schools and workplaces are the likeliest places for transmission.[45] That said, we are unlikely to lock down the hardest-hit cities, or

40 https://www.sciencemag.org/news/2020/02/united-states-badly-bungled-coronavirus-testing-things-may-soon-improve

41 https://www.seattletimes.com/seattle-news/health/gates-funded-program-will-soon-offer-home-testing-kits-for-new-coronavirus/

42 https://www.nytimes.com/2020/03/03/world/coronavirus-live-news-updates.html

43 https://www.edweek.org/ew/section/multimedia/map-coronavirus-and-school-closures.html

44 https://www.chicagotribune.com/coronavirus/ct-coronavirus-chicago-new-developments-20200307-pf3rb73gnzdgvlk3uuz4v6sihm-story.html#nt=oft-Double%20Chain~Flex%20Feature~top-news-curated-chain~6th-case-645p~~1~yes-art~curated~curatedpage

45 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3191213/#!po=21.1538

prevent Americans from leaving their homes, as our culture and government would only bear these sorts of restricted freedoms in a far worse pandemic, in our opinion. In addition, certain factors make us more exposed than China, including the high number of workers who have limited sick leave and can't afford to stay home sick, or lack health insurance and wouldn't seek care, as well as and the much higher percentage of our population that is urban (where diseases spread more rapidly).[46] On the other hand, we are likely much more prepared for the taxing of our hospital system, as we appear to have a massive lead over other developed nations in the number of ICU beds per citizen.[47]

Base Case: Coronavirus Spread Begins to Resemble a Severe but Manageable Flu: 60% Probability
We assume a global fatality rate of 0.5% of those infected in our base case, much lower than levels reported to date, with even lower rates for developed countries (able to put risk mitigation measures in place) and the working age population (the disease is most severe in patients over the age of 65, and particularly those over the age of 80 or with preexisting conditions). We expect newer cases to become easier to diagnose and hospitals to learn how to best treat. As shown in Exhibit 4, current numbers show a 4.4% death rate in Hubei province, which includes Wuhan, versus a 1%-2% death rate outside of Wuhan, with most of these numbers still reflective of China's fatality rates. This should further lower the economic impact, even if global death rates are much higher than recent pandemics. This distinguishes coronavirus from influenza pandemics, which often target younger patients as well (and Spanish flu hit in a patient's prime).

This 0.5% global fatality rate is still well ahead of death rates from the flu, which is around 0.1%. Given the high transmissibility, we also expect 20% of the global population to be infected, or roughly 1.5 billion people, which is above the high end of the typical range for seasonal flu of 3%-11%,[48] but consistent with the U.S. Department of Health and Human Services, or HHS', moderate to very severe pandemic projections of 20%-30% infection rates[49] as well as infection rates for prior pandemic flu (between 20% and 40% of the U.S. population were infected by Spanish flu, Asian flu, and Hong Kong flu).[50] This could result in nearly 8 million deaths globally, or more than 200,000 deaths in the U.S., well ahead of the typical U.S. deaths from seasonal flu (12,000-61,000, according to the CDC).

Given the potential for a second wave, we think the impact on the economy could be felt for the remainder of 2020, and we assume this could cost the U.S. 1.5% of 2020 GDP, consistent with Congressional Budget Office estimates of the impact of a more mild pandemic, similar to the 1957 or 1968 pandemics.[51]

See page 26 for more details on our economic analysis.

46 https://www.nytimes.com/2020/03/06/business/coronavirus-economy-us-china.html?referringSource=articleShare
47 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3551445/#!po=20.8333
48 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5934309/pdf/nihms944068.pdf
49 Pandemic Influenza Plan, 2017 Update, Department of Health and Human Services
50 Interim Pre-pandemic Planning Guidance: Community Strategy for Pandemic Influenza Mitigation in the United States, CDC, Feb 2007
51 https://www.cbo.gov/system/files/2018-10/05-22-avian-flu.pdf

Assume Treatment Available in Mid- to Late-2020, Vaccine in Mid- to Late-2021

We assume that progress with a coronavirus vaccine will take time, with the first vaccines potentially ready for patients if this turns into a recurrent virus like seasonal flu in the 2021-22 flu season (swine flu from 2009 is now part of the seasonal flu waves). However, we assume we could see the first treatments become available to patients with severe illness by May, if data in April support the efficacy of Gilead's remdesivir.

Other drugs are also in development or entering development, as shown in Exhibits 13-15. This could also reduce the need for expensive and supply-constrained treatment including ventilators. We expect that initial supply of Gilead's drug could come pre-approval and may not benefit Gilead's cash flows, but that the drug would be approved for a potential second wave in the fall, and for future stockpiling for seasonal recurrence or future coronavirus pandemics (as the drug did show preliminary efficacy in other coronaviruses as well).

U.S. Could See Ventilator Shortage but Lower Assumed Death Rate

In the U.S., we assume slightly lower death rates (0.3% of infected), due to better care than other developed markets and developing markets. We assume, consistent with CDC expectations, that there will be significant community spread in the U.S. and significant impact on daily life. We expect an outbreak could last for 2-3 months, with potential for a second wave hitting in the fall. There are likely to be measures taken to achieve social distancing (school closures and working-from-home recommendations for up to three months).

In this scenario, we assume that hospitals will be stretched to care for severely ill patients, as they are during a typical severe flu season, with ventilators used at capacity. If all of the patients we assume will reach the ICU need a ventilator, this would be almost 600,000 patients in the U.S. in this base-case scenario. With the number of ventilators in the U.S. likely approaching 100,000[52] and a disease spread across months, we think this could be manageable, assuming the seasonal flu season begins to ramp down as anticipated. However, this depends on the speed of increase in cases and whether treatments (like remdesivir) become available.

52 https://www.nytimes.com/2020/02/29/health/coronavirus-preparation-united-states.html?referringSource=articleShare

Exhibit 10 Scenarios for U.S. Health Impact From Pandemic Flu and COVID-19: HHS and Morningstar Analysis

	Pandemic Severity	Percentage Infected	Percentage Seeking Outpatient Care	Percentage Hospitalized	ICU	Deaths	Patient Deaths	Deaths (as % of Infected)
	Moderate	20%	10%	0.3%	0.1%	0.02%	49,050	0.1%
HHS 2017	Moderate	30%	15%	0.3%	0.1%	0.02%	73,575	0.1%
Pandemic	Severe	20%	10%	1.2%	0.4%	0.16%	521,156	0.8%
Influenza	Severe	30%	15%	1.8%	0.5%	0.24%	786,844	0.8%
Scenarios	Very Severe	20%	10%	2.4%	0.7%	0.41%	1,328,438	2.0%
	Very Severe	30%	15%	3.6%	1.1%	0.60%	1,972,219	2.0%
Morningstar	Base case	20%	10%	0.9%	0.2%	0.06%	206,010	0.3%
COVID-19	Bull case	10%	5%	0.3%	0.0%	0.01%	29,430	0.1%
Scenarios	Bear case	30%	15%	1.8%	0.5%	0.20%	662,175	0.7%

*all percentages, unless otherwise specified, are of total U.S. population in 2018 (327 million)
Sources: Morningstar, HHS.

Bear Case: Severe Pandemic More Akin to Spanish Flu, With Mitigation Measures Slightly Improving Comparisons: 15% Probability

In a bear case, we assume a potential pandemic cost of 5% of 2020 GDP, similar to the 1918 Spanish flu, consistent with past pandemic analysis from the Congressional Budget Office.[53] This would be the result of extended (potentially six month) school closures, employees working from home, and significant impact on retail and service industries, as well as the higher pressure from employees caring for sick family members. However, we do not assume widespread use of extreme measures such as walling off cities or entirely stopping transport (even though the U.S. government has the authority to limit civil liberties to protect public health). Even if the virus fades by the end of 2020, we would expect recurrence of the disease as well as significantly more time for the economy to ramp back to its normal more functional level, although long-term impact is still relatively low.

We assume less significant improvement from ex-Hubei fatality rates, with a roughly 0.8% fatality rate for the remainder of the pandemic. This is similar to the U.K. action plan from March 2020, which discloses a worst-case scenario where 1% of infected patients die.[54] In such a scenario, we assume 30% of the global population could be infected, consistent with HHS' moderate to very severe pandemic projections[55], but a smaller number than worst-case scenarios put forward by Harvard's Marc Lipsitch (40%-70%) and Australia's government (25%-70%, with 50% in a severe scenario[56]). Our assumptions imply more than 18 million deaths globally and nearly 700,000 in the U.S.

We don't assume as high a percentage of the world's population to succumb to the coronavirus in this scenario as in the Spanish flu (even in this bearish analysis, we assume 0.24% of the population could

53 https://www.cbo.gov/system/files/2018-10/05-22-avian-flu.pdf

54 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/869827/Coronavirus_action_plan_-_a_guide_to_what_you_can_expect_across_the_UK.pdf

55 Pandemic Influenza Plan, 2017 Update, Department of Health and Human Services. https://www.cdc.gov/flu/pandemic-resources/pdf/pan-flu-report-2017v2.pdf

56 https://www.smh.com.au/national/australia-would-need-1-5-million-beds-if-coronavirus-pandemic-hits-20200226-p544fi.html

die). There were more than 50 million deaths from Spanish flu, at a time when the world's population was just under 2 billion, implying more than 2% of the population died from the disease (roughly one third were infected).[57] We assume mitigation measures are much improved from a century ago, and would be applied more consistently. For example, cities like St. Louis that reacted quickly with school closures, halting public transport, and isolation of those who were sick had much lower death rates than Philadelphia and Pittsburgh, which were more hesitant to risk the economic hit of shutting down businesses.[58] This benefit, however, is partly countered by greater international travel in modern society (although Spanish flu occurred at the end of the First World War, allowing troops to spread the disease across continents). Perhaps even more importantly, patients frequently died within hours of developing symptoms of Spanish flu, limiting the ability for diagnosis and treatment to improve outcomes. Coronavirus is extremely different in that sense, with the average time between developing symptoms and hospitalization (in severe cases) of at least nine days.[59] We think this buys time for patients to get diagnosed and get treatment, whether that is targeted treatment from novel medicines or simply the standard of care in hospitals.

Bull Case: COVID-19 Infects Widely but Fades in Severity, Like 2009 Pandemic: 25% Probability

We see limited economic impact in a bull-case scenario, where COVID-19 essentially slightly extends the typical flu season (which was already severe). In this scenario, we assume that fatality rates begin to fade rapidly, as they already have beyond Hubei province, settling closer to 0.1%, consistent with a typical flu. Given the high transmissibility, we still have a pandemic to be declared in this scenario. We model 10% of the global population infected, or roughly 770 million people, which is at the high end of the typical range for seasonal flu of 3%-11%,[60] but would generally be seen as successful mitigation of a pandemic.[61] This results in less than 800,000 deaths globally this year (around 30,000 in the U.S.). We assume coronavirus does not recur (and does not experience a second wave, effectively disappearing with warmer weather in the summer months), mostly limiting the economic impact to the first quarter, with China remaining the most heavily exposed by far.

Pharmaceutical Innovation and Pandemics: Moderna and Gilead Lead the Pipeline

Two key ways of slowing or potentially stopping the coronavirus—treatments and vaccines—are quickly making their way into clinical trials. While the fastest timeline for vaccines to reach patients, even Moderna's mRNA vaccine that was developed in record time, is 12-18 months, we think treatments stand a chance at becoming available this year. China has already recommended several drugs approved for other purposes in the treatment of coronavirus, including HIV combination Kaletra, flu antiviral Arbidol (approved in China and Russia), and Roche's Actemra (Actemra is used to treat immune overreaction that can cause lung damage, and does not slow the virus itself). Gilead's remdesivir stands out for its potential to treat coronavirus, however, as the drug rapidly moved to phase 3 studies, with data expected by April.

57 Taubenberger, Jeffery K, and David M Morens, 1918 Influenza: The Mother of All Pandemics

58 https://www.nytimes.com/2020/02/28/sunday-review/coronavirus-quarantine.html?referringSource=articleShare

59 Fauci, Anthony S. et al. Covid-19-Navigating the Uncharted. New England Journal of Medicine, Feb 28, 2020

60 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5934309/pdf/nihms944068.pdf

61 https://www.pnas.org/content/pnas/103/15/5935.full.pdf

Exhibit 11 Gilead's Remdesivir and Moderna's mRNA-1273 Are the Leading Treatment and Vaccine Programs in Clinical Studies

Drug	Firm	Prophylaxis or Treatment	Type of Drug	Background	Status
Remdesivir	Gilead	Treatment (prophylaxis in the future?)	Antiviral small molecule, attacks common portion of coronaviruses	Remdesivir is an off-the-shelf drug (studied in Ebola), which made this fast to clinical trials. The drug worked in a variety of animal models for other coronaviruses, and first case study of use in 1 patient was published in the New England Journal of Medicine on Jan. 31.	Gilead began two phase 3 studies in Feb 2020, and a China trial is poised to release data on April 27. The high number of trials and fewer new China patients have made recruitment more challenging. Gilead was granted three China patents in Feb 2020, although one for coronavirus is still under review (China-based BrightGene is already manufacturing remdesivir, and China could invoke a compulsory license in a time of crisis).
mRNA-1273	Moderna	Prophylaxis	Nucleic acid based (Moderna's mRNA platform technology)	The vaccine instructs the body to make Spike (S) protein from the coronavirus, which is necesary for membrane fusion and host cell infection and is also the target for past MERS and SARS vaccine designs. The protein then creates an immune response. Moderna got funding for this program from CEPI, but also has 6 vaccines in the clinic and made the initial vaccine supplies in its new Norwood facility.	The first trial started in early March (Moderna shipped to NIAID 42 days after sequence selection, a record for vaccines). This trial, which involves a two-shot series in healthy volunteers, should have data in three months, followed by a 6-8 month phase 2 test in hundreds or thousands, at which point the vaccine could be produced for broader use in the field. We assume at least a year until the vaccine could become widely available, in time for a potential 2021-22 season if this becomes seasonal, but beyond efficacy, manufacturing could also delay release.

Sources: Morningstar, company reports,
https://www.wsj.com/articles/drugmaker-moderna-delivers-first-coronavirus-vaccine-for-human-testing-11582579099
https://scrip.pharmaintelligence.informa.com/SC141719/Moderna-Marches-First-Coronavirus-Vaccine-To-US-Test
https://scrip.pharmaintelligence.informa.com/SC141737/Fewer-Wuhan-Patients-For-Gilead-Remdesivir-Study-WHO
https://pink.pharmaintelligence.informa.com/PS141747/Market-For-COVID19-Therapeutics-Will-Exceed-Government-Demand-US-Believes

The FDA has a Medical Countermeasures Initiative that could allow authorization of a COVID-19 treatment for emergency use (called the EUA pathway), like Emergent BioSolution's anthrax vaccine, and COVID-19 developers could also use the standard accelerated approval pathway at the FDA.[62] Fortunately, the structural similarities between SARS and SARS-CoV-2 could allow drug developers to dust off old SARS drugs from their libraries; if these prove effective, it could shave months off development times, particularly if safety was established during the initial SARS outbreak. For example, researchers have determined that Nsp15 inhibitors could work against both viruses.[63] In addition, Gilead's remdesivir, which has a huge lead in development among unapproved drugs, was on the shelf after being initially developed for Ebola, which allowed Gilead to quickly move into studies when it saw signs of efficacy in coronaviruses.

As the coronavirus is structurally related to the virus causing SARS (2002-03 outbreak) and also follows the outbreak of another coronavirus disease, MERS (since 2012), we think there will be an increasing prioritization of coronavirus vaccine development (perhaps even efforts to develop a universal vaccine for any coronavirus outbreak) and future pandemic preparedness, regardless of whether coronavirus becomes a widespread pandemic. It took 20 months for a SARS vaccine to reach human testing, and years to do the same for MERS, but this timeline is improving dramatically. It took only six months to move to testing for Zika virus, and Moderna entered coronavirus testing in two months.

The creation of the Coalition for Epidemic Preparedness Innovations, or CEPI, in 2017 (following Ebola and Zika outbreaks) is tasked with coordinating global responses to new outbreaks and serves as a

62 https://pink.pharmaintelligence.informa.com/PS141589/Coronavirus-Efforts-Could-Benefit-From-LittleUsed-Medical-Countermeasures-Incentives
63 https://news.northwestern.edu/stories/2020/03/new-coronavirus-protein-reveals-drug-target/

public/private funding engine that is supporting development at firms like Moderna and Inovio through the COVID-19 outbreak. Moderna's peers focusing on mRNA technology, CureVac and BioNTech, are also moving forward preclinically.

Larger vaccine makers are entering the coronavirus space more slowly, perhaps because they focus on older technologies, or perhaps because of past efforts for diseases that faded before a treatment could be approved. Glaxo bought Okairos in 2013 for Ebola vaccine development but sold the technology in 2019. Sanofi partnered with the U.S. government on a Zika vaccine, but then exited the collaboration, reportedly due to discussions on pricing.

Adding Remdesivir to Gilead Model with 70% Probability of Approval, 40% Probability of Stockpile

Bruce Aylward at the World Health Organization cited remdesivir as "the one drug right now that we think may have efficacy," while in Beijing in late February. While the drug did not perform as well as Regeneron's REGN-EB3 in an Ebola trial, it has shown preclinical efficacy in both SARS and MERS, and we have seen one impressive recovery of the first U.S. coronavirus patient reported on Jan. 31 in the New England Journal of Medicine.[64]

Remdesivir is a nucleotide analog with broad activity across RNA viruses.[65] Gilead rapidly collaborated with universities in China to begin testing remdesivir in sick patients in February, with data expected in April, and additional studies, including two phase 3 studies run by Gilead, have also been initiated, as shown in Exhibit 12. We expect data from these trials would be sufficient for breakthrough status and priority review at unprecedented speeds.

Exhibit 12 Gilead's Current Clinical Trials for Remdesivir as a Treatment for COVID-19

Type of Patients	Phase	Start Date	Data Due	Location	Identifier	Sponsor	Dose	Patients
Severe respiratory disease	3	6-Feb	April	Beijing	NCT04257656	Capital Medical University	IV once daily for 9 days	453
Mild/moderate respiratory disease	3	12-Feb	April	Wuhan	NCT04252664	Capital Medical University	IV once daily for 9 days	308
Lab-confirmed COVID-19 and one other criteria*	2	21-Feb	April	U of Nebraska	NCT04280705	National Institute of Allergy and Infectious Diseases (NIAID)	IV once daily up to 10 days	394
Severe disease	3	March	May	TBD	NCT04292899	Gilead	IV 5 or 10 days	400
Moderate disease	3	March	May	TBD	NCT04292730	Gilead	IV 5 or 10 days	600

Note: * x-ray, crackles on exam, ventilation or oxygen necessary, and so on
Sources: Morningstar, clinicaltrials.gov.

We haven't included remdesivir in our model to this point, given scarce evidence of efficacy, several other generics in testing, and uncertainty around the global spread of the disease. Initially, with most

64 https://www.nejm.org/doi/pdf/10.1056/NEJMoa2001191?articleTools=true
65 https://www.jbc.org/content/early/2020/02/24/jbc.AC120.013056.full.pdf

cases in China, we assumed that there could be generic options that serve the market as well, limiting Gilead's penetration in that market regardless of the drug's efficacy. In addition, the first wave of cases is likely to rise and fall before Gilead will be able to garner approval, even at a very accelerated pace (data are expected in April, and while Gilead is ramping up manufacturing at risk ahead of data, manufacturing capabilities for millions of patients are unclear at this point).

However, as our base case now includes wide spread of the disease to 20% of the population, we now assume a 70% chance that Gilead will be able to sell remdesivir for future waves of coronavirus (beginning as early as the summer of 2020) and a 40% chance that it will be stockpiled for future years. We assume initial supply in the spring of 2020 will be largely provided prior to approval in severely ill patients. We assume a price around $500 per patient, which is above the roughly $150 price tag for Tamiflu, but we also assume that use could be reserved for more severe cases, at least initially while Gilead ramps manufacturing.

We assume a much lower stockpiling price in the U.S. of $50 per person and assume the U.S. could gradually build enough supply to serve a quarter of the population. Overall, this leads to peak global sales of $1.4 billion in 2021, as Gilead could see both seasonal and stockpiling sales. Tamiflu pandemic stockpile sales peaked at CHF 2.1 billion in 2006 for avian flu and also hit CHF 1.9 billion in 2009 for swine flu. We do not model sales beyond 2023, as uncertainty on commercial potential grows as the likelihood of effective vaccines rises. This has a modest impact on our Gilead valuation, which we have raised to $85 per share from $84. However, if other treatments fail, vaccine development stalls, and coronavirus does make annual recurrences, we could be begin to see remdesivir used for both treatment and antiviral prophylaxis (akin to the use of Truvada and Descovy to prevent transmission of HIV), and sustained use would have a significant impact on our fair value estimate (carrying $1 billion in annual sales beyond 2023 could raise our fair value estimate closer to $90 per share).

Moderna's mRNA-1273 Is Most Advanced Among Vaccines and Could be Available in 2021

Among vaccine makers, Moderna has the lead. Moderna has created a nucleic-acid based vaccine, basically providing the body with the blueprint for it to manufacture certain proteins that are present on the virus. The body then mounts an immune response to the protein, but also to any virus with that protein on display. However, there are suggestions that there could be durability issues with responses based on this technology.[66] Regardless, it will take at least one year to adequately test any new vaccine in sufficient numbers of patients for it to be safe for widespread use.

That said, Moderna's mRNA technology has allowed it to bring a vaccine candidate into testing just two months after receiving the genetic sequence of SARS-CoV-2, which demonstrates significant progress with innovative new technologies that could become nimble enough, with time, to rapidly serve a new outbreak.

66 https://scrip.pharmaintelligence.informa.com/SC141771/China-Rallies-Behind-Coronavirus-Vaccines-But-Small-Players-May-Have-Best-Shot

With a safety study in progress and efficacy studies to be conducted this summer, we would expect potential approval in early 2021, putting the firm in good position to supply the vaccine, should this become a recurring virus like influenza. While Moderna does not have any marketed products based on its mRNA technology, it does have several products in testing for a range of diseases, and we think stands a decent chance at becoming a diversified biotech in the long run. Moderna's CEO has said he wouldn't price higher than other respiratory virus vaccines, putting a high end at $800 per year (the cost of four shots of pneumonia vaccine Prevnar-13).

Beyond Moderna and Gilead, there are dozens of other firms vying to enter the market. AbbVie's HIV combination pill Kaletra, generic malaria medicine chloroquine, and antiviral flu medicines represent approved Western medicines that could prove effective for this novel coronavirus. Many traditional Chinese medicines are currently in trials in China, as well, by one count comprising 80 of 139 interventional coronavirus clinical trials in China.[67] The pipeline also contains several novel vaccines and treatments that are still at the preclinical stage, as shown in Exhibits 13-15.

67 https://pink.pharmaintelligence.informa.com/PS141754/Surging-China-Coronavirus-Trials-Prompt-Tougher-Criteria

Exhibit 13 Potential Coronavirus Vaccines (Beyond Moderna's Leading Program)

Vaccine	Firm	Status
AdVac/PER.C6 technology	J&J	J&J is reviewing SARS and MERS vaccine candidates from its shelves for coronavirus efficacy, with vaccine available at scale (300 million doses a year) in 8-12 months.
Flublok technology	Sanofi	Sanofi is working with BARDA on a vaccine, using influenza Flublok technology. They could enter the clinic in 12-18 months and receive approval in 3-4 years.
COVID-19 S-Trimer	Clover/GSK	Clover has manufacturing capabilities (mammalian cell culture) that are among the largest in China, but is not yet initiating a clinical trial. Glaxo provides pandemic adjuvant (booster).
Vectored	GeoVax/BravoVax	GeoVax (U.S.) shipped vaccine for U.S. studies, using same technology as for Ebola and Lassa fever vaccines. BravoVax (Wuhan) is China partner (to bring to phase 1 in 2021)
Nanoparticle vaccines	Novavax	Novavax is doing very early work on coronavirus, with a vaccine candidate yet to be selected to enter phase 1 testing in May or June.
Peptide vaccine	Epivax/Generex	Epivax has computational tools, and Generex makes peptide vaccines. Generex has received funding for research from a Chinese consortium.
mRNA	CureVac	Working with CEPI, CureVac has two mRNA candidates that do not target the spike protein poised to enter trials by summer. mRNA is self-amplifying and could churn out 1 million doses every two weeks, if approved.
mRNA	BioNTech	Pfizer may expand its flu vaccine partnership with BioNTech to coronavirus.
Nucleic acid based (DNA plasmid) INO-4700	Inovio/Beijing Advaccine	Supported by CEPI (continuing a MERS-based partnership), Inovio plans to start a clinical study in China starting in June 2020 (partnered with Beijing Advaccine), with manufacturing by TX-based VGXI.
Protein expression vector	Migal	Migal's vaccine for avian coronavirus infectious bronchitis virus (IBV) could work against coronavirus in humans.
Recombinant vaccine, oral	Vaxart	Using its VAAST platform, Vaxart plans to generate vaccine candidates for coronavirus.
Horsepox vaccine	Tonix	TNX-1800 is under development as a smallpox vaccine and monkeypox vaccine, but plan to develop for coronavirus.
Linear DNA vaccine	LineaRx/Takis	Collaboration aimed at developing a vaccine (currently preclinical)
Plant-derived vaccine	iBio/Beijing CC-Pharming	Vaccine expertise on MERS from CC-Pharming and iBio's manufacturing facility design specifically for a pandemic form the basis of this collaboration, which is still in research phases.
Intranasal vaccine	Altimmune	The firm has designed a vaccine that could start clinical testing in August, but needs a partner (its NasoVAX technology was also used to design an influenza vaccine).
Vaccine platform	SK Bioscience	This South Korean vaccine specialist (with manufacturing expertise) has a platform that could be adapted for mutating viruses, but still in research stage for coronavirus.

Sources: Morningstar, company reports,
https://www.genengnews.com/a-lists/how-to-conquer-coronavirus-top-35-treatments-in-development/
https://invivo.pharmaintelligence.informa.com/IV124466/Fact-File-Coronavirus-Pipeline-And-Corporate-Updates

Exhibit 14 Coronavirus Treatments in Testing (Beyond Gilead's Remdesivir)

Clinical-stage treatment	Firm	Status
Prezcobix (darunavir/cobicistat)	J&J	J&J has donated the HIV drug to Chinese hospitals, where it is in clinical testing.
Kaletra (lopinavir/ritonavir)	AbbVie	This HIV drug combo began a trial in China in coronavirus in February, and has been formally authorized to treat pneumonia caused by coronavirus in China, and AbbVie has donated supplies. Data in late January in a handful of patients supported efficacy.
Arbidol (umifenovir)	Pharmstandard	This flu drug is recommended by Chinese authorities, and is in testing alone and with Kaletra, ASC09, and other medicines.
Avigan (favipiravir)	Fujifilm	Approved in Japan and China for flu, Avigan was also used in Guinea for Ebola (it is generic in China, being tested by Zhejiang Hisun). It showed better efficacy and fewer side effects than Kaletra in a study at a Shenzhen hospital. It is also being tested in mild patients in Japan, and has been recommended by the country's health minister, but potential birth defects could limit wide use.
Panaphix (PAX-1)	Komipharm	Panaphix is a non-narcotic analgesic (NaAsO2) intended to ease inflammation and has been filed to start a trial in S Korea.
Chloroquine phosphate	Bayer	This generic malaria drug is in testing in China, and researchers have reported that chloroquine is highly effective. Bayer has donated supply of its branded version Resechin.
ATR-002	Atriva	This MEK inhibitor is entering phase 2 to treat RNA-based virus respiratory symptoms, but there is no data for this novel coronavirus.
Interferon-1B		Approved for treatment of autoimmune diseases, interferon is being studied as potential supportive care in coronavirus.
Actemra	Roche/Chugai	Used to treat arthritis but also to tamp down immune systems in dangerous cytokine storms in cancer patients (CAR-T treatment can trigger this), this is also being studied in patients with respiratory distress due to coronavirus in China.
Marketed hyperimmune globulin (plasma-derived protein)	Takeda	Takeda announced studying activity of its plasma-derived hyperimmunoglobulins in March, already being used as treatment in China
Camrelizumab	Incyte/Shanghai Hengrui	PD-1 antibody camrelizumab is being tested in China in combination with hormone thymosin.
APN01	Apeiron Biologics	A recombinant rhACE2 enzyme, APN01 is in clinical testing in China to treat patients with severe infection.
Ganovo (danoprevir) and ASC09	Ascletis Pharma	These protease inhibitors (designed to treat HIV) are in clinical trals in China, with reports of success in a handful of patients (also being tested in combination).

Sources: Morningstar, company reports.
https://www.genengnews.com/a-lists/how-to-conquer-coronavirus-top-35-treatments-in-development/,
https://invivo.pharmaintelligence.informa.com/IV124466/Fact-File-Coronavirus-Pipeline-And-Corporate-Updates

Exhibit 15 Potential Coronavirus Treatments (Preclinical Stage)

Preclinical treatment	Firm	Status
REGN3048/REGN3051	Regeneron	BARDA is working with Regeneron to develop antibodies that could be used in combination (REGN3048 and REGN3051 completed a phase 1 study in MERS in 2019). The drugs use VelociSuite technology, similar to Ebola drug REGN-EB3 (which reached animal testing in 6 months and human testing in 12 months).
Galidesivir (adenosine analog)	Biocryst	Under contract with HHS, who will decide whether galidesivir (originally developed to treat filoviruses like Ebola and Marburg virus disease, and currently in a phase 2 trial in yellow fever) could have activity with COVID-19.
Novel hyperimmune globulin TAK-888 (plasma protein from recovered patients, used with Ebola)	Takeda	This specific SARS-CoV-2 polyclonal hyperimmune globulin is being developed, as of March--since it is being isolated from recovered patients, it could be faster to develop than most treatments.
siRNA	Vir/Alnylam	Expanding on their 2017 infectious disease partnership, the new collaboration uses Alnylam's lung delivery technology (ALNY has already made more than 350 siRNAs targeting the virus) and Vir's infectious disease expertise.
Antibodies	Vir/WuXi	Vir has two antibodies that bind to the Spike protein, with WuXi has the potential future manufacturing partner. Could be used as treatment or prophylaxis.
Antiviral nanomedicine	Nanoviricides	Nanoviricides has found potential candidates in its library that could be tested in coronavirus.
Antibodies	ImmunoPrecise Antibodies	ImmunoPrecise has committed to finding treatments using proprietary drug discovery platforms.

Sources: Morningstar, company reports.
https://www.genengnews.com/a-lists/how-to-conquer-coronavirus-top-35-treatments-in-development/,
https://invivo.pharmaintelligence.informa.com/IV124466/Fact-File-Coronavirus-Pipeline-And-Corporate-Updates

Economic Impact: We Forecast Minimal Long-Term Effect on GDP From Coronavirus

Although we project a grim set of scenarios in terms of fatalities in our analysis, our view on the economic impact is much more sanguine. Weighting our scenarios by probability, we forecast an average negative 0.2% long-term impact on World GDP due to the COVID-19 pandemic. To be sure, we expect a much larger impact in the short run (with an average negative 1.5% impact on 2020 World GDP across our scenarios). However, equity valuations on average should be unscathed if our long-term projections on GDP are correct. Therefore, we think a 10%+ fall in global equities since the outbreak began is a gross overreaction.

What Are the Likely Channels for a Pandemic to Affect GDP?

In the short run, there are many channels through which a pandemic could negatively impact GDP. Below we list some of the channels categorized into "supply-side" and "demand-side." Supply side factors include those which affect the productive capacity of the economy (often referred to as "Potential GDP"). Demand side factors are those which affect actual GDP without affecting the productive capacity of the economy.

Key Supply-Side Factors:

- Labor supply would be curtailed by death, illness, quarantining, and preventative furloughs. This could come either from government restrictions (for example, mandatory quarantines), or from voluntary worker decision to avoid risk of infection.
- Businesses could close in at-risk industries to mitigate infection risk for employees and customers alike. Tourism, transportation, retail, and restaurants are possible examples.
- Regions or countries not directly impacted by the pandemic could see supply chain impact via trading partners hit with the virus.

Key Demand-Side Factors:

- "Confidence" is the key demand side channel. Confidence is an elusive concept to quantify or model in a precise way, but it undoubtedly is a major demand-side driver of economic activity.
    - Falling consumer confidence could cause lower household consumption.
    - Falling business confidence could cause lower investment.
- Laid off or temporarily furloughed workers in affected sectors will likely reduce their short-term consumption, even if workers expect to regain employment in the near future.

Most Short-Run Factors Don't Make Sense as Long-Run Factors

While all of the factors listed above are serious potential drivers of short run GDP impact, most of them should abate once the pandemic is over, and therefore they aren't logical contributors to long-term GDP impact.

On the supply side, for example, laid off or furloughed workers will be able to return to work when the outbreak subsides (with the exception of fatalities). On the demand side, confidence should return quickly, and consumers and businesses will be eager to make up for postponed expenditures.

Some Agree Short-Run Impact Could Be Very Large, but Long-Run Impact Should Be Minimal

In Exhibit 16, we list research papers which have done formal modeling of pandemic scenarios. In accordance with our framework on the previous page, many find a large short-run GDP impact, but none find a significant long run impact (even in a very severe scenario). Some of the papers include an explicit long-term model. McKibben finds that the impact of the pandemic shock on GDP fades to virtually zero by about four years after the pandemic occurs.

Within range of the 0.2% population fatality rate projected in our bear-case scenario, the papers in Exhibit 16 project a short run GDP decrease of 9.3% (Kennedy), 2% (McKibben), and 1% (CBO). The Kennedy paper is the clear outlier; this is chiefly because it is the only paper to incorporate confidence effects in the authors' economic model (accounting for 550 basis points of their total projected impact). We agree with the inclusion of confidence effects, though we think the arbitrary magnitudes chosen in the Kennedy paper (including a 10% hit to household consumption in the first quarter of the pandemic) are too high.

Exhibit 16 Projections for Short-Run Pandemic Impact Vary Wildly, but Most Agree Long Term
Selected research papers modeling economic impact of a global pandemic

	Fatalities	GDP Impact:		
Research Paper	(% of World Pop)	Short Run	Long Run	Notes
Kennedy (2006)	0.2%	-9.3%	Minimal	Focus on Australia
McKibben (2006)	0.02%	-0.7%	~0	
McKibben (2006)	0.2%	-2.0%	~0	
McKibben (2006)	1.0%	-4.8%	<1%	
Burns (2006)	1.0%	-3.1%	N/A	
CBO (2006)	2.0%	-4.0%	N/A	Focus on U.S.
CBO (2006)	0.3%	-1.0%	N/A	Focus on U.S.

Details:

1) Kennedy, Thomson, Vujanovic (2006), "A Primer on The Macroeconomic Effects of An Influenza Pandemic"
2) McKibben and Sidorenko (2006) "Global macroeconomic consequences of pandemic influenza"
3) Burns, Mensbrugghe, Timmer (2006), "Evaluating the Economic Consequences of Avian Influenza"
4) Congressional Budget Office (2006), "A Potential Influenza Pandemic"

Other Papers:

1) Brainerd and Siegler (2002), "The Economic Effects of the 1918 Influenza Epidemic"

Source: Various papers (cited in table), Morningstar.

Central Banks Can Mitigate Demand-Side Impact but Not Supply Side

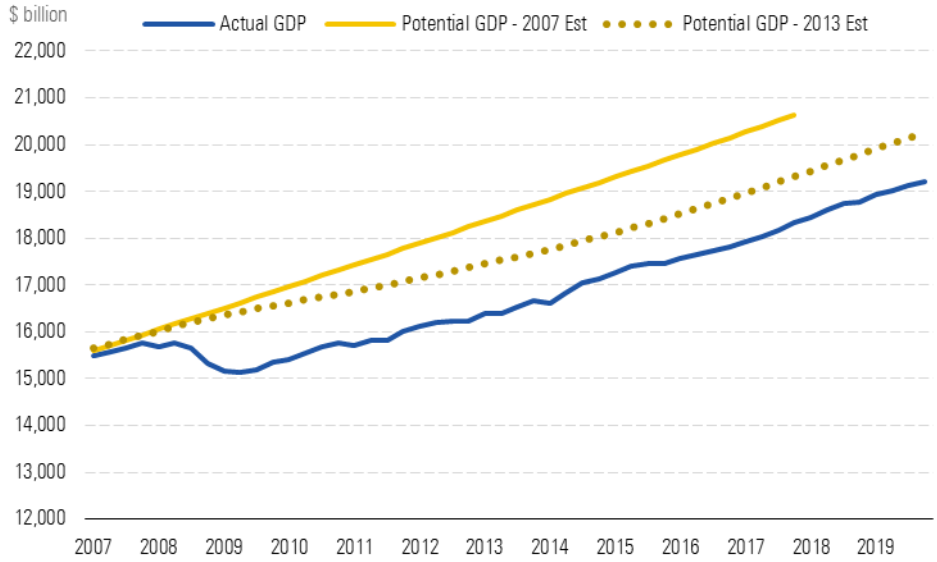
Central banks have some room to counteract the short-term GDP impact from COVID-19, and other countercyclical policies such as fiscal policy may have a role to play. However, countercyclical policies work via the demand side of the economy. These policies can compensate for a fall in confidence, for example (as the Federal Reserve has already attempted to do with a 50-basis-point rate cut on March 3).

However, countercyclical policies have only limited ability to mitigate supply side impacts; for example, they cannot make up for the absent workers dragging on the economy's productive capacity.

Unlike in 2008 Recession, We Don't Think Recession Will Translate Into Long-Term GDP Loss

As discussed above, economic theory suggests that many short-run factors aren't consequential for long-term GDP, including in the pandemic-specific models listed in Exhibit 16. However, the recent empirical record of recessions gives us some pause in assigning zero long-term import to short-run factors. Many recent recessions have not seen a return to the pre-recession trend in GDP growth. The post-2008 Great Recession in the U.S. is the most illustrative case. As shown in Exhibit 17 below, not only did the Great Recession cause an immediate 4% fall in U.S. real GDP, but by 2013 it had fallen 10% below the pre-crisis (2007) estimate of potential GDP. Therefore, seemingly the recession had deleteriously impacted the country's productive capacity, in addition to causing a shortfall in demand.

Exhibit 17 Example of Great Recession Looks Ominous, but We Think COVID-19 Situation Is Very Different
Actual GDP and Potential GDP (2007 and 2013 estimates) in chained 2012 dollars.



Source: St. Louis Federal Reserve, U.S. Congressional Budget Office, Morningstar.

However, we think several characteristics make a potential pandemic generated economic slowdown different from usual recessions (particularly the post-2008 Great Recession).

First, recent recessions have been accompanied by large scale reallocation of labor and other resources across sectors. For example, the U.S. housing bust required massive reallocation of labor away from construction and real estate into other sectors. Unemployed workers in these sectors took many years to regain employment. Likewise, while the post-2000 tech bust was less consequential for labor markets, it still required a large redirection of business investment away from IT equipment and software. By contrast, workers unemployed/put on furlough because of coronavirus are likely to resume their former

positions. Overall, the former pattern of economic activity can be resumed, whereas usual recessions and their aftermath involve a reconfiguration of economic activity.

Second, recession duration is driven in part by lack of recovery in confidence. Confidence is impossible to measure with any degree of concreteness. Yet, it seems logical that economic confidence would quickly rebound once the epidemic receded. In contrast, confidence did not recover quickly after the 2008 global financial crisis, with households and businesses remaining much more conservative in their expenditure and other behavior.

We Forecast a Negligible Long-Term GDP Impact From COVID-19 (Though 2020 Looks Bad)
We forecast an average negative0.2% long-term impact on global GDP due to COVID-19, which is quite small compared with the market reaction thus far (on average the fair value of equities should vary in line with GDP). Even in our bear case we forecast just a 0.6% long-term decrease in GDP.

In each scenario, we start by forecasting the short-run (2020) impact. These impacts are informed largely by the cited research on Exhibit 16 above. In particular, in the bear-case scenario our forecast 5% World GDP impact is somewhat closer to the Kennedy paper's projection of greater impact because of its inclusion of confidence effects.

The main driver of our forecast long-run GDP impact is the fatality rate as percent of population, as fatalities permanently reduce the economy's productive capacity via the labor force (with an assumption that the working age fatality rate is just 60% of the overall fatality rate). We also include an incremental reduction equal to 10% of the 2020 GDP impact, in order to incorporate potential long-run effects of short-run decreases in output (as discussed on the previous page).

Exhibit 18 We Forecast a Negligible Long-Term GDP Impact From COVID-19 (Though 2020 Looks Bad)

	Fatalities	World GDP Impact:		
Scenario	**(% of World Pop)**	**2020**	**Long Run**	**Probability**
Bear	0.2%	-5.00%	-0.6%	15%
Base	0.1%	-1.25%	-0.2%	60%
Bull	0.01%	-0.10%	0.0%	25%
Avg	**0.10%**	**-1.5%**	**-0.2%**	

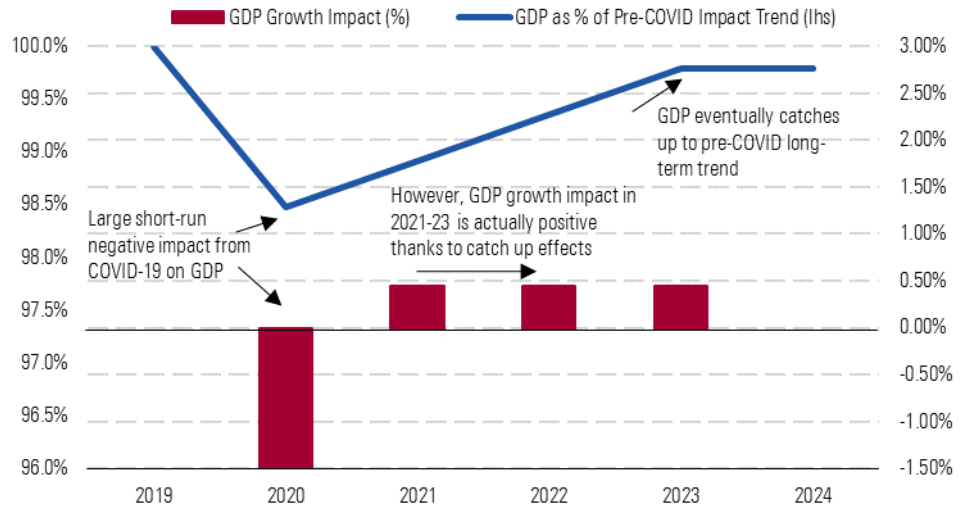
Source: Morningstar.

Short-Run Impact Looks Daunting, but GDP Will Experience Catch-Up Growth as COVID-19 Fades
While the short-run GDP hit of 1.5% in our average scenario (and especially 5% in the bear case) looks daunting, it's important to reiterate that this is a temporary shock to the economy. Many investors intuitively think of shocks to growth as being permanent, as many financial series are well modeled as (geometric) random walks.

To make this more concrete, consider Exhibit 19 below, an illustrative example based on our average COVID-19 scenario impact. The blue line is the ratio of scenario GDP to the level of GDP that would have

occurred in each year in absence of the COVID-19 shock (presumably on a long-term upward trend). Growth falls by 1.5% in the first year (2020), and we assume that the economy reaches its long-run impact amount (negative 0.2%) by 2023. This is illustrated in the blue line returning to nearly 100% by 2023. A perhaps counterintuitive aspect of this dynamic is that in the years following the initial downward shock (2021 to 2023), GDP growth is actually higher than we would have expected in the absence of COVID-19. This represents catch-up effects—as absent workers return to work or consumers resume their spending habits, this will cause temporarily higher growth.

Exhibit 19 Large Short-Run Negative Impact From COVID-19 Will Eventually Reverse, as GDP Returns to Trend
Illustrative GDP impact timeline based on our average scenario

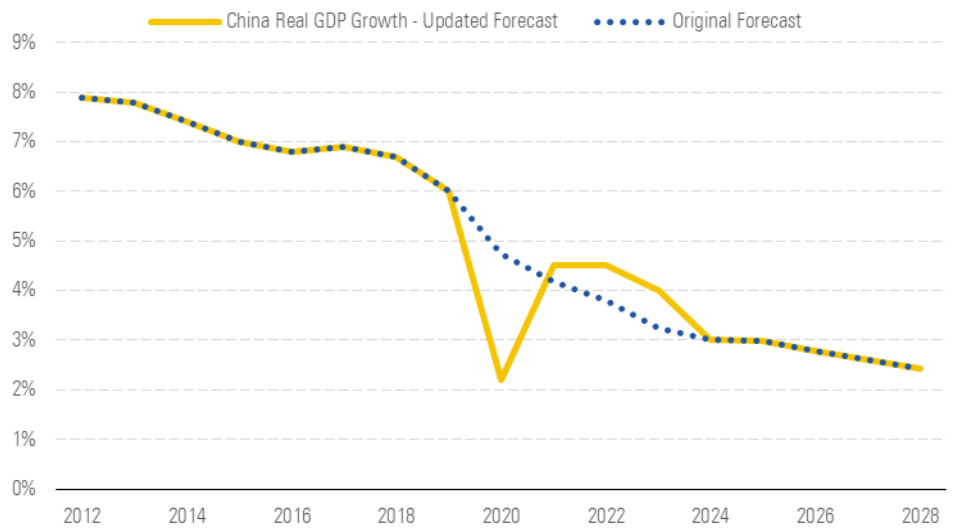


Source: Morningstar.

We're Lowering Our 2020 China GDP Forecast, but Long-Term Largely Unaffected

We're lowering our 2020 China real GDP growth forecast by 250 basis points, to 2.2% from 4.7% in our prior forecast. According to official numbers, this would be China's slowest growth since 1976. China is the epicenter of the outbreak, and the intensive countermeasures taken by the government have hit economic activity hard in the first quarter. By the same token, however, we think China has contained its risk to the extent that we don't expect any greater long-run impact for China than for the world average (which is minimal). As such, we expect strong catch-up growth in the years after 2020.

Exhibit 20 We're Lowering Our 2020 China GDP Forecast, but Long-Term Largely Unaffected
Morningstar China real GDP forecast



Source: China National Bureau of Statistics, Morningstar.

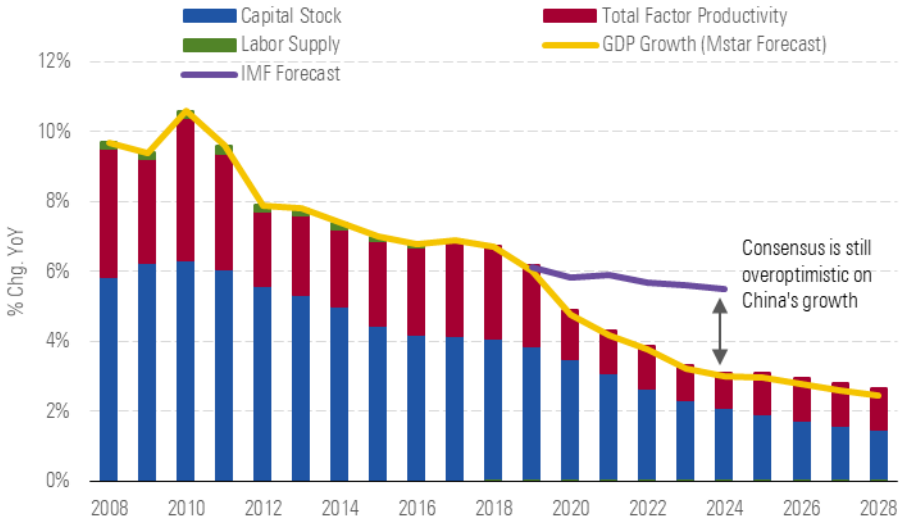
Our Long-Term China GDP Forecasts Were Already Bearish Prior to COVID-19 Outbreak

Our long-term China GDP forecasts were already bearish relative to consensus prior to the COVID-19 outbreak. In Exhibit 21 below, we show a disaggregation of GDP forecasts for China (using our pre-COVID-19 impact numbers). We forecast about a 3.25% average real GDP growth rate over the next 10 years. This is meaningfully below consensus, exemplified by the IMF's forecast (pre-COVID) for almost 6% growth over the next five years.

First, we think growth in the capital stock will slow, as China's investment share of GDP (currently in the mid-40s) falls to a more normal level. In particular, China needs to restrain its investment spending, which has been fueled heavily by debt, for financial stability purposes. Its debt-to-GDP has soared in recent years to about 260% at year-end 2019.

Next, we also think productivity growth will slow. The typical country that's followed China's pattern of fast growth historically has experienced a subsequent productivity slowdown. For China, key factors enabling productivity growth in the past (such as urbanization and catch-up to the world technology frontier) are running out of room.

Exhibit 21 We're Lowering Our 2020 China GDP Forecast (but Long-Term Largely Unaffected)
Morningstar China real GDP forecast



Source: China National Bureau of Statistics, Morningstar.

Related Research: for more information on our China macroeconomic views, please see our report, China Diagnostics: Fourth Quarter 2019.

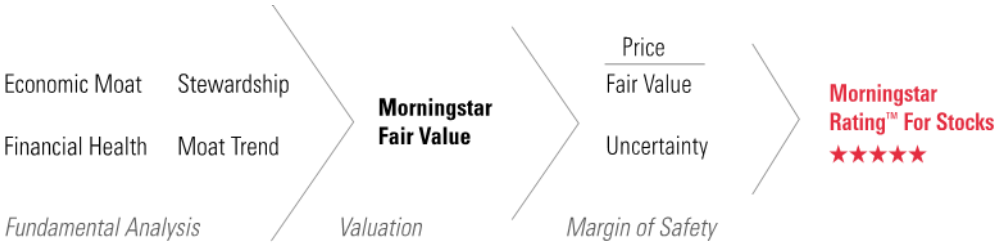
Research Methodology for Valuing Companies

Overview

At the heart of our valuation system is a detailed projection of a company's future cash flows, resulting from our analysts' research. Analysts create custom industry and company assumptions to feed income statement, balance sheet, and capital investment assumptions into our globally standardized, proprietary discounted cash flow, or DCF, modeling templates. We use scenario analysis, in-depth competitive advantage analysis, and a variety of other analytical tools to augment this process. Moreover, we think analyzing valuation through discounted cash flows presents a better lens for viewing cyclical companies, high-growth firms, businesses with finite lives (for example, mines), or companies expected to generate negative earnings over the next few years. That said, we don't dismiss multiples altogether but rather use them as supporting cross-checks for our DCF-based fair value estimates. We also acknowledge that DCF models offer their own challenges (including a potential proliferation of estimated inputs and the possibility that the method may miss short-term market-price movements), but we believe these negatives are mitigated by deep analysis and our long-term approach.

Morningstar's equity research group ("we," "our") believes that a company's intrinsic worth results from the future cash flows it can generate. The Morningstar Rating for stocks identifies stocks trading at a discount or premium to their intrinsic worth—or fair value estimate, in Morningstar terminology. Five-star stocks sell for the biggest risk-adjusted discount to their fair values, whereas 1-star stocks trade at premiums to their intrinsic worth.

Morningstar Research Methodology



Source: Morningstar.

Four key components drive the Morningstar rating: 1) our assessment of the firm's economic moat, 2) our estimate of the stock's fair value, 3) our uncertainty around that fair value estimate and 4) the current market price. This process ultimately culminates in our single-point star rating.

Economic Moat

The concept of an economic moat plays a vital role not only in our qualitative assessment of a firm's long-term investment potential, but also in the actual calculation of our fair value estimates. An economic moat is a structural feature that allows a firm to sustain excess profits over a long period of time. We define economic profits as returns on invested capital (or ROIC) over and above our estimate of a firm's cost of capital, or weighted average cost of capital (or WACC). Without a moat, profits are more susceptible to competition. We have identified five sources of economic moats: intangible assets, switching costs, network effect, cost advantage, and efficient scale.

Companies with a narrow moat are those we believe are more likely than not to achieve normalized excess returns for at least the next 10 years. Wide-moat companies are those in which we have very high confidence that excess returns will remain for 10 years, with excess returns more likely than not to remain for at least 20 years. The longer a firm generates economic profits, the higher its intrinsic value. We believe low-quality, no-moat companies will see their normalized returns gravitate toward the firm's cost of capital more quickly than companies with moats.

To assess the sustainability of excess profits, analysts perform ongoing assessments of the moat trend. A firm's moat trend is positive in cases where we think its sources of competitive advantage are growing stronger; stable where we don't anticipate changes to competitive advantages over the next several years; or negative when we see signs of deterioration.

Estimated Fair Value

Combining our analysts' financial forecasts with the firm's economic moat helps us assess how long returns on invested capital are likely to exceed the firm's cost of capital. Returns of firms with a wide economic moat rating are assumed to fade to the perpetuity

period over a longer period of time than the returns of narrow-moat firms, and both will fade slower than no-moat firms, increasing our estimate of their intrinsic value.

Our model is divided into three distinct stages:

Stage I: Explicit Forecast
In this stage, which can last five to 10 years, analysts make full financial statement forecasts, including items such as revenue, profit margins, tax rates, changes in working-capital accounts, and capital spending. Based on these projections, we calculate earnings before interest, after taxes, or EBI, and the net new investment, or NNI, to derive our annual free cash flow forecast.

Stage II: Fade
The second stage of our model is the period it will take the company's return on new invested capital—the return on capital of the next dollar invested, or RONIC—to decline (or rise) to its cost of capital. During the Stage II period, we use a formula to approximate cash flows in lieu of explicitly modeling the income statement, balance sheet, and cash flow statement as we do in Stage I. The length of the second stage depends on the strength of the company's economic moat. We forecast this period to last anywhere from one year (for companies with no economic moat) to 10–15 years or more (for wide-moat companies). During this period, cash flows are forecast using four assumptions: an average growth rate for EBI over the period, a normalized investment rate, average return on new invested capital (RONIC), and the number of years until perpetuity, when excess returns cease. The investment rate and return on new invested capital decline until a perpetuity value is calculated. In the case of firms that do not earn their cost of capital, we assume marginal ROICs rise to the firm's cost of capital (usually attributable to less reinvestment), and we may truncate the second stage.

Stage III: Perpetuity
Once a company's marginal ROIC hits its cost of capital, we calculate a continuing value, using a standard perpetuity formula. At perpetuity, we assume that any growth or decline or investment in the business neither creates nor destroys value and that any new investment provides a return in line with estimated WACC.

Because a dollar earned today is worth more than a dollar earned tomorrow, we discount our projections of cash flows in stages I, II, and III to arrive at a total present value of expected future cash flows. Because we are modeling free cash flow to the firm—representing cash available to provide a return to all capital providers—we discount future cash flows using the WACC, which is a weighted average of the costs of equity, debt, and preferred stock (and any other funding sources), using expected future proportionate long-term market-value weights.

Uncertainty Around That Fair Value Estimate
Morningstar's Uncertainty Rating captures a range of likely potential intrinsic values for a company and uses it to assign the margin of safety required before investing, which in turn explicitly drives our stock star rating system. The Uncertainty Rating represents the analysts' ability to bound the estimated value of the shares in a company around the Fair Value Estimate, based on the characteristics of the business underlying the stock, including operating and financial leverage, sales sensitivity to the overall economy, product concentration, pricing power, and other company-specific factors.

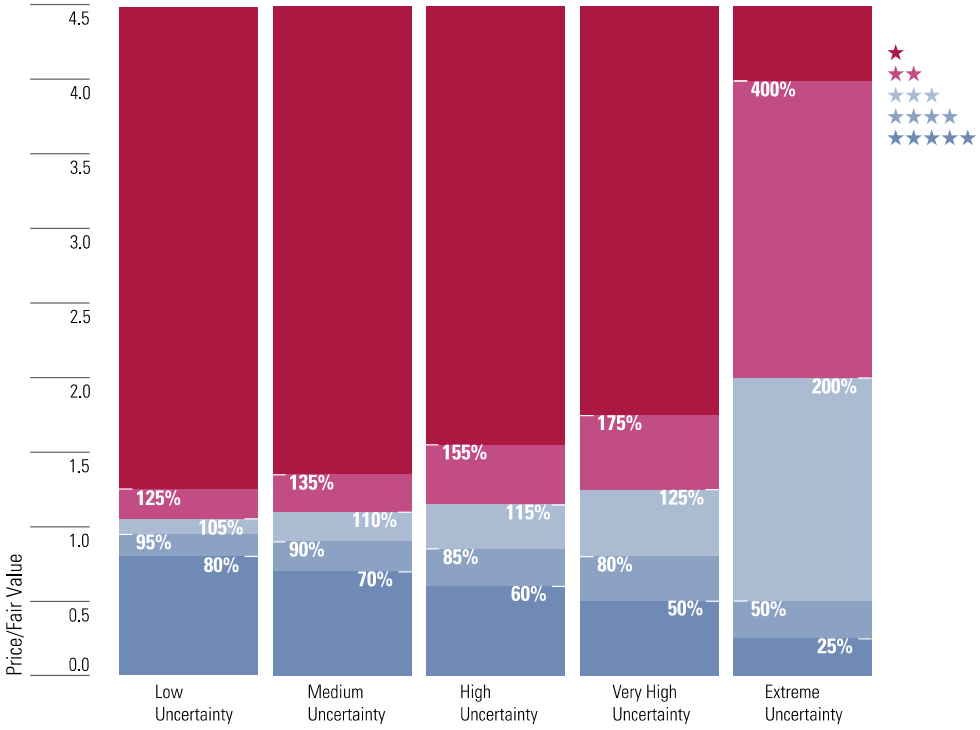
Analysts consider at least two scenarios in addition to their base case: a bull case and a bear case. Assumptions are chosen such that the analyst believes there is a 25% probability that the company will perform better than the bull case, and a 25% probability that the company will perform worse than the bear case. The distance between the bull and bear cases is an important indicator of the uncertainty underlying the fair value estimate.

Our recommended margin of safety widens as our uncertainty of the estimated value of the equity increases. The more uncertain we are about the estimated value of the equity, the greater the discount we require relative to our estimate of the value of the firm before we would recommend the purchase of the shares. In addition, the uncertainty rating provides guidance in portfolio construction based on risk tolerance.

Our uncertainty ratings for our qualitative analysis are low, medium, high, very high, and extreme.

- Low–margin of safety for 5-star rating is a 20% discount and for 1-star rating is 25% premium.
- Medium–margin of safety for 5-star rating is a 30% discount and for 1-star rating is 35% premium.
- High–margin of safety for 5-star rating is a 40% discount and for 1-star rating is 55% premium.
- Very High–margin of safety for 5-star rating is a 50% discount and for 1-star rating is 75% premium.
- Extreme– margin of safety for 5-star rating is a 75% discount and for 1-star rating is 300% premium.

Morningstar Equity Research Star Rating Methodology



Market Price

The market prices used in this analysis and noted in the report come from exchange on which the stock is listed which we believe is a reliable source.

For more details about our methodology, please go to https://shareholders.morningstar.com.

Morningstar Star Rating for Stocks

Once we determine the fair value estimate of a stock, we compare it with the stock's current market price on a daily basis, and the star rating is automatically re-calculated at the market close on every day the market on which the stock is listed is open. Our analysts keep close tabs on the companies they follow, and, based on thorough and ongoing analysis, raise or lower their fair value estimates as warranted.

Please note, there is no predefined distribution of stars. That is, the percentage of stocks that earn 5 stars can fluctuate daily, so the star ratings, in the aggregate, can serve as a gauge of the broader market's valuation. When there are many 5-star stocks, the stock market as a whole is more undervalued, in our opinion, than when very few companies garner our highest rating.

We expect that if our base-case assumptions are true the market price will converge on our fair value estimate over time, generally within three years (although it is impossible to predict the exact time frame in which market prices may adjust).

Our star ratings are guideposts to a broad audience and individuals must consider their own specific investment goals, risk tolerance, tax situation, time horizon, income needs, and complete investment portfolio, among other factors.

The Morningstar Star Ratings for stocks are defined below:

★★★★★ We believe appreciation beyond a fair risk-adjusted return is highly likely over a multiyear time frame. Scenario analysis developed by our analysts indicates that the current market price represents an excessively pessimistic outlook, limiting downside risk and maximizing upside potential.

★★★★ We believe appreciation beyond a fair risk-adjusted return is likely.

★★★ Indicates our belief that investors are likely to receive a fair risk-adjusted return (approximately cost of equity).

★★ We believe investors are likely to receive a less than fair risk-adjusted return.

★ Indicates a high probability of undesirable risk-adjusted returns from the current market price over a multiyear time frame, based on our analysis. Scenario analysis by our analysts indicates that the market is pricing in an excessively optimistic outlook, limiting upside potential and leaving the investor exposed to Capital loss.

Risk Warning
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