UNIVERSITÀ POLITECNICA DELLE MARCHE

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Il coronavirus ed il suo impatto sull'economia mondiale

Coronavirus and its impact on Global Economy

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ABSTRACT (ITALIANO)

Durante questa pandemia ognuno di noi è sempre rimasto attaccato alla tv per sapere quale fosse il destino dell'umanità e del sistema che ci governa.
La quarantena, nel bene e nel male, ci ha fatto riflettere su molte cose.

In questo lavoro ho voluto riportare tutto quello che è successo in quei mesi bui e tristi, ma anche in quelli successivi, quando a poco a poco siamo tornati a questa "normalità" un po' particolare.
Durante il lockdown ho iniziato a navigare in Internet alla ricerca di notizie e articoli che mettessero in evidenza tutti gli effetti che il coronavirus ha portato all'economia globale e nelle persone, al fine di comprendere e segnalare tutto quello che è successo e cosa succederà in futuro.

Sono partito da un documentario su Netflix, intitolato "This Pandemic: Explained", da cui ho preso ispirazione per il primo e secondo capitolo, dall'origine del virus, come si trasmette, quali sono i sintomi, fino al tema "vaccino", che tutti aspettiamo con ansia.

Poi sono passato all'impatto generale che ha avuto la pandemia, considerando tutte le variabili da essa influenzate, come consumi, produzione, settori colpiti, paesi colpiti e così via.

In seguito, ho concentrato la mia attenzione su 3 fattori molto importanti, che sono:
- Variabili macroeconomiche (PIL, occupazione, paesi in via di sviluppo e sviluppati, povertà e ambiente);
- Impatto sulla produzione e sugli scambi tra i paesi di tutto il mondo;
- Politiche e strategie di coping, che sono state utilizzate, che vengono utilizzate ora e quelle che verranno utilizzate in futuro per far fronte a tali situazioni.

Dopodiché, negli ultimi capitoli, ho deciso di porre l'attenzione su articoli più scientifici, passando da modelli di simulazione (che possono aiutare a capire meglio se i governi stanno scegliendo bene cosa fare e come fare, con una panoramica di cosa succede se si sceglie in un modo o nell'altro di reagire a questo tipo di situazione), all'uso di campioni statistici, utilizzati per dare un quadro completo di come gli individui sopravvivono in un periodo di isolamento e come fornire tutti gli strumenti necessari per farli superare i tempi più bui e dare un futuro luminoso all'umanità.

INTRODUCTION

During this pandemic each of us has always remained attached to the TV to know what the fate of humanity and the system that governs us were.
The quarantine, for better or for worse, made us reflect on many things.

In this work I wanted to report everything that happened in those dark and sad months, but also in the following ones, when little by little we returned to this somewhat particular "normality".
During the lockdown, I started browsing the internet in search of news and articles that would highlight all the effects that the coronavirus has brought to global economy and beyond, in order to understand and report everything that happened, and what is going to happen in the future.

I started from a documentary on Netflix, called "This Pandemic: Explained", from which I took inspiration for the first and second chapter, from the origin of the virus, how it is transmitted, what are the symptoms, up to the theme "vaccine", which we are all anxiously waiting for.

Then I moved on to the general impact that the pandemic has had, considering all the variables affected by it, such as consumption, production, affected sectors, affected countries and so on.

Then I focused my attention on 3 very important factors, which are:
- Macroeconomic variables (GDP, Employment, Developing and developed countries, poverty and environment);
- Impact on production and trade between countries all over the world;
- Policies and coping strategies, that have been used, that are used now and those that will be used in the future to cope with such situations.

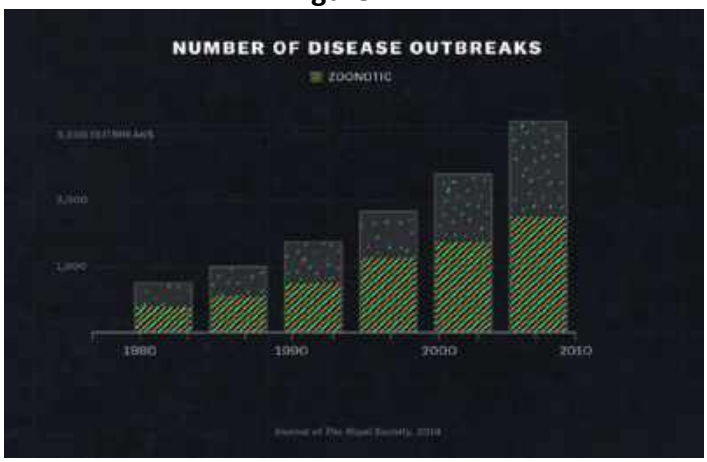
After that, in the last chapters, I decided to put the attention on more scientific articles, moving from simulation models (which can help to understand better if governments are choosing well what to do and how to do, with an overview of what happens if you choose one way or another to react to these kind of situation), to the use of statistical samples, used for give a complete picture of how individuals survive in a lockdown period and how to give all the necessary instruments for make them overcome darkest times and give a bright future to humanity.

CHAPTER 1 - CORONAVIRUS IN FEW WORDS

Before closing borders and locking down citizens, many world leaders have underestimated the virus, but lot of specialists in infectious diseases knew that a pandemic like this was coming, even on spring 2019, months and months before the virus began to spread.
For example, Bill Gates said, about the possibility of a pandemic, during spring 2019: “Pandemic is the greatest risk if we think about something that could kill millions of people today, comparable to the past World Wars. There will be economic shut down, the cost for humanity will be unbelievable and every country will be interested in this.”
So, countries around the world have to invest today on public health, even if things are going good, because one day the situation could be bad, as it is nowadays.

Talking about viruses, Dr. Peter Daszak, that is the EcoHealth Alliance President, said: “In wildlife there are 1.5 millions of viruses that we don’t know anything about yet. One of these can jump from animals to humans, even right now.
We know some pretty lethal ones, but we expect that there are others more lethal and easily transmissible, of which we have no vaccines or medicines, and they are the biggest risk.”
When the virus jumps from an animal to a human it’s called **zoonotic virus**, and for decades these have caused more and more diseases outbreaks, as **Figure 1.1** below shows:

Figure 1.1



Source: *Journal of The Royal Society* (2014)

That is what happened with SARS in 2002 and with MERS in 2012, both of them are coronaviruses that had killed thousands of people around the world, causing panic around it for a little period of time, but experts stayed worried and they have expected that a new coronavirus could have spread again in the future.
Among all viruses that exist, why this one has caused a pandemic and why this one can end?

Viruses were one of the first living things on Earth, but they're not alive like we are, but they need to parasitize other living cells to reproduce and their only goal is to survive and replicate themselves.
The official name of this virus is "**SARS-CoV-2**" and "**COVID-19**" is the name of the disease that it causes, which stands for "**Coronavirus Disease 2019**", and the name "Corona" (Crown) derives from its crown-shaped spikes.
It spreads through droplets when we sneeze, cough or speak that can directly enter into our organism through our eyes, mouth or nose.
The virus can live on surfaces for hours, so people can pick it up with their hands and infect themselves if they touch their face, something that each person does on average 20 times per hour.
Once inside the body, the virus' spikes act like a key that locks onto the proteins that covers a lot of human cells and when it's broken in, the virus gives them instruction to produce more copies of itself, potentially invading more and more cells, which can lead to some symptoms, listed in the **Figure 2.1** below:

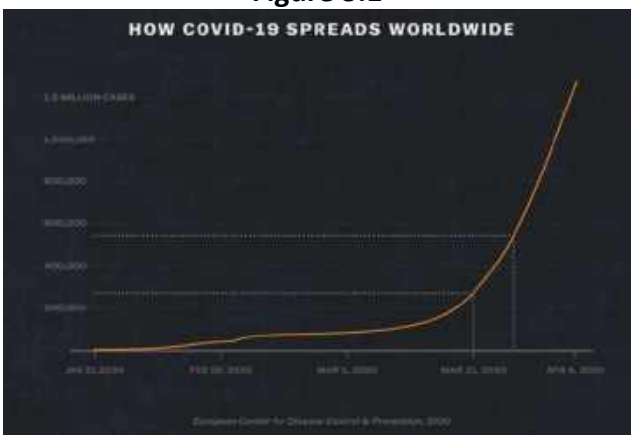
Figure 2.1

Source: *WHO/Covid Symptom Tracker Study* (2020)

You can be infected and spread it without symptoms, or they can be mistaken for the flu and that's what makes this coronavirus so devious.
So, the most significant diseases are often caused by viruses that are silent and slow, like HIV, or move rapidly and cause symptoms, like fever and coughing, that could be confused with other diseases.

Going about their life, a person with this coronavirus likely infects a couple other people and each of those infects a couple more and so on, which is why the number of cases increases on an exponential curve, doubling every several days, as **Figure 3.1** demonstrates:

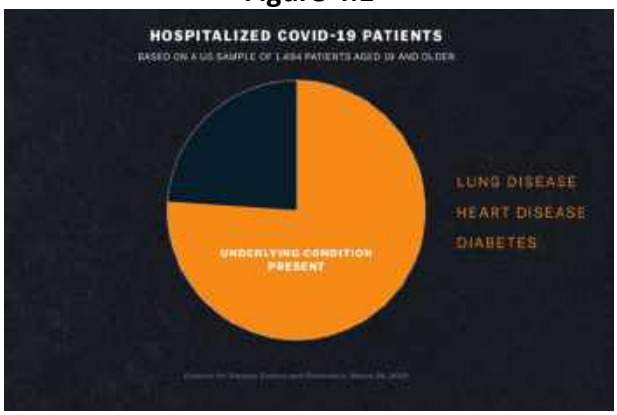
Figure 3.1



Source: *European Center for Disease Control & Prevention* (2020)

Some of those people will end up with a severe lung infection and certain groups are especially at risk.
In one US sample, around ¾ of people who were hospitalized had at least one underlying health condition like those indicated in **Figure 4.1**:

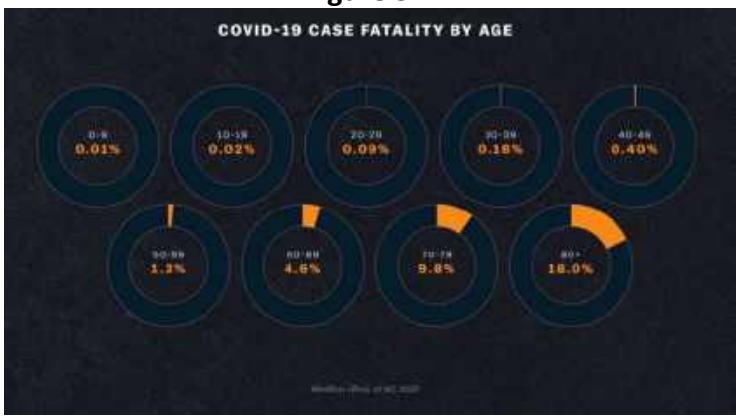
Figure 4.1



Source: *Centers for Disease Control and Prevention* (March 28, 2020)

The risk of dying is greater the older you get, as indicated on this data (**Figure 5.1**) that Hubei, China reported 2 months after their outbreak began:

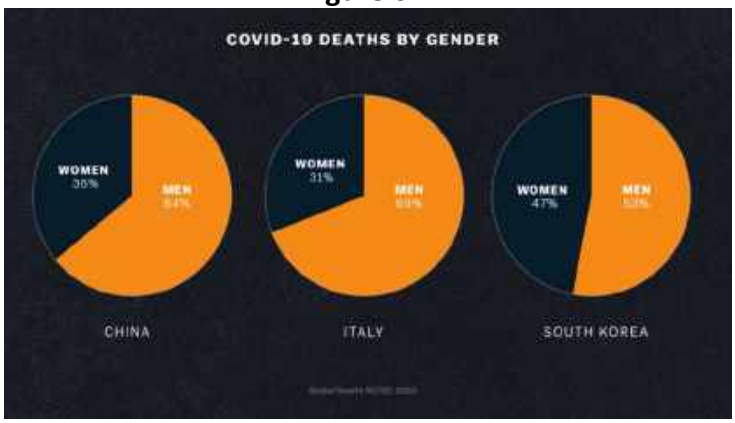
Figure 5.1



Source: *MedRxiv (Riou, et al.)* (2020)

It emerges that the risk is higher for men (**Figure 6.1**), possibly for some biological factors, or because they're more likely to smoke or because men, according to some studies, aren't as good about washing their hands.

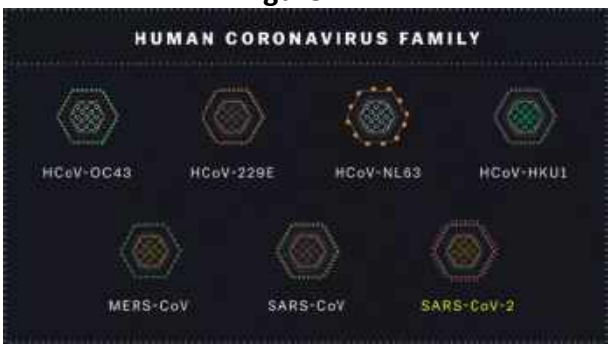
Figure 6.1



Source: *Global Health 50/50* (2020)

This one is just the youngest in a whole family of **7 coronaviruses** known to infect humans, shown in **Figure 7.1**:

Figure 7.1



Source: *WHO*

It's now compared to SARS and MERS because they've killed a lot of people, but the first four are actually more successfully viruses. They cause up to a third of common colds and they're everywhere.

Viruses can be better at spreading if they don't make their host that sick, just like bats that are teeming with viruses because they don't really bother them.
But viruses can transform into a new one once they get into human population, and that's what scientists believe happened with **SARS** in 2002, that just like this coronavirus, emerged in a live animal market in China (Guangdong Province) and, since it was a new zoonotic virus, there were no treatments and no vaccine. But SARS was a lot less dangerous than COVID-19 because people could spread it only when they had symptoms, so it was easier to contain it by just quarantined sick people. It was also a lot more deadly (10%), which made it harder for the virus to spread and survivors probably have a sort of immunity and can't be re-infected. Eventually, the only people the virus can find are those who have immunity to it. In the end SARS infected around 8.000 people in at least 29 countries with 774 deaths.

Since then, a group called EcoHealth Alliance has been coming to these caves in Sothern China, catching bats, scanning them for viruses and flagging the ones that could most easily make the leap to us. When they find them, they raise the alert and the government of China comes in and tries to reduce the exposure of those population to viruses. They've found a lot so far, including hundreds of coronaviruses and label them as high or low risk, depending on how similar they are to viruses that already infect humans.
And few years ago, they discovered one that they called **"Bat coronavirus RaTG13"**, which met the criteria for low risk.

When scientists sequenced the genome of the virus behind COVID-19, they found that 96% of it was identical to that bat virus, and they believe the bat virus likely evolved into this new virus that could infect humans.

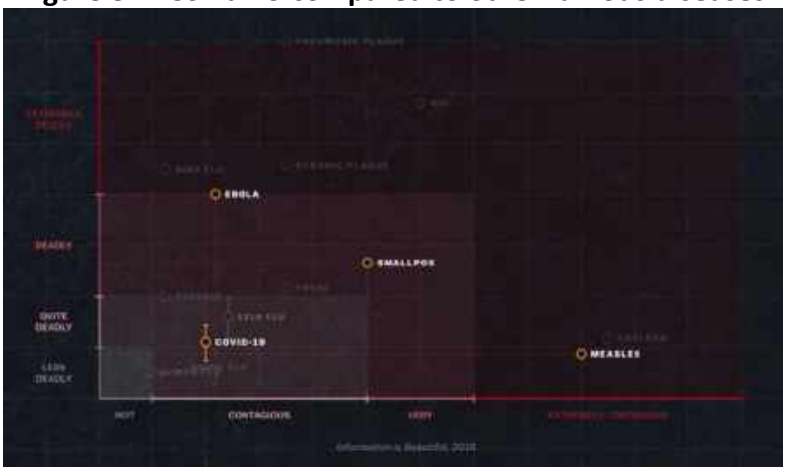
As Dr. Peter Daszak (EcoHealth Alliance President) said on March 2020:
"At the time, our goal was to find SARS-related viruses and this one looked too distant and it seemed unable to get into people. So, it didn't look like it was a clear and present danger, unfortunately."
It's impossible to predict all the ways a virus might evolve. Scientists think this one may have mutated in another bat, or it may have jumped into another species before jumping to us (pangolin, snake or fish).

That same kind of fluke happened on a farm in Kansas, US in 1918.
Experts are uncertain, but they believe that the **1918 flu pandemic** could have started when a bird with the flu and a human with the flu met the same pig. The bird flu couldn't infect humans and humans flu couldn't infect birds, but in one of the pig's cells those two combined created a new zoonotic virus called **"H1N1"**. That new virus definitely could infect humans. For a disease to become a pandemic, spreading around the world in months, leading to potentially millions of deaths, it has to find an extraordinary balance of **contagiousness (abscissa)** and **deadliness (ordinate).** Diseases are divided in these two scales.

1918 flu was airborne, meaning the virus could hang in the air, infecting anyone who inhaled it, something like one in every three people on Earth and killed from 3 to 20% of those infected (medical record-keeping was not great at that time). But that was nothing compared to **Smallpox**, which killed 30% of the people who got it and was also more contagious.
Then there's **Ebola**, which is even deadlier, but far fewer people have died from it, in part because it's so deadly and people who have it don't infect too many others because they get so sick, they stay home and then most don't survive.
One of the unexpected things about viruses is that sometimes the ones which have obvious symptoms, that kills people at a very high rate, doesn't become pandemic, they can't do that.
While a disease like **Measles**, which is far less deadly than Ebola, used to kill millions of people a year.

So, where this current pandemic fall? Isn't clear yet, but experts place it here (**Figure 8.1**):

Figure 8.1: Covid-19 compared to other famous diseases



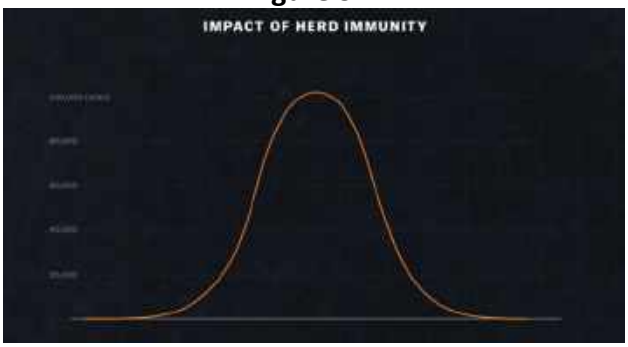
Source: *Information is Beautiful* (2018)

It means that is deadlier than Measles, but less contagious; far less deadly than Ebola and nowhere near as bad as Smallpox. It's close to the lower estimates for the 1918 flu, so it could be worse, but its balance is just bad enough to be devastating.

But we can end pandemic, like we have already done it in the past.
In 20th century we discovered the **antibiotics**, so for example **Bubonic plague**, **Tuberculosis, Cholera, Typhoid** and other bacterial diseases became far less deadly. But antibiotics don't work against this coronavirus, or any viruses.
We have effective drugs against them, like **HIV**, which can now be far less contagious and deadly. But safe antiviral drugs are hard to develop, so the best way to defeat a virus is through **immunity**.

When viruses spread through a population some infected people die, but others survive, and their immune systems learn how to recognize and fight off the virus. When that happens in a lot of people it's much harder for the disease to spread, and this phenomenon is called **"Herd immunity"**, which cause the slowdown of infections rate and the virus dies out, as **Figure 9.1** cases' curve demonstrates:

Figure 9.1



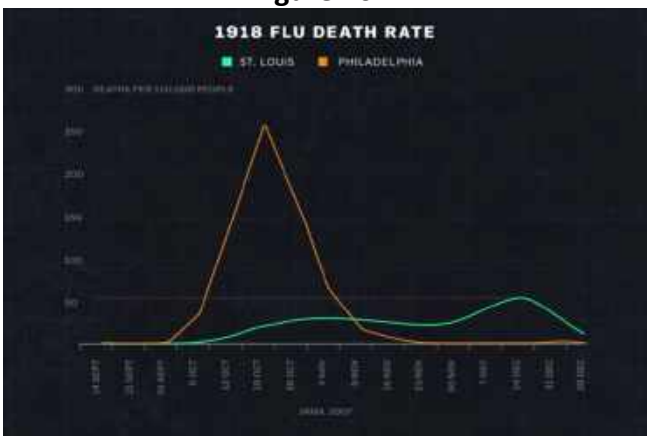
Source: *WHO*

But with COVID-19, if the world just waited to achieve Herd immunity naturally, millions would die, and other coronaviruses don't even give **lifelong immunity (approx. 1-2 years)**, and for this one we just don't know yet. This makes even more crucial to find a vaccine and, if enough people get vaccinated, it's a safe and life-saving shortcut to Herd immunity.

The first vaccine was created to fight Smallpox, and in 1980, after a massive global vaccination campaign, this one was the first virus ever declared eradicated from the world, and diseases like Polio and Measles don't cause nearly the amount of deaths they used to. But vaccines are also hard to develop, and specialists thinks that it's going take a year to a year and a half to know if it works.
So, while we wait, the best we can do is slow it down, using an old school method invented during the Black Death called **"Quarantine"**, or **"Social distancing"**. These avoid crowds and close contact with other people, so the virus has fewer chances to spread.

During 1918 flu, one American city, St. Louis, took that approach quickly, shutting its schools and public spaces, while Philadelphia didn't and allowed a big parade in the streets.
As a result, as we can see on the graph in **Figure 10.1**, St. Louis flattened their curve of death rate, which means the disease killed people for a longer period, but fewer died compared to Philadelphia.

Figure 10.1



Source: *JAMA* (2007)

Because, as **Italy** learned in March, it's much harder for hospitals to save lives if too many people get infected at once, then also other states decide to request the same thing **"Go home and stay home"**.
Countries really have to on a hardcore national lockdown to really suppress that curve, and then we have to, at some point, gradually and carefully come out of that situation. **South Korea** is one model, as in April they've managed to rein in their outbreak without a lockdown by testing widely and retracting the steps of people who came back positive. The problem is that if we're not careful, that outbreak can last a long time.

Turning back to St. Louis, in November of 1918 the city decided to end the social distancing policies, and as a result the death rate jumped, and the city quickly locked down again, as it can be seen in **Figure 10.1**.

In a pandemic like this, until you have a vaccine, you have limited options, because virus had a head start, and this is a situation that experts have always feared. We could be more ready for a pandemic like a flu or a SARS; however, if a really fast-moving respiratory pathogen came out, we wouldn't be able to hold these numbers down.

The World Health Organization (WHO) is meant to lead the global response to a pandemic like this. The fact is that's actually a quite small organization, dependent on voluntary contributions, they don't have planes or teams standing by, a research and development budget to make these tools.

In 2005, WHO draw up a huge blueprint (*International Health Regulations, 3rd edition*) for how the world should prepare and respond to a crisis like this. Among other things, countries had to develop the capacity to detect outbreaks and quickly notify WHO (*Part II – Information and Public Health response: Article 5 on Surveillance and article 6 on Notification*), and 196 countries signed onto this, but most never complied.

A recent **WHO report** (*A world at risk: Annual report on global preparedness for health emergences, Global Preparedness Monitoring Board – September 2019*) even acknowledged: "There is a real threat of a rapidly moving, highly lethal pandemic of a respiratory pathogen. […] The world is not prepared."
That was three months before the first case of COVID-19, and of course our healthcare systems weren't prepared, so doctors and nurses have been forced to use makeshift masks, that make them infect and sick.
In China, many of the first people with COVID-19 appear to have caught the disease at a hospital.

Three weeks before China began the containment measures against COVID-19, a 33-year-old doctor at Wuhan Center Hospital, **Dr. Li Wenliang**, sent a group chat to other doctors, alerting them to the outbreak: "The latest info is that the coronavirus infection has been confirmed, they're currently conducting analysis."
A few days later the Wuhan Police made him sign a letter, warning that he would receive the full sanction of the law if he "stubbornly persists" in his opinions.
By the time the WHO declared a public health emergency on January 30th, Dr. Li Wenliang had likely already contracted COVID-19, because he died of it a week later.

Three weeks after that, it's estimated that 114.000 people in China were infected, and **Figure 11.1.1** shows where it spreads.
If China had implemented its containment measures just two week earlier, researchers found it would have looked like in **Figure 11.2.1**, and three weeks earlier like in **Figure 11.3.1**.
The number of cases could have been cut by as much as 95%.

Figure 11.1.1

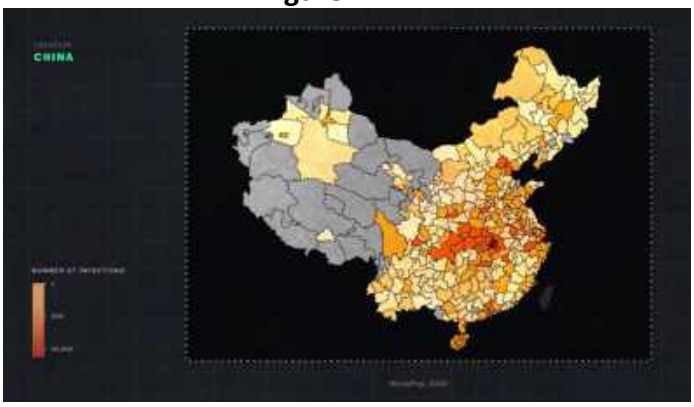


Figure 11.2.1

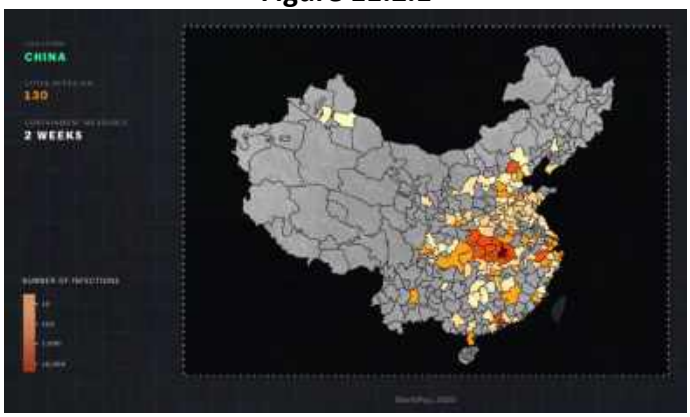
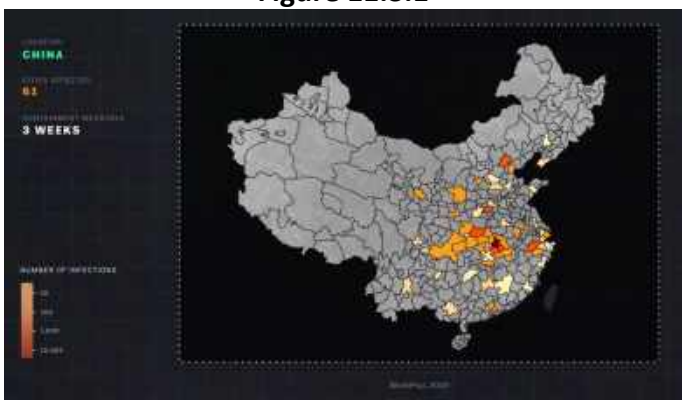


Figure 11.3.1



Source: *WorldPop* (2020)

And while China was locked down in February, **Italy** wasn't, and it became the next epicenter of the virus. When Italy locked down in March, the **US** didn't, and became the next epicenter.

Then cases started to rise also in poorer countries where lockdowns are harder and healthcare systems, already fragile, collapses. So, we need to get faster at containment.
Ideally, we want to catch the viruses at the source, but it isn't just China or bats. **Figure 12.1** shows the places where a new virus is most likely to make the leap to humans:

Figure 12.1: Places where viruses might infect humans

Source: *EcoHealth Alliance* (2017)

So, the frontline for disease emergence are places like the end of the road in a tropical forest, where someone's just build a new mining concession, people have moved in, there's no food supply, so they go out and hunt wildlife; or it's a farm in Southeast Asia, that's been expanding and intensifying, that has bats nearby that spread viruses into the pigs of the farm.

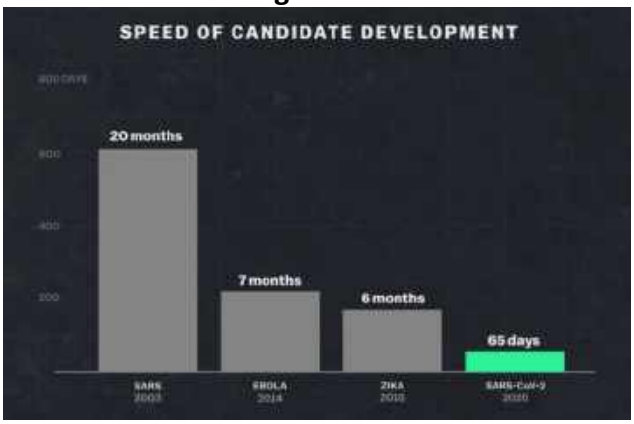
The truth is that human behavior has made pandemics like this one inevitable. Deforestation is bringing more wild animals into contact with more people, and factory farming is pushing animals closer together, giving their viruses more opportunities to combine into one that could infect us. Then we give them more ways than ever to spread. As Dr. Peter Daszak (EcoHealth Alliance President) said: "I think one of the best lessons about pandemics is: we think that it's something happening over there. Well, we know from COVID-19 that what happens over there can very easily get here."

Fortunately, this new virus, after it was identified, its sequence was shared few days later, and so testing began immediately across the globe, and scientists are committing entire labs to creating a vaccine, and also the world's fastest supercomputer has run thousands of simulations and identified 77 drug compounds that might effectively stop the virus.

CHAPTER 2 - THE VACCINE RACE

Right now, there is a worldwide hunt for ways to fight this coronavirus and scientists are trying everything, from existing medicines to new therapies.
But the most likely way we'll end this pandemic is a vaccine.
On **March 16th, 2020**, the **first experimental vaccine** was tested on **Jennifer Haller** in Seattle, US. Other test vaccines are made pretty quickly, as **Figure 1.2** shows, but this vaccine candidate crushed all records and it was made in just **65 days**:

Figure 1.2



Source: *WHO*

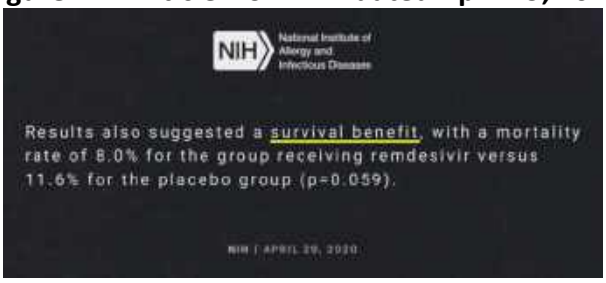
If it's going to end this pandemic, though, it's got a long way still to go, because any potential vaccine has a difficult path ahead, a long and twisting course full of challenges and trials. In US, typically it takes a vaccine candidate a decade or so to make it from start to finish, and around 90% fail to complete it.
We don't have that kind of time because everyday people are dying, and economic losses are mounting. Experts are hoping a vaccine can be widely available in 2021, and, to pull that off, it will have to get through every stretch of this course in record time.

Fortunately, more than 100 vaccine candidates are giving it a shot, made by scientists all over the world, from veterans at universities (e.g. Houston, Oxford, Baltimore) to pharmaceutical giants (e.g. Johnson & Johnson), using proven techniques and approaches that have never been tested before. But getting a vaccine is also going to take a lot of money, collaboration and brave volunteers. Together, they're in the one of the most high-stakes scientific races in history, and the big question is: **how fast can we do it?**

This coronavirus, and all viruses, are hard to fight, in part because they're so simple. They're basically only little vehicles that carry instructions on how to make more of themselves and, to reproduce, they smuggle these into our cells and force our cellular machinery to make more and more viruses.
Then they spread through the body and hijack more cells, damaging them in the process, which makes us feel sick. But we're not defenseless because cells in our immune system can find the intruder and identify a marker, a distinguish feature which we call an **antigen**, then they mobilize to seek out and destroy anything with that antigen. Our immune system also produces little molecules called **antibodies**, that stick to that antigen, tagging and subduing the virus.
But from the day we're infected, it can take almost **2 weeks** for this response to ramp up (**Figure 3.2, left side**): That is enough time for this coronavirus to swarm through the body, wreaking havoc, and sometimes our immune system ramps up too much and causes even more harm. In some people this damage becomes overwhelming, and they die. This is where having a treatment would help.

Some inject antibodies, either synthetic ones made in lab, or from the blood of people who've recovered, others rein in our immune systems if they're getting out of control, and some, like "**Remdesivir**", actually enters in our cells to block the virus from copying itself. Early results (**Figure 2.2**) showed it could potentially make the virus less deadly, according to **NIH**:

Figure 2.2: Article from NIH dated April 29, 2020

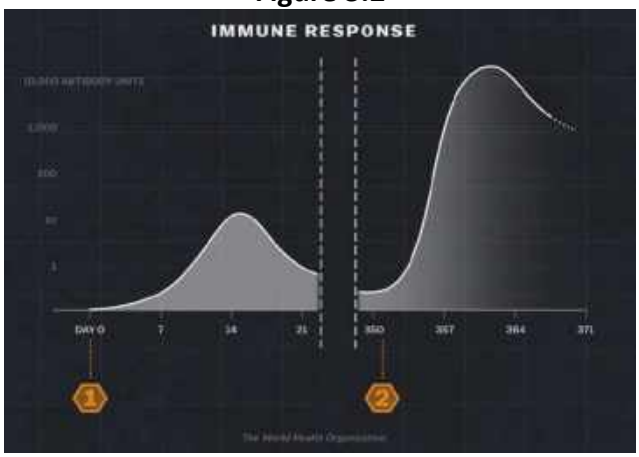


Source: *NIH (National Institutes of Health)*

But none of these treatments can stop a person from getting sick or spreading this virus to others. A vaccine would, and it does it by taking advantage of something our bodies have evolved over millions of years: **memory**.
After it deals with a virus, our immune system remembers the antigens, sometimes forever, or just for a while. We can remember these other coronaviruses for a couple of years.

So, if this one is similar and it shows up in our bodies again in that time, our immune system can ramp up much faster with overwhelming force (**Figure 3.2, right side**), whipping out the virus before it can make us sick or spread to someone else:

Figure 3.2



Source: *WHO*

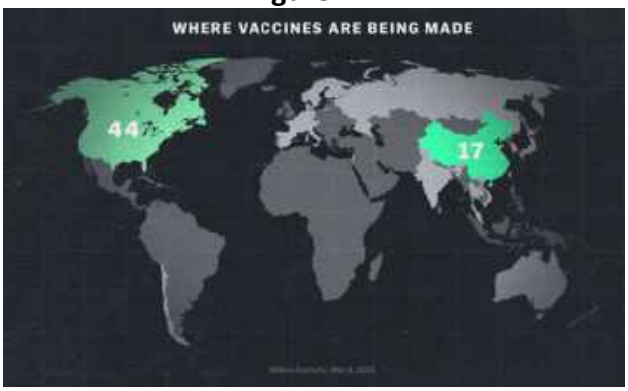
This is what it means to be immune to a virus. A vaccine makes us immune by safely showing the body what a virus looks like, faking this first infection to teach your body how to respond, so when it does encounter the real virus, it's ready.

No vaccine is 100% effective, meaning not everyone who receives one will be perfectly immune, but these don't need to be perfect to end epidemics.
Smallpox used to be a leading cause of death, and measles killed millions a year, most of them children, but thanks to vaccines that are around 95% effective, we wiped it out and made enormous progress against measles.
Vaccine makers are hoping to make one that effective.
They are one of the most important inventions in human history, but the world doesn't agree on much. More than 90% of all people believe that childhood vaccinations are important (according to *Wellcome Trust Global Monitor*).
That is crucial, because to wipe out an infectious disease you need most people in the world to be immune, so the already mentioned "herd immunity".

The idea is that individuals become immune either by getting infected and surviving, or by getting vaccinated. When enough people are immune, the virus has trouble spreading, and slows down. So, if you get vaccinated, not only you protect yourself, but also weak members in the community like newborns, elderly and people with weak immune systems.

Defeating an infectious disease requires the whole world coming together, and in the Covid-19 race, the world has come together like never before.
In **Figure 4.2** is shown where most of the vaccines are made:

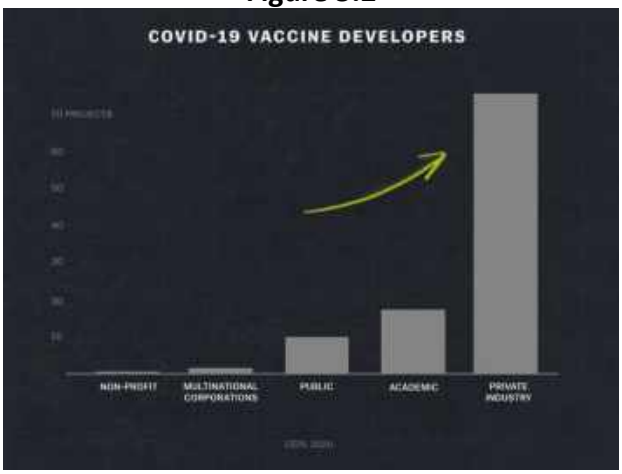
Figure 4.2



Source: *Milken Institute* (May 5, 2020)

It emerges that, out of the over 100 candidates in the race in May, almost half are in North America and 17 in China, and they're funded in different ways, most by private industry, as evidenced by the graph in **Figure 5.2**:

Figure 5.2



Source: *CEPI* (2020)

But the main difference between them is their vaccine platform, how they're showing the body what the virus looks like. Some vaccines inject a weakened version of the virus into the body, so it can't reproduce or do damage, but it still has the antigen, so our immune system can learn what to watch out for.

That's how we vaccinate against polio, measles, mumps, and rubella, chicken pox, rotavirus, and for the flu.
This is by far the most tried-and-true method, but it's a slow way to do it.
We have to grow the virus for months in other living cells, like chicken eggs, a method we've been using for decades, and we call these **"1st generation vaccines"**, and there are **9** in the race as of early May.

Other scientists are trying a newer approach, that, instead of the whole coronavirus, they're giving the body only just an antigen, a piece they think will activate the immune response. Those need to be grown, sometimes in yeast cells, or attached to another harmless virus. This is how the vaccine for hepatitis B works, for whooping cough and meningitis B. We will call them **"2nd generation vaccines"**, and they're the most popular kind in the Covid-19 race, with **72 candidates**.

Finally, there's a brand-new type of vaccine that doesn't use any part of the actual virus at all, but gives our bodies the virus instructions, tiny pieces of genetic code that tell our cells to produce the antigens, which then activate the immune response. No vaccine using this approach has ever been approved for use in humans, and we'll call them **"3rd generation vaccines"**, and they're **27** in the race. Because they don't involve growing any part of any virus, they can be made very fast, and this type of vaccine is the one used for the first time for this coronavirus, from an US company called **"Moderna"**.

But making a vaccine candidate isn't the hard part, but the next phase is, called **"Clinical trials"**. Traditionally, there are 3 phases:

1) **First phase**, teams give their vaccines to a small group of people, wait a few months and see if any of them report dangerous side effects.
2) If everything looks good, the vaccine moves on (**second phase**) and is given to a couple hundred people, again, to see if there are any dangerous side effects, but also to see if people's immune systems ramp up. This phase requires more waiting, usually months.
3) Then (**third phase**), the candidate moves on where thousands are vaccinated to triple-check for side effects and see how well it works. That's another few months or years of waiting, because this isn't like testing a drug, where you give it to people with a disease and see if it makes them better, but you give it to people who don't have a disease, and then checking later to see if they still don't have the disease.

In normal times this whole process needs around 4 years, testing around 5.000 people, but vaccine developers are hoping to do some of this testing simultaneously, still testing the same amount of people, but all in around 18 months. It's how some candidates are moving so quickly (e.g. **Moderna** is in the phase 2 on May; **Cansino Biologics** is in the phase 2 on April; **Oxford University** on phase 1 and 2 on April). This stage of the race can't go any faster, for good reason, because you have to do the trials of every phase before testing a vaccine to the population.

For example, during WW2, allied soldiers were vaccinated for yellow fever, but thousands developed jaundice and hepatitis, and some died.
If the vaccine makers had done their research, they would have discovered reports of these side effects dating back to 1885, all reported by the American Journal of Public Health in 2013.
Then, in 1950s, some poorly made vaccines infected 40.000 people with polio, and killed around 200. Known as the **"Cutter incident"**, it led the US government to tighten requirements for vaccine manufacturers.
In fact, today nothing is licensed without undergoing extremely stringent safety considerations, and even after it's licensed, the vaccine continues to be monitored. According to US government and Health Resources & Services Administration (HRSA), for every million doses of vaccine that are distributed, only one person is compensated for serious side effects, as they explain in their article about data & statistics.

Vaccines need to pass an extra-high bar because they're given to healthy people, and this isn't the first race for a vaccine, and also this isn't the first coronavirus the world have faced.

When SARS and MERS viruses caused outbreaks, scientists got to work on vaccines, including a team at Oxford University, that learnt a lot about coronaviruses and their biology. In 2018, they got a promising MERS candidate into human trials, hoping to stop the next outbreak of this rare coronavirus, but then a year later, this latest coronavirus broke out.
Because it was similar, the team easily adapted their MERS vaccine into a COVID-19 one, they sped through the first phase of trials, putting them on track to begin the next phases in the summer. So, if everything goes well, there is the possibility that millions of doses can be available in the autumn.

Unfortunately, Oxford University's Professor **Peter Hotez** also made a promising coronavirus vaccine for SARS years ago, but then the grant ended, and everything has stopped, hoping to receive in the future new funding.
This situation happened to so many promising vaccines, that this stage is called "the vaccine Valley of Death". Of these vaccine candidates that scientists want to make in record time, only Ebola reached the finish line.
This because when these other two outbreaks ended, so did the funding.
Peter's COVID-19 candidate is based on his SARS candidate, but if he had been able to test it back then, they would have the safety testing potentially finished.

In 2017, a group of people funded in part by the Gates Foundation came together to fix this and called themselves **"CEPI" (Coalition for Epidemic Preparedness Innovations)**. They aggregate funding and create a pool of funds to support vaccine development, so, as Bill Gates said: "We can play fair broker and take those billions that are available for tools for the world and make sure they go to the right place".
As of May, CEPI is behind nine COVID-19 candidates, including two of the early front-runners: Oxford's new candidate, and Moderna's; and it's the success of these two and one from China (Cansino), that give experts hope that we can have a vaccine approved in 18 months, but that isn't the end of the race, not even close.

Remember that Herd Immunity have to be reached, in order to end this pandemic, and for this coronavirus experts estimate that means at least 60% of the world needs to become immune, out of almost 8 billion people, something that has never been made in the history of the world. Even the bottles to contain the vaccines, a special type of glass, the world doesn't have enough of that.

To make billion doses, you need a lot of factories, but each type of vaccine requires different kind of factory and ramping up production in enough factories can take years, but a lot of the giants have a shortcut, because they have the factories to start production now, like **Johnson & Johnson**, that, as Dr. Paul Stoffels (Johnson & Johnson Belgium) said: "We have one big plant which is fully operational and can spit out 300 million vaccines, and we are very quickly setting up additional plants in the world."
But the newer types of vaccines don't have many, or any, factories yet, so some are placing bets on candidates now, building factories for the ones they think might survive trials.

And even if we can make that many doses, we'll still need to give the vaccine to people all over the world, and that's when politics can get in the way.
During the **swine flu epidemic** in 2009, an Australian company was among the first to make a vaccine, and the government made them sell to Australians first. Canada made a similar move, and while US promised to donate some of its supply, they waited until the epidemic was over.
So, it matters where a vaccine is made, because there is **"Vaccine nationalism"**, a term that is used by some popular newspapers (**Figure 6.2.1 – Figure 6.2.2**).

Figure 6.2.1

Source: The New York Times; *P. S. Goodman, K. Thomas, S. L. Wee and J. Gettleman* (April 10, 2020)

Figure 6.2.2

Source: Politico; *A. Hernandez-Morales* (March 15, 2020)

World leaders have come together and called for cooperation, like Angela Merkel, Paul Kagame (Rwanda President, *during WHO meeting, April 24, 2020*), and Kang Kyung-Wha (Foreign Minister of South Korea, *during European Commission meeting, May 4, 2020*). But, as of May, US hasn't been one of them.

Who can get a vaccine will also depend on its **price**.
Remember that these vaccines are mainly funded privately and based on how some vaccine makers' stocks have risen (**Figure 7.2**), some clearly see a potential windfall ahead.

Figure 7.2

Source: *NYSE & NASDAQ* (May 2020)

But so far, some companies like Johnson & Johnson have promised to make their vaccine affordable, as little as $10 a dose.
That is critical, because a vaccine can only win if it gets to billions of people, including those who can't afford it.
So, to vaccinate enough of the world, we'll actually need more than one winner.

This race isn't really between candidates, but between humanity and the virus, that simple little vehicle that's paralyzed economies and ended hundreds of thousands of lives around the world.
We can only beat it by doing what we've never done before: making a vaccine for everyone in record time.

CHAPTER 3 - THE ECONOMIC IMPACT

The **coronavirus (COVID-19)** pandemic, which was first detected in China, has infected people in 188 countries. Its outbreak has led to health crisis in several countries, to disruptions of the global economy and left businesses around the world counting costs and wondering what recovery could look like.
The economic fallout from the pandemic might represent one of the biggest shocks of recent decades.

Global value chains (GVCs) have already come under pressure as a viable model for the organization of international production since the outbreak of the epidemic in China, and even more so since the virus turned into a global pandemic. Some analysts expect a major reshuffling of the global production network as a result of the pandemic.

Here is a selection of charts and maps to understand the economic impact of the virus so far.

3.1 - Global shares in flux

Big shifts in stock markets, where shares in companies are bought and sold, can affect the value of pensions or **individual savings accounts (ISAs).**
The FTSE, Dow Jones Industrial Average and the Nikkei all saw huge falls as the number of Covid-19 cases grew, with the first two that saw their biggest quarterly drops in the first three months of the year since 1987.
All these shifts are displayed in **Figure 1.3** below, that are data about this topic shared by Bloomerg in June.

Figure 1.3

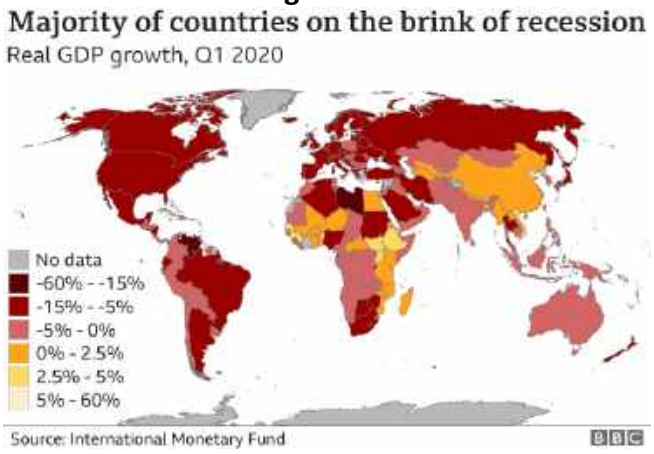
Source: *Bloomerg* (June 29, 2020)

In response, central banks in many countries, including the UK, slashed interest rates, and that should, in theory, make borrowing cheaper and encourage spending to boost the economy. Global markets have since recovered some ground as governments have intervened, but some analysts have warned that they could be volatile until fears of a second wave of the pandemic are eased.

3.2 - Risk of recession

If the economy is growing, that generally means more wealth and more new jobs and it's measured by looking at the percentage change in gross domestic product, or the value of goods and services produced, typically over three months or a year.
But the **IMF (International Monetary Fund)** says that the global economy will shrink by 3% this year. It is displayed in **Figure 2.3**, that shows how this pandemic has affected countries around the world. It described the decline as the worst since the Great Depression of the 1930s.

Figure 2.3



Source: *IMF*

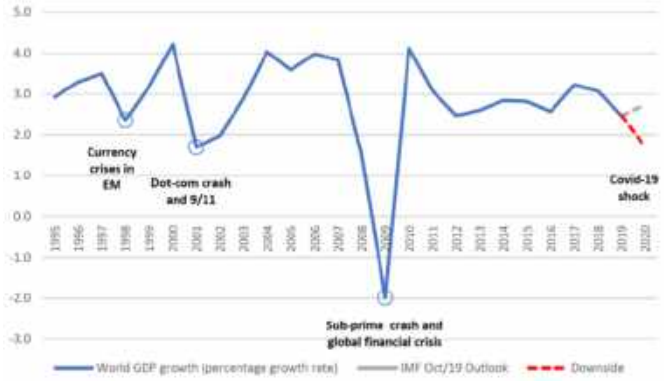
Although it said that the coronavirus has plunged the world into a "crisis like no other", it does expect global growth to rise to 5.8% next year if the pandemic fades in the second half of 2020.
That's driven primarily by growth in countries such as India and China.
Recovery in big, services-reliant, economies that have been hit hard by the outbreak, such as the UK or Italy, is expected to be a slow process.

3.3 - Data on world manufacturing production

Data by **UNIDO (United Nations Industrial Development Organization)** showed a consistent decline in production growth, indicating an overall economic slowdown already before the outbreak of the COVID-19 crisis.
Manufacturing output growth fell below the landmark of 1% and remained at 0.7% in the fourth quarter of 2019, when only three industries registered a positive year-over-year growth rate in all country groups, namely basic pharmaceutical products, beverages and food products.

While these three industries represent essential basic consumer goods and are likely to continue to perform well over the coming months, other manufacturing industries suffer a severe blow due to the coronavirus outbreak and the resulting economic implications. Consequently, world GDP growth decline in the next months, as **Fig. 3.3** shows:

Fig. 3.3 - Global GDP growth, 1995–2020



Source: *UNCTAD (United Nations Conference on Trade and Development) calculations based on IMF (International Monetary Fund), WEO (World Economic Outlook)* (October 2019)

3.4 - Three main channels of the global economy disrupted: demand, supply, and finance

On the **demand side**, a combination of reduced income and fear of contagion result in lower private spending. Although some of these effects might be offset by increased government spending, the COVID-19 shock's net demand effect is negative in the short run.

This could be amplified by negative **supply side** effects, attributable to a sudden halt in manufacturing activities in the most affected regions and the resulting bottlenecks in global value chains. If left unaddressed, such disruptions will in turn trigger widespread factory closures due to the lack of intermediary inputs, even in areas less affected by the virus.

Lastly, increased risk aversion and a flight-to-liquidity in the face of uncertainty caused by the COVID-19 shock, the **financial markets** stress weigh heavily on the global economy. So, as a result, there are fluctuations in the foreign exchange market.

3.5 - Substantial increase in unemployment

A substantial increase in **global unemployment** seems almost certain.
For the **ILO (International Labour Organization)**, the pandemic disproportionally affect not only those workers with underlying health conditions, but also young people who are more vulnerable to decreased labor demand, women, who are over-represented in those sectors that are likely to be affected most (such as services or in occupations on the front lines of the pandemic, e.g. nurses), as well as unprotected workers in the so-called 'gig economy' and migrants.

3.6 - Capital flight

The pandemic has already triggered capital flight and a sharp reversal of international investment in emerging markets.
Whereas a group of 24 emerging markets including China, India, South Africa and Brazil, had a net inflow of investments of $79 billion in 2019, $70 billion in investments had already exited those countries in the last two months alone according to the Institute of International Finance (*New York Times, 2020*).

With this in mind, the decision by the G20 governments to "**do whatever it takes**" to minimize the social and economic fallout due to the coronavirus - and most importantly, to ensure cross-border flows of vital medical supplies, agricultural products and other goods and services – was welcomed (*The Guardian, 2020*).

3.7 - Possibility of insolvency and default

This capital flight has reignited fears that countries such as Argentina, Turkey or South Africa, could be sliding toward insolvency and default soon.
This could be further accelerated by currency depreciations in these countries. The Argentine peso continued to devalue and decreased by another 6% against the dollar this year alone. Similarly, the Turkish lira has dropped by 10% since January due to investors pulling out money and Turkish companies facing bankruptcy.
While these are only two examples, the situation is becoming equally dire in many other low and middle-income countries and requires urgent attention from policymakers and the international community.

3.8 - Significant contraction of FDI (Foreign Direct Investment)

The effect of the pandemic is similarly dramatic when we look at **foreign direct investment (FDI)**. On 26 March, UNCTAD estimated a collapse of global FDI by – 30% to – 40% during 2020–2021, much more than the previous projections of -5% to -15% two weeks earlier. While those countries most severely affected by COVID-19 will be hardest hit, other countries are also likely to feel the virus's full impact as supply chain disruptions on investment prospects.
Over two-thirds of the 100 multinational companies tracked by UNCTAD have issued statements on the effects the virus has had on their business.
Many are reducing capital expenditure in affected areas, and to date, 41 have issued profit alerts.
Lower profits translate into lower **reinvested earnings**, a major component of FDI. A wider sample of the top 5.000 listed companies shows that the earnings forecasts for the fiscal year 2020 have been revised down by an average of 30%. The hardest hit sectors are the **energy and basic materials industries** (-208% for energy, with an additional shock caused by the recent drop in oil prices), **airlines** (-116%) and the **automotive industry** (-47%).

3.9 - Trouble in global value chains; supply chain contagion; travel industry

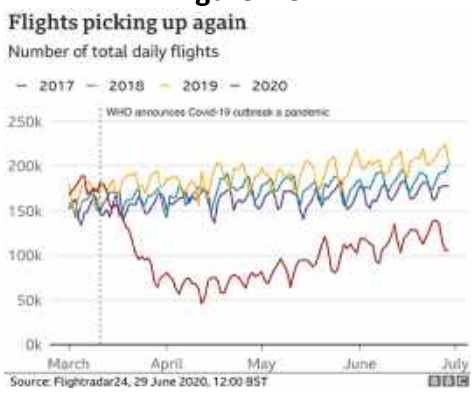
As outlined by *Richard Baldwin and Eiichi Tomiura* in their *essay published on 6 March 2020*, the hardest hit countries account for the majority of **global GDP, manufacturing production and exports.** Furthermore, the mitigation policies introduced will result in a global slowdown in aggregate demand.
Global supply chains have fundamentally changed how supply shocks propagate.

As industrial parts and components are increasingly traded, a supply shock in a globally integrated economy is likely to create “supply chain contagion” via the trade in intermediate goods.

Baldwin and Tomiura develop different supply chain scenarios based on the WTO’s Global Value Chain Development Report 2019 and by citing case studies from The Economist. They also use data from the **OECD** (Organization for Economic Co-operation and Development) Trade in Value Added database to quantify the importance of inter-linkages for different countries.
The authors find a mixed picture for trade in services, as some industries such as **tourism and air travel** will be hit hard, while others, such as **ICT (Information and Communications Technology)** and **medical services**, will not be as affected.

As regards **travel industry**, it has been badly damaged, with airlines cutting flights and customers cancelling business trips and holidays.
Many countries introduced travel restrictions to try to contain the virus.
Data from the flight tracking service Flight Radar 24 (**Figure 4.3**) shows that the number of flights globally took a huge hit in 2020.

Figure 4.3



Source: *Flightradar24* (June 29, 2020)

But as the spread of infections has eased in some areas, the industry has started to open back up.
Spain, for example, has reopened its borders to visitors from most of Europe without having to quarantine, and for months it was under one of Europe's toughest lockdowns.
Travel companies also said that bookings from the UK had "exploded" after the government announced current restrictions will be eased.

3.10 - Impact on production and trade

According to reports by academics and practitioners on the impacts of the coronavirus, the virus implies both a **demand and a supply shock**.

1) Supply shock
From the supply side perspective, production is affected, on the one hand, because of reductions in labour supply as a consequence of the number of workers infected, thus reducing the number of people available to work, and because value chains are disrupted, on the other.
Countries that rely on equipment and components from regions affected by the virus experience disruptions in the production process.

2) Demand shock
Demand for manufactured goods reduced as a consequence of the pandemic. This usually occurs for two reasons:

- **First**, the propensity to consume decreases as workers who are required to stay at home in support of "social distancing" measures tend to prioritize saving overspending.
- **Second**, firms that are experiencing disruptions in the production process may decrease their consumption of intermediate goods.

Supply and demand shocks can manifest in different ways across countries and different industries.
The **differences between various regions** could be as follows:

- Economies like China, Europe and US are mostly affected by direct impacts on their population's health condition;
- The majority of developing countries are mostly affected by indirect impacts relating to their level of inter-linkages with countries affected by the coronavirus, i.e. their demand for goods or the supply of goods and services. However, as COVID-19 further spreads to developing countries, the direct impacts on those countries are likely to increase.
- It is plausible to assume that resource-rich developing countries are also affected by a reduction in commodity prices (e.g. copper, oil) driven by reduced international demand for such goods, and that developed countries will experience a drop in the production of transformed manufactured goods.

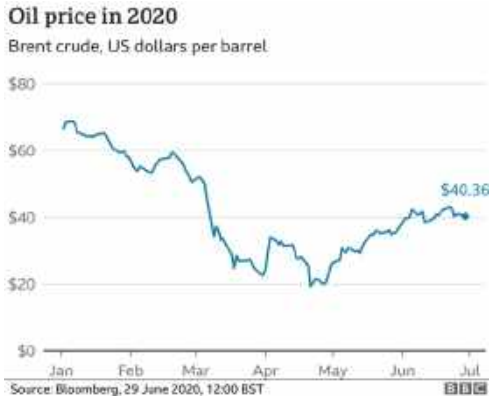
3.11 - Impact on manufacturing industries

Anecdotal evidence is reporting losses for the manufacturing sector beyond China, namely also for many rich developed countries.
According to **IBIS World**, relevant impacts are being registered in many countries such as Australia, Canada, Germany, New Zealand and the United States.
Recurrent losses in these countries are reported in the domestic market, particularly in the food industry due to the closure of pubs, restaurants and other caterers.
Heavy losses are being registered on the international markets in the automotive industry (a huge decrease in sales of 82% in Germany), and in high-tech industries such as computers and electronics, the traditional champions of revealed comparative advantage in rich countries.

3.12 - Oil price recovery

Demand for oil all but dried up as lockdowns across the world kept people inside. The crude oil price had already been affected by a row between Opec, the group of oil producers, and Russia. Coronavirus drove the price down further, as **Figure 5.3**, published by Bloomerg in June, demonstrates.

Figure 5.3



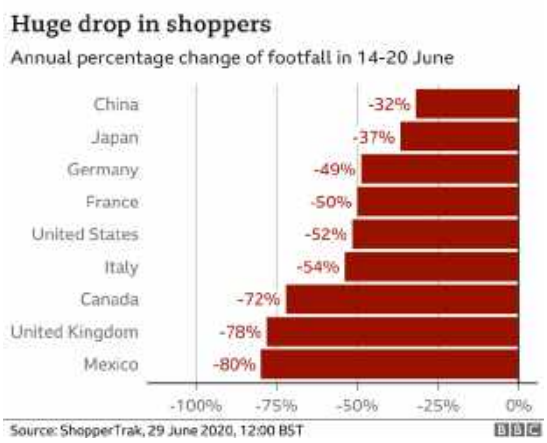
Source: *Bloomerg* (June 29, 2020)

Brent crude is the benchmark used by Europe and the rest of the world, and its price dipped below $20, to the lowest level seen in 18 years.
Prices have recently regained ground as travel restrictions in some countries have been relaxed, boosting demand for fuel.

3.13 - Consumer confidence

Retail footfall also saw unprecedented lows as shoppers stayed at home in a bid to stop the spread of Covid-19.
Pedestrian numbers have since risen as lockdown measures have been rolled back, according to research firm ShopperTrak, showed in **Figure 6.3**.

Figure 6.3



Source: *ShopperTrak* (June 29, 2020)

Separate research suggests that consumers might still be feeling anxious about their return to stores.
More than half of UK customers expect they will now go shopping less often over the next one or two years, according to a survey of more than 1.000 people by accountancy giant EY (*Ernst & Young*).

3.14 - Vaccine hopes

Governments around the world have pledged billions of dollars for a Covid-19 vaccine and treatment options.
A number of pharmaceutical firms are in a race to develop and test potential drugs that could help nations get back to "normal".
Bloomerg has reported the percentage change in share value of two of many of these companies, which are **AstraZeneca and Roche**, shown in **Figure 7.3** below.

Figure 7.3

Source: *Bloomerg* (June 29, 2020)

Shares in some companies have shot up on the hopes that some will be approved and distributed at scale.
AstraZeneca's share price, for example, has hit record highs.
The Drug company says it will be able to produce two billion doses of a vaccine.
"Until such medical interventions become available, no country is safe," the IMF said of the pandemic that has disrupted the global economy.

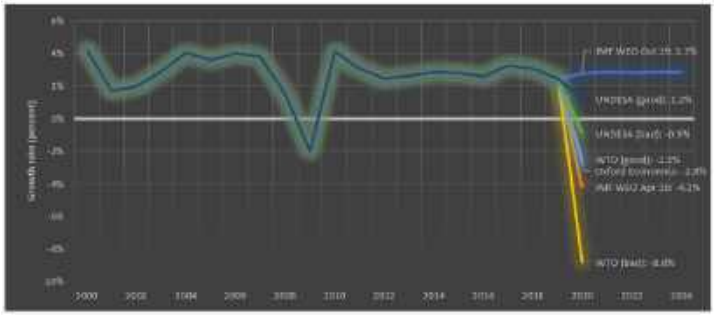
CHAPTER 4 - IMPACT ON MACROECONOMIC VARIABLES

The projected impact of COVID-19 worsens every week, and its accelerated spread has brought the world economy to a standstill. Projections of the potential impacts of the COVID-19 shock on the global economy vary considerably. Yet there is near unanimous consensus that the world economy is facing the most serious challenge of the post-war era due to the sudden halt in economic activity in both advanced and developing countries.

4.1 – GDP

Containment measures have led to further downward predictions of world GDP growth. In mid-April, the International Monetary Fund (IMF) updated its global growth projections and stressed that the global economy is expected to experience its worst recession since the Great Depression.
The WTO's latest forecasts are even worse, projecting a negative growth rate of nearly 9% for 2020 in the worst-case scenario (**Figure 1.4**).
Other projections conducted at the beginning of the month were more optimistic, such as that of the United Nations Department of Economic and Social Affairs (UNDESA): in the worst-case scenario, global GDP will contract by up to 1%.

Figure 1.4: World growth outlook for 2020 (projections by different organizations)



Note: The projections are based on market exchange rates and were carried out on the following dates: IMF = 14 April; Oxford Economics = 14 April; UNDESA = 1 April; WTO = 9 April. UNDESA and WTO distinguish between two possible scenarios on the pandemic's severity. The projections carried out by the IMF World Economic Outlook (WEO) 2019 (blue line) are used as the baseline for comparison.

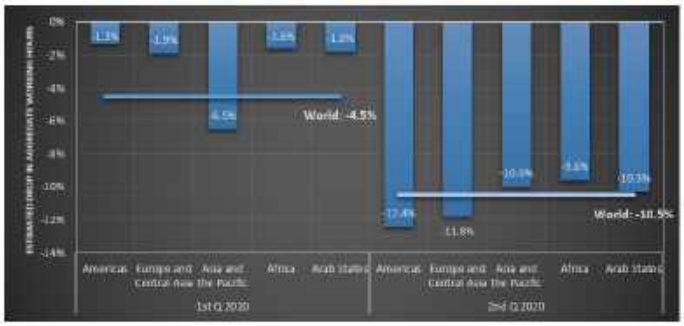
Source: *UNIDO elaboration based on Oxford Economics (2020), IMF (2019 and 2020), UNDESA (2020) and WTO (2020).*

Among these projections, the International Monetary Fund's (IMF) is the main reference point for assessing the economic impact of COVID-19.
Accordingly, global growth will shrink by -4.2%, a difference of 7 percentage points compared to the projections published before the outbreak of the crisis (*IMF 2020*).

4.2 – Employment

The impact on employment will be worse than initially expected.
The **ILO's** previously predicted rise in unemployment of up to 25 million in 2020, with losses in labour income in the range of $860 billion to $3.4 trillion, seems accurate, if not underestimated. According to them, these numbers may underestimate the real magnitude of COVID-19's impact.
Their latest summary states that the current containment measures are affecting close to 2,7 billion workers, representing around 81% of the world's workforce.
The third edition of the ILO Monitor on COVID-19's impact on labour contends that the share of workers affected by temporary workplace closures has decreased from 81% to 68% over the last two weeks.
Unemployment rates are skyrocketing, working hours are expected to decrease in all regions, with the ´Americas´ and ´Europe and Central Asia´ to be hit hardest with 12,4% and 11,8%, respectively (**Figure 2.4**).

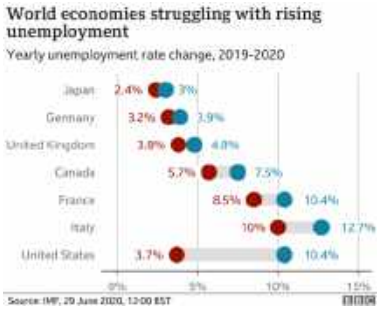
Figure 2.4: Estimated effects on aggregate working hours by region



Source: *UNIDO elaboration based on ILO* (2020).

Also **Figure 3.4**, that shows data from an IMF research, demonstrates that in the major economies unemployment rates have increased as a result of the coronavirus outbreak.

Figure 3.4



Source: *IMF* (June 29, 2020)

In the United States, the proportion of people out of work has hit 10.4%, signaling an end to a decade of expansion for one of the world's largest economies. Millions of workers have also been put on government-supported job retention schemes as parts of the economy, such as tourism or hospitality, came to a standstill under lockdown.

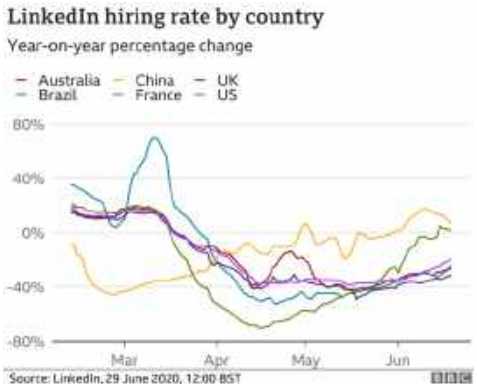
However, the data differs between countries, as France, Germany and Italy provide figures on applications, for example, whereas the UK counts workers currently enrolled in the **Figure 4.4** below, that is a data from OECD Statistic research.

Figure 4.4

Source: *OECD, Government statistics offices, Bloomerg*

But there have since been some signs of recovery in the global jobs market. China and France, for example, have seen increases in hiring rates as shutdowns eased, according to networking platform **LinkedIn**, as **Figure 5.4** indicates.

Figure 5.4



Source*:* *LinkedIn* (June 29, 2020)

However, some experts have warned it could be years before levels of employment return to those seen before the pandemic.

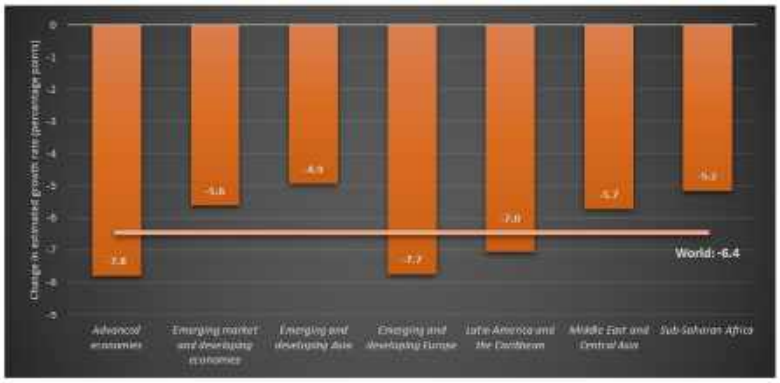
4.3 – Developing countries

The crisis is expected to hit workers in low and middle-income countries particularly hard, where the share of those working in informal sectors, and who therefore have limited access to adequate health and social protection, is higher. To make matters worse, the expected massive job losses among migrant workers will likely have knock on effects on economies that heavily depend on remittances. Furthermore, the containment measures in advanced economies have already started impacting less developed countries through lower trade and investment.

Different projections for economic growth in 2020 predict an overall contraction around the world, but some regional differences emerge.

While advanced economies are expected to be hit hardest by the COVID-19 crisis, emerging and developing Europe and countries in Latin America and the Caribbean have seen the largest downward revision of GDP growth projections, as **Figure 6.4** shows.

Figure 6.4: Regional differences of GDP growth rate projected for 2020 in the IMF's WEO (Oct 2019 and Apr 2020)



Source: *UNIDO elaboration based on IMF* (2019, 2020).

4.4 – Capital flight

The rattling of financial markets, together with tightened liquidity conditions in many countries, have led to unprecedented outflows of capital from developing countries. **UNCTAD** illustrates the net debt and equity outflows from the main emerging economies, which amounted to $59 billion in the month since the COVID-19 crisis went global (21 February to 24 March).

Capital flows are flooding back to advanced economies, and **Global foreign direct investment (FDI)** is equally affected, and the weeks since the outbreak of the COVID-19 crisis went global have witnessed unprecedented outflows of capital from emerging economies.
UNCTAD's latest Global Investment Trend Monitor warns that FDI could experience downward pressure of between -30% and -40% in 2020–2021.

4.5 – SDGs (Sustainable Development Goals)

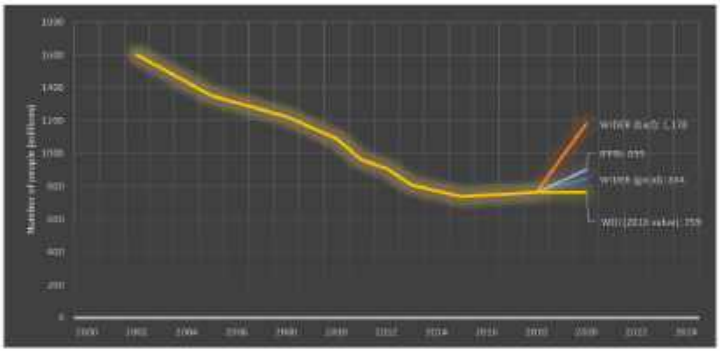
The **United Nations (UN)** has expressed concern that the COVID-19 crisis will lead to a reversal of decades of progress in the fight against poverty, and that already high levels of inequality within and between countries will be further exacerbated. The crisis will therefore inevitably and adversely impact the implementation of the 2030 Agenda for Sustainable Development.
The COVID-19 pandemic is expected to negatively influence almost all **SDGs.**
The current crisis will also severely affect the prospects for industrialization in developing countries.

Human development is on course to decline for the first time since 1990.
The emerging picture shows a grave deterioration of socio-economic development. This is well reflected in the latest projections of the Human Development Index for 2020.
According to **UNDP Administrator Achim Steiner**: "The world has seen many crises over the past 30 years, including the Global Financial Crisis of 2007-09. Each has hit human development hard but, overall, development gains accrued globally year-on-year. COVID-19 – with its triple hit to health, education, and income – may change this trend." (*UNDP, 2020*).

4.6 – Poverty

Global extreme poverty is expected to rise for the first time in decades.
Researchers have attempted to estimate the impact of the COVID-19 crisis on global extreme poverty (**Figure 7.4**).
These estimates produce a wide range of results, with expected increase of people living under the $1.90 PPP poverty line ranges from 85 million to 420 million, and an increase of over 50% relative to the most recent figures from 2018.
Despite the wide dispersion of results, all projections seem to indicate that global poverty is likely to increase for the first time since 1990.

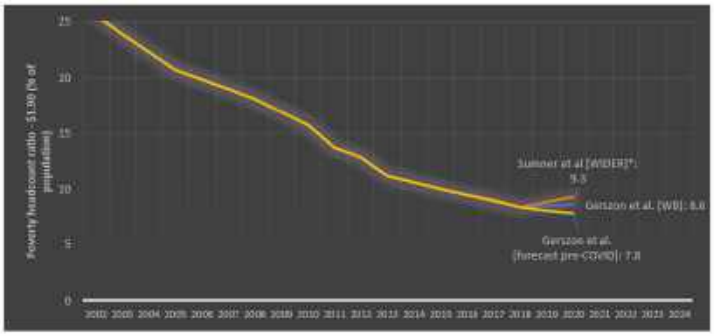
Figure 7.4: Number of people below the $ 1.90 PPP poverty line: latest projections by different organizations



Note: The projections were carried out on the following dates: Laborde et al. [IFPRI] = 16 April; Summer et al. [UNU-WIDER] = 8 April. The values of the World Bank's WDI 2018 (yellow line) are used as the baseline for comparison.
Source: *UNIDO elaboration based on Laborde et al. (2020), Summer et al. (2020) and World Bank WDI database.*

Assuming a drop in global GDP based on the **IMF estimate**, the expected increase in the share of people living in extreme poverty will range from 0.8% to 1.5 percentage points, equivalent to an increase of between 50 million to 70 million people compared with the original estimates for 2020.
Other figures using different GDP growth projections and poverty baselines indicate an increase of nearly 420 million additional people living in extreme poverty (**Figure 8.4**).

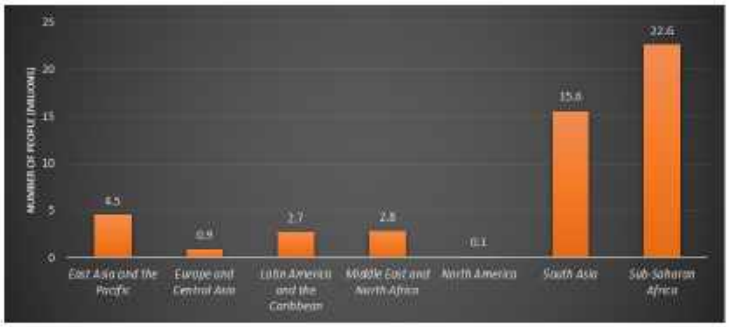
Figure 8.4: World extreme poverty headcount ratio (latest projections by different organizations)



Note: The projections were carried out on the following dates: *Gerszon et al.* [World Bank] = 20 April; *Sumner et al.* [UNU-WIDER] = 8 April. The pre-COVID-19 forecast of *Gerszon et al.* (yellow line) is used as the baseline for comparison. The estimates by *Sumner et al.* are adjusted to match the baseline of *Gerszon et al.* and only the "good" scenario is presented (5% drop in global GDP).
Source: *UNIDO elaboration based on Gernson et al. (2020) and Sumner et al. (2020).*

As regards Sub-Saharan Africa, it is severely affected by poverty.
As **Figure 9.4** illustrates, the regional distribution of the expected increase in extreme poverty is heavily skewed towards sub-Saharan Africa and South Asia, with nearly 50% of those pushed below the poverty line living in sub-Saharan Africa. The UN Economic Commission for Africa arrives at a similar conclusion, where a projected GDP contraction of -2.6% in the worst case could deprive 19 million people of their livelihoods and, in the context of weak social protection programs in Africa, push up to an additional 29 million people into poverty.

Figure 9.4: Projected increase in the number of people below the $ 1.90 PPP poverty line as a result of COVID-19, by region



Source: *UNIDO elaboration based on Gerszon Mahler et al.* (2020)

4.7 – Environment and CO2

The flip side to the halt in economic activities is an improvement in the environment.

As the COVID-19 crisis continues to unfold, it also continues to cut energy demand and CO2 emission.

A comprehensive study conducted by **Carbon Brief** estimates that the pandemic could cause emission cuts of around 2.000 million tonnes in 2020, equivalent to 5.5% of total global CO2 emission in 2019 (Evans, 2020).

If this is the case, the COVID-19 crisis would be responsible for the largest annual drop in global CO2 emission in history.

CHAPTER 5 – IMPACT ON PRODUCTION AND TRADE

COVID-19 is severely impacting manufacturing production in developing countries because:

1) Demand from high-income countries for manufacturing goods and raw materials is decreasing;
2) Value chains are being disrupted due to delays in the delivery of necessary components and supplies from more technologically advanced countries;
3) Other factors, including policies (e.g. restriction of movement of goods and people), inability of employees to reach the workplace or financial constraints, which affect the normal production process.

UN economists have estimated a $50 billion decrease in manufacturing production in *February 2020*, and the **IMF** warns that the negative economic effects will be felt "very intensively" in developing countries that sell raw materials. All these negative channels will inevitably have an impact on exports from developing countries. The losses in export volume will be further intensified by the decline in energy and commodity prices. **UNCTAD** projects that developing countries as a whole (excluding China) will lose nearly $800 billion in terms of export revenue in 2020.

5.1 - Impact in the first quarter of 2020 and comparisons between previous year

Beyond the economic projections for 2020, international organizations are starting to publish initial data on countries' economic performance.
The UNIDO database provides preliminary data on the index of industrial performance in January/February/March 2020 compared to December 2019, representing the pre-crisis period.

Impacts in Africa:
Fully in line with the global economic prospects, a recent report of the **African Union (AU)** states that: "Regardless of the scenario whether optimistic or pessimistic, Covid-19 will have a harmful socioeconomic effect on Africa".
Losses related to the fall of the global oil price are estimated at $65 billion.
Losses amounting to $19 billion are expected in Nigeria alone, and the crisis will also affect manufacturing firms. According to the AU report, the automotive industry (-44%), airlines (-42%) and energy and basic materials industries (-13%) face even higher losses.

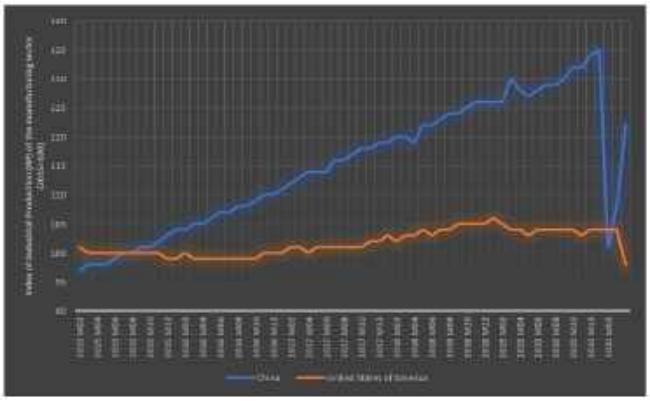
MNE perspectives of profits in developing countries have been revised downwards by 16%. This revision amounts to 1% in Africa compared to 18% in Asia, and 6% in Latin America.

Impacts in Latin America:
CEPAL estimates a 1.8% contraction in regional GDP in Latin America, a 10% increase in unemployment and a rise in the number of people living in poverty to between 35 million and 220 million (of its 620 million inhabitants).
The number of those living in extreme poverty could climb from 67.4 million to 90 million. Much of the negative impact could stem from the drop in the price of commodities and food (copper for Chile and Peru, fish meal for Peru, soy for Brazil, Argentina and Uruguay, beef for Uruguay and Argentina, shrimp for Ecuador) and the close trade relations with China, one of the largest buyers of Latin American goods.

Impacts in Asia:
According to the **BBC**, China experienced a 13.5% reduction in industrial production in the first two months of 2020. It is the world's largest exporter and produces one-third of all global manufacturing goods. The newly published *Asian Development Bank Outlook 2020, revising the 6 March 2020 update*, asserts that China remains the epicenter of the crisis, but developing Asia has only been hit by a 7.7% decrease in industrial production since the beginning of 2020.
Countries that are less affected by the virus are India, NIEs and the ASEAN 5; their industrial production continues to show a positive growth rate.

In February 2020, 24 out of 34 high-income and developing countries included in UNIDO's COVID-19 database still registered an increase in industrial production compared to December 2019.
China was hit hard by the crisis with a 20% drop in industrial production following the country's lockdown. The reduction in China's export potential could be an important factor in the disruption of global value chains (*Seric et al., 2020*).
However, in March 2020, China made a strong recovery, with only a 10% reduction in industrial production compared to December 2019 (**Figure 1.5**).
A rapid recovery of China and other heavily affected players could invalidate the most pessimistic projections and result in lower losses in other countries.
In March 2020, industrial production in the **United States** dropped by 6% (vs December 2019) after the lockdown was implemented (**Figure 1.5**).

Figure 1.5: Index of Industrial Production (IIP) of the manufacturing sector in China and in the United States



Source: *UNIDO Statistics Data Portal*

Heterogeneity of impacts across industries in the U.S. and China:
By comparing the U.S. and China, an analysis of the Index of Industrial Production at industry level reveals a certain level of heterogeneity of the impacts across industries (March 2020 vs December 2019), depending on the economy's structural composition and on the country-specific and international circumstances. The industries most affected in the US are motor vehicles (-25%), other transport equipment (-19%), wearing apparel (-19%), while in China they are other manufacturing (-23%), furniture (-22%) and leather (-14%).

Trade data confirms strong impact of lockdown and containment measures.
The findings of an analysis of OECD data on the trade of goods over the period December 2019 (pre-crisis) to March 2020 are similar to those obtained from industrial production data. By comparing data on the trade of goods from February 2020 and December 2019, 18 out of 35 countries still show a positive increase in overall exports, with only Finland (-25%), Chile (-11%) and Norway (-8%) registering negative performances.
Among a group of non-OECD countries including Argentina, Brazil, China, Colombia, Costa Rica, India, Indonesia, Russia and South Africa, only Argentina (-10%) and Russia (-10%) suffered losses. Data for March 2020 are only available for four countries, namely Argentina, Brazil, China and India.
Brazil continues to show a positive increase in exports compared to the country's December levels (+5%), while India, Argentina and China recorded losses (30%, 20% and 5%, respectively, compared to December 2019), with the first one's collapse in exports caused by the lockdown adopted in March.

Majority of countries hit hard by the crisis.

When comparing data for the periods March 2020 vs December 2019 (pre-crisis) and March 2020 vs March 2019 (year-over-year approach), the majority of countries considered (77% and 72%, respectively) registered a negative IIP growth. The average negative growth rates across the 48 countries are -4.8% and -4.6%, respectively.

As with other projections presented in this bulletin, the impact is particularly severe in Europe and in the Americas, while its effect is weaker in Russia and Asia (**Table 1.5**).

Table 1.5: Average change in Index of Industrial Production (IIP) across world regions

	United States	Central and South America	Europe	Asia	Russian Federation
Number of countries	1	6	31	9	1
March 2020 vs December 2019	-6.4	-7.2	-5.0	-3.1	-0.26
March 2020 vs March 2019	-6.4	-6.6	-6.0	0.87	2.89

Source: *UNIDO Statistics Portal*

Lower and upper middle-income countries severely affected.

When is conduct the same exercise and consider income levels, the evidence shows that the impact of COVID-19 is particularly acute in countries that make up the upper and lower middle-income country group (**Table 2.5**).

The data, albeit not exhaustive, imply that the effects of the crisis could be particularly severe on this country group's industrial production.

Table 2.5: Average change in Index of Industrial Production (IIP) across world regions by income level

	High income	Upper middle income	Lower middle income	Upper and lower middle income
Number of countries	30	15	3	18
March 2020 vs December 2019	-4.2	-5.8	-5.8	-5.8
March 2020 vs March 2019	-4.7	-4.8	-4.4	-4.7

Source: *UNIDO Statistics Portal*

Now, it is repeated the same exercise by weighting the reduction rate of the IIP and take the size of the economy, represented by manufacturing value added, into account. This is important to ensure that the reduction rates of small countries do not skew the calculated averages.

The IIP's average reduction rates (**Table 3.5**) are amplified by the fact that many countries with an extremely negative industrial performance are those that are the most industrialized (e.g. USA, China, and high-income European countries).

Table 3.5: Weighted average change in Index of Industrial Production (IIP) across world regions by income level

	High income	Upper and lower middle income
Number of countries	30	18
March 2020 vs December 2019	-6.2	-10.0
March 2020 vs March 2019	-7.3	-6.0

Source: *UNIDO Statistics Portal*

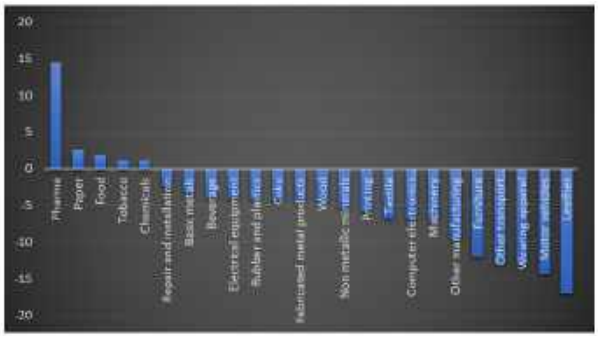
Note: Weights are calculated using manufacturing value added as included in the UNIDO INDSTAT database for the last available year when official data are available.

Leather, wearing apparel and motor vehicles are the losers, pharma and food are the winners.

Based on the available data at sector level, it is calculated the average reduction rate across countries by comparing March 2020 vs December 2019 and March 2020 vs March 2019. The overwhelming majority of manufacturing industries, according to both calculations, registered a downturn (**Figures 2.5 and 3.5**).

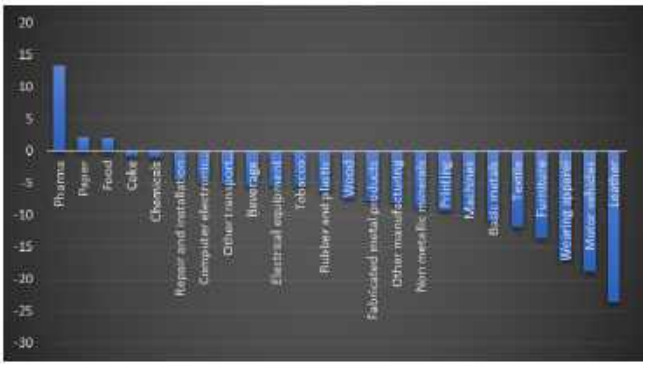
Pharmaceuticals, together with the **food industry**, emerge as clear **winners** of the crisis. Paper also achieved a positive average growth rate according to both calculations. The chemical and tobacco industries also had a positive growth rate compared to December 2019. Based on both calculations, **leather, wearing apparel and motor vehicles** are the **losers.** Data incorporate the wide heterogeneity across countries.

Figure 2.5: Average percentage change in IIP across countries calculated for each ISIC rev. 4 industry. March 2020 vs December 2019



Source: *UNIDO Statistics Portal*

Figure 3.5: Average change in IIP across countries calculated for each ISIC rev. 4 industry. March 2020 vs March 2019.



Source: *UNIDO Statistics Portal*

Q1 of 2020 had severe impacts on trade of goods for high-income and upper and lower middle-income countries.

Fresh data from the OECD on the export of goods suggest that trade for high-income and lower and upper middle-income countries has been severely affected by the crisis.(Non-OECD countries is a group of countries that includes Argentina, Brazil, China, Costa Rica, India, Indonesia, Russia, South Africa, Mexico and Turkey. The high-income group consists of the OECD high-income countries) The pre-crisis period for both March 2019 and December 2019 is used as a comparator (**Table 4.5**).

Table 4.5: Reduction in export of goods (%) for a sample of high-income and upper middle-income countries

	High income	Upper and lower middle income
Number of countries	35	10
March 2020 vs December 2019	-9.0	-7.4
March 2020 vs March 2019	-11.5	-7.5

Source: *OECD*

The most recent data from UNIDO's seasonally adjusted Index of Industrial Production (April 2020 vs December 2019) indicate that both lower- and upper middle-income countries have been significantly impacted by COVID-19 (**Table 5.5**).

Table 5.5: Average loss in % in the Index of Industrial Production (IIP) across countries. April 2020 vs December 2019

High-income (30 countries)	Upper middle-income (13 countries)	Lower middle-income (6 countries)
18%	24%	22%

Source: *UNIDO elaboration based on Statistic Data Portal*

5.2 - Economic losses are not correlated to health impacts.

Recent data from the Centre for Systems Science and Engineering at Johns Hopkins University show that the spread of the pandemic in terms of case numbers and deaths is quite asymmetric across countries, as shows **Figure 4.5**. Sub-Saharan Africa, for example, one of the poorest regions in the world, does not seem to have been severely impacted by COVID-19.

Figure 4.5: Spread of COVID-19 around the globe

Source: *Centre for Systems Science at the Engineering at John Hopkins University*

A study by *Noy et al.* (2020) finds that the direct costs of the COVID-19 pandemic associated with illness and mortality are lower than the indirect losses caused by the crisis. A low impact of COVID-19 in terms of case numbers and deaths does not necessarily translate into a low economic impact.

For example, according to a recent report of the **African Development Bank, African countries**—though many of them have so far not been significantly affected by COVID-19—are projected to contract by 1.7 per cent in 2020, dropping by 5.6 percentage points relative to the January 2020 pre-COVID-19 projection. Many countries are experiencing a recession, even though COVID-19 has not had a serious effect on them in terms of health.

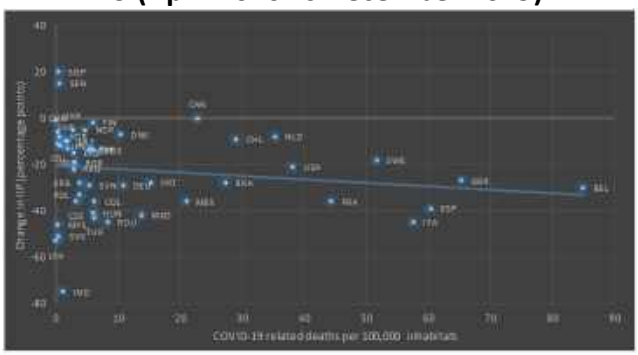
Even minor public health events can severely affect firms in lower income countries due to their poor socio-economic conditions (**vulnerability**) and their weak capacity to respond to crises (**resilience**). Moreover, in a globalized world, many countries are suffering indirect consequences from value chain disruptions and lower international demand for goods due to widespread recession.

Recent data derived from UNIDO's Index of Industrial Production (IIP) for the analysis of 49 countries representing around 87 per cent of world **manufacturing value added (MVA).**

A comparison of IIP data (adjusted to take seasonal effects into account) for March 2020 vs December 2019 shows that approximately 81% of countries have experienced a decrease in industrial production of 6% on average.
A comparison of data for April 2020 vs December 2019 reveals that industrial production fell by 20% on average in 93% of countries.
A comparison between April 2020 and March 2019 as well as between March 2020 and March 2019 shows similar results (an increase in the average decrease in IIP and in the number of countries affected).

As **Figure 5.5** illustrates, a decrease in the IIP does not necessarily translate into a high impact in terms of health.
Countries with a similar number of COVID-19-related deaths may experience different levels of economic loss, depending on the severity of the containment measures implemented or their indirect effects.

Figure 5.5: Relationship between decrease in industrial production and COVID-19 (April 2020 vs December 2019)

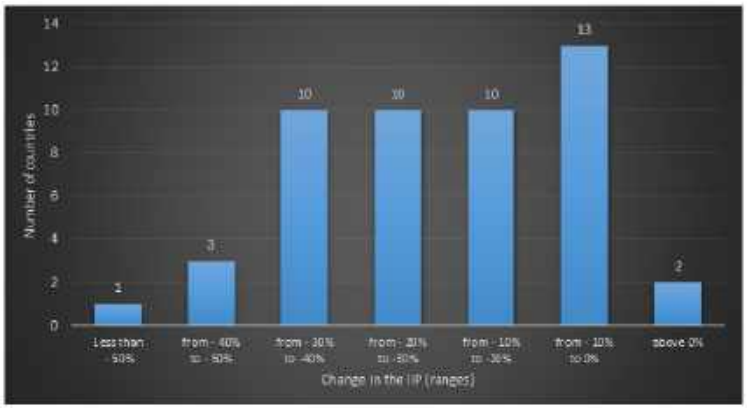


Note: Cumulative COVID-19 deaths per 100.000 population extracted from the Johns Hopkins University of Medicine.
Source: *UNIDO elaboration based on Statistic Data Portal*

Heterogeneous impacts, but with negative signs.
The distribution of decreases in industrial production is heterogeneous across countries and varies from positive values to losses of more than 50%.
India's IIP fell by 65%, reflecting the drastic cut in exports already flagged in a previous issue of UNIDO's COVID-19 economic impact analysis.
An interesting picture (**Figure 6.5**) emerges when countries are categorized based on the decrease in their industrial production by comparing data from April 2020 and March 2019. About 50% of the countries suffered a decrease in industrial production of over 20%.

The group of countries whose IIP fell between 20% and 30% represents the median of the sample. The group with decreases in IIP of between 10% and 20% includes the highest number of countries.

Figure 6.5: Distribution of decreases in IIP (April 2020 vs December 2019) across a sample of 49 countries

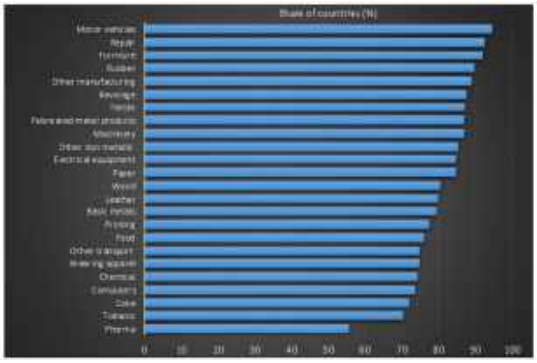


Source: *UNIDO elaboration based on Statistic Data Portal*

Industrial production across the globe deteriorated further in April 2020 compared to March 2020. It continued declining in 90% of the countries included in our sample, with an average drop of 15% within one month.
Monthly reductions were further observed in India (-55%), North Macedonia (-35%), Malaysia (-34%), Turkey (-33%) and Slovakia (-32%).
Countries that registered an increase in industrial production were Senegal (+9%), Canada (+7%) and Singapore (+4%).

Manufacturing in crisis in many countries.
All manufacturing industries were affected by the crisis over the period March 2019–April 2020. The share of countries that experienced a decrease in manufacturing varies from 55% (pharma) to 94% (motor vehicles).
In a previous UNIDO COVID-19 economic impact analysis, pharma was actually identified as one of the very few "winners", while motor vehicles were (and continues to be) one of the biggest "losers", as **Figure 7.5** shows.
This demonstrates that the negative trend continued into April across all industries, even though some industries, such as pharma, seem to be slightly less affected than other more vulnerable industries.

Figure 7.5: Share of countries (%) registering a decrease in industrial production over the period March – April 2020 in different industries



Source: *UNIDO elaboration based on Statistic Data Portal*

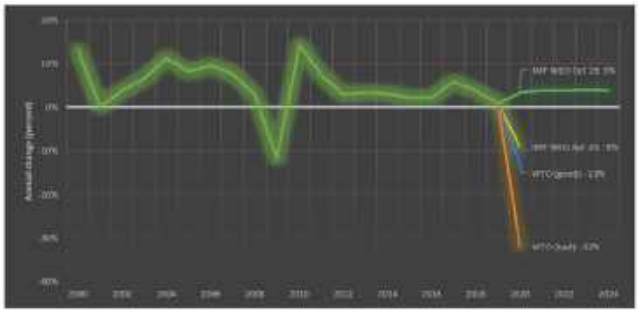
5.3 - Trade

Trade and GVC disruptions are at the center of the storm.

The projections for the volume of trade of goods and services are even more dire. In the World Economic Outlook, the IMF revised its projections of growth in the trade of goods and services from an earlier estimated 3% to -9%.

The WTO, which measures trade in terms of the average change in exports and imports of merchandise (excluding services), predicted a decline of between 13% and 32% (**Figure 8.5**).

Figure 8.5: Annual change in the volume of global trade (latest projections by different organizations)



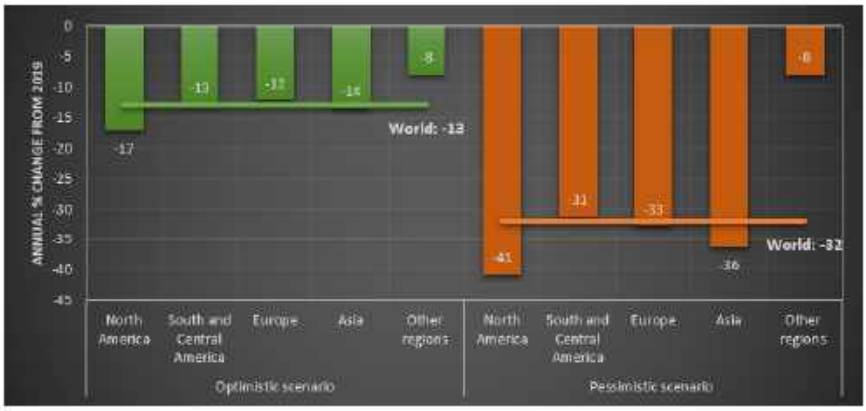
Note: Change in trade is calculated as the average in the change of exports and imports. WTO projections include only merchandise trade (excluding services). IMF figures include goods and services. The projections were carried out on the following dates: IMF = 14 April; WTO = 9 April. The projections carried out by the IMF in its World Economic Outlook (WEO) 2019 (green line) are used as the baseline for comparison.

Source: *UNIDO elaboration based on IMF (2019, 2020) and WTO (2020).*

Actual data for the first quarter of 2020 confirm trade projections.
Data for the first quarter of 2020 suggest that the COVID-19 pandemic has reduced global trade values by 3%. This downturn is expected to accelerate in the second quarter of 2020, with world trade projected to record a quarter-on-quarter decline of 27%, according to the latest UNCTAD assessment.

North America and Asia expected to suffer more from global trade decline.
Nearly all regions are expected to suffer double-digit declines in trade volume, even in the most optimistic scenarios. In a regional comparison, as illustrated in **Figure 9.5**, North America and Asia are predicted to suffer the highest negative impacts on their export volumes.

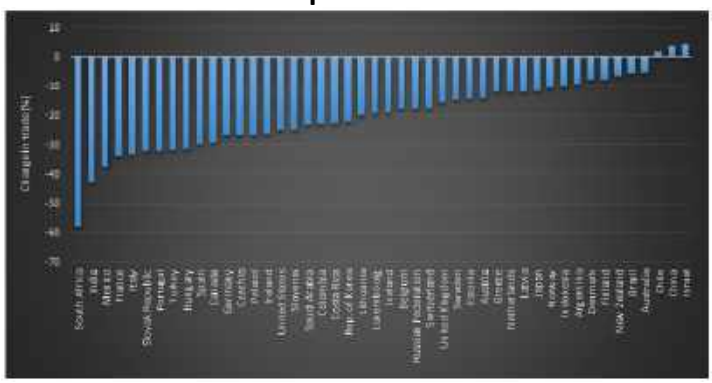
Figure 9.5: Projected annual change in the volume of global trade, by region



Source: *UNIDO*

Trade losses for nearly all high- and lower income countries in March – April 2020.
Over the period March – April 2020, trade trends closely followed those for industrial production. Forty-three out of 46 countries experienced a lower level of trade in goods (**Figure 10.5**). South Africa, India, Mexico, France and Italy are the five countries that suffered the highest reductions in trade volume over that period. Israel, China and Chile recorded an increase in trade.
China further consolidated its path of rapid recovery, as already highlighted in the previous chapter. Note that the top 10 countries with the highest reductions in trade volume includes both high-income and upper middle-income economies, reinforcing the fact that COVID-19 has a severe impact on both industrialized and developing countries.

Figure 10.5: Change of trade in goods in % by country for the period March – April 2020



Source: *OECD trade in goods statistics*

These figures clearly show that the COVID-19 crisis has affected the majority of countries around the world. Fresh primary data collected by UNIDO in several Asian countries provides some preliminary evidence on the pandemic's impact on firms.

5.4 - A closer look at firms

Aggregate results ultimately hinge on what happens at the firm level
The economic impact of COVID-19 on the industrial sector ultimately depends on how the continued containment measures and related restrictions affect manufacturing firms. The extent of firms' productive capacities, their degree of integration in domestic and global production networks and the type of market they serve are important factors determining the extent of the crisis' impact on firms. Accordingly, some firms (and countries) are better suited to quickly respond and adapt their operations, thus reducing the shock's overall impact on their profits, cash flow and staff.

However, firm-level evidence is still scarce.
More than three months after the WHO declared COVID-19 a pandemic, harmonized firm-level industrial data remain limited, despite the avalanche of firm surveys initiated by national and international organizations.
Aside from some country-level efforts to analyze the effects of the crisis on firms, it is difficult to find manufacturing enterprise-level data that can be analyzed and compared across different countries.

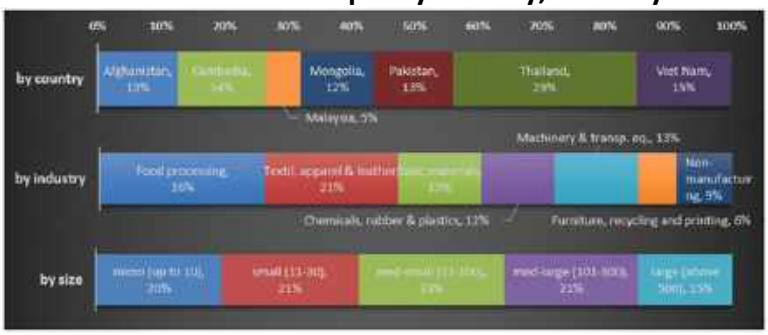
UNIDO is piloting firm-level surveys in several Asian economies.

To fill this gap, UNIDO is piloting firm-level surveys across manufacturing firms in several emerging economies in Asia. The first round of the survey included seven countries and collected a total of 1.040 valid responses.

It was implemented online between mid-April and early June in collaboration with governments, business chambers and other agencies operating in the participating countries. The results obtained provide new insights into the differential impacts the crisis has had on countries, industries and types of firms, as well as into the main responses adopted by firms and governments.

Figure 11.5 summarizes the structure of responses in terms of countries, industries and firm size.

Figure 11.5: Distribution of sample by country, industry and firm size



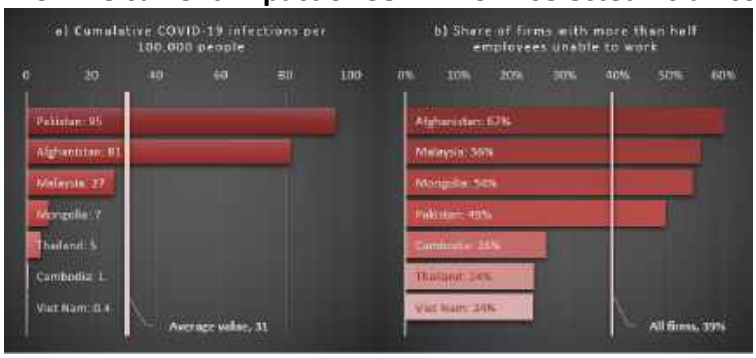
Note: Size is defined in terms of employees.

Source: *UNIDO elaboration*

The pandemic's short-term impact differs widely across countries.

The impact of COVID-19 in terms of cumulative incidences in these countries per 100.000 population differed considerably across the countries surveyed (**Figure 12.5, Panel a**). While Pakistan and Afghanistan reported over 80 cases per 100.000 population, Thailand, Cambodia and Viet Nam had fewer than five cases. These differences are also partially reflected in the share of firms that stated that more than half of their employees were unable to work during the survey period (**Panel b**): firms in Afghanistan and Pakistan were affected more heavily than those in Thailand and Viet Nam. Over half of the employees of a very large share of firms in Malaysia and Mongolia were also unable to perform work, indicating that the actual number of COVID-19 infections was not the only factor at play. On average, more than one-third of the firms surveyed claimed that at least half of their workforce was unable to work.

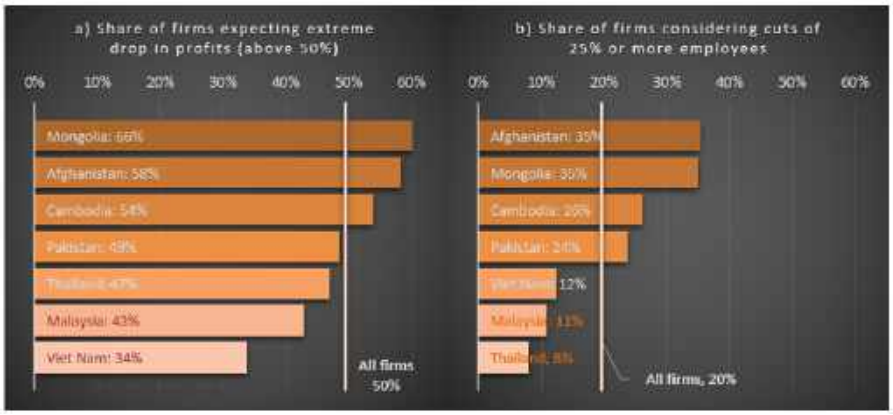
Figure 12.5: The current impact of COVID-19 in selected Asian countries



Note: Cumulative COVID-19 infections per 100.000 population extracted from the European Centre for Disease Prevention and Control.
Source: *UNIDO elaboration*

The prospects for profit and job growth are equally gloomy.
The results on firms' expectations about future profits and employment growth are less dispersed across countries and portray a gloomy picture.
Half of the firms surveyed expect a drastic decline in company profits (50% or higher) for the year 2020 (**Figure 13.5, Panel a**). Moreover, 20% of firms stated that they had to lay off employees or are planning to cut one quarter or more of their staff (**Panel b**). The largest share of firms expecting massive cuts both in terms of profits and employment is in Mongolia and Afghanistan.

Figure 13.5: The expected impact of COVID-19 on firms' profits and employment, by country



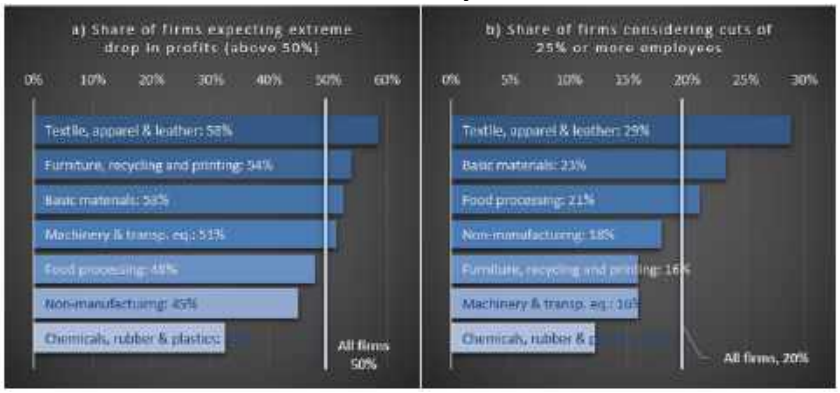
Source: *UNIDO elaboration*

Not all industries are equally affected: textile and apparel firms expect to be the hardest hit; chemical and plastic expect to be the least impacted by COVID-19.

Firms in the textile, apparel and leather industries tend to anticipate the largest plunge in profits and jobs, while firms in the chemical, plastic and rubber industries expect below average decreases (**Figure 14.5**).

The basic materials industries also expect their profits and employment to be hit hard. In the furniture, recycling and printing industries, a large share of firms is anticipating a serious decline in profits (54%), but only 16% expect that they will be forced to announce drastic job cuts, which lies below the average share of firms included in the survey. Similar trends are observed in the machinery and transport equipment industries.

Figure 14.5: Expected impact of COVID-19 on firms' profits and employment, by industry



Source: *UNIDO elaboration*

The main problems firms are facing also differ across industries.

The different expectations across firms arise from the very challenges they face (**Figure 15.5**).

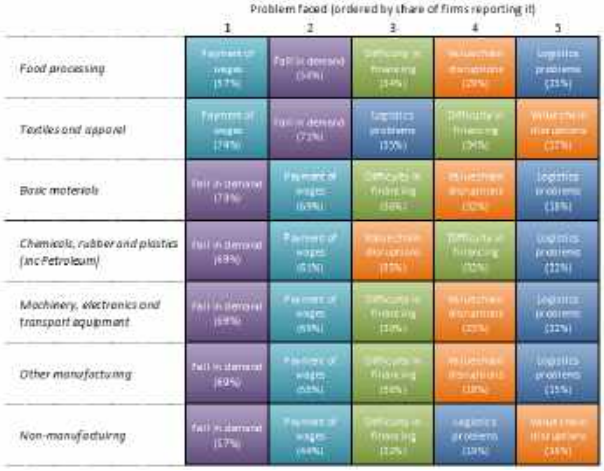
Two major challenges widely reported by firms are:

1) Contraction in demand;
2) Payment of wages.

The most pressing problem in labor-intensive industries (such as textile and apparel) seems to be the payment of wages. The plunge in demand is a widespread concern among other industries.

Firms in the textile and apparel industry are also particularly concerned about logistics problems, while upstream and downstream chain disruptions are deemed a more serious problem for firms in the chemical, rubber and plastic industries than for other industries.

Figure 15.5: Top 5 problems reported by firms, across industries

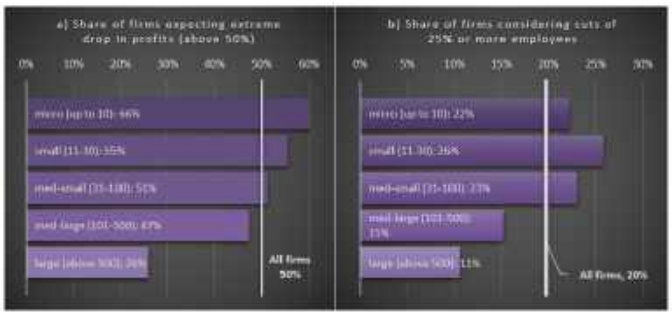


Note: The values in brackets indicate the share of firms in the industry that reported this particular problem.
Source: *UNIDO elaboration*

Differences also exist across firm size: SMEs are expecting a larger decrease in profits and more job cuts than large firms.

Size also matters, as smaller firms, on average, tend to anticipate a much larger decline in profits than larger firms (**Figure 16.5**). The same applies to job cuts, although micro firms are expecting to slash fewer jobs than small and medium-small firms.

Figure 16.5: Expected impact of COVID-19 on firms' profits and employment, by firm size

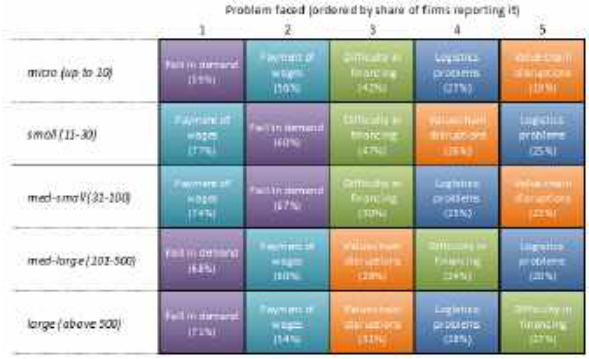


Note: Bars according to firm size. Only manufacturing firms are considered.
Source: *UNIDO elaboration*

The problems small firms are dealing with are not necessarily the same as those larger firms are facing.

The payment of wages seems to be more problematic for small and medium-small firms, as **Figure 17.5** demonstrates.
By the same token, difficulties in financing are less relevant for medium-large and large firms. For them, value chain disruptions triggered by the COVID-19 crisis represent a far more pressing problem.

Figure 17.5: Top 5 problems reported by firms, across size



Note: The values in brackets represent the share of firms in the industry that reported this particular problem. Only manufacturing firms are considered.
Source: *UNIDO elaboration*

Firm heterogeneity calls for tailored policy responses.
A general conclusion that can be drawn from these results is that not all firms are affected by COVID-19 the same way. Differences are observed across countries, industries and firm size.
The type of problems industries and firms face also differ across different firm types. It follows that the policy responses implemented by governments to support firms in their recovery efforts should be tailored to account for these differences.

CHAPTER 6 – POLICIES AND COPING STRATEGIES

The situation urging governments to act fast and boldly have gained increasing support across the political spectrum, to prevent a complete economic and social breakdown owing to the containment strategies.
One key question the ongoing crisis has sparked is whether the unprecedented economic measures could be transformed into long-lasting ones and whether they could pave the way towards more structural reforms. In its report, the **UN** calls for solidarity and widespread cooperation as a means to building more equitable, inclusive and resilient societies that are better prepared to tackle pandemics, climate change and other challenges.

As the pandemic's epicenter shifted—first from Asia to Europe, then to the Americas and the rest of the world—and as some countries have gradually started resuming economic activities, two interrelated issues have gained center stage in the economic policy debate:

1) How to shape recovery plans to foster a more inclusive and sustainable post-crisis world;
2) How to boost international support for developing countries to ensure their economic survival and to bolster their fragile healthcare systems, while sowing the seeds for a better future.

Both of these issues have major implications for industrial development opportunities and policies.

A rapidly changing trend for policy actions is visible, which has shifted from a focus on companies' and households' cash flow problems towards measures that support industries in adjusting to changing business conditions and that increase their resilience and help them develop systemic competitiveness in a newly structured global production network.

6.1 - Short- versus medium- and long-term measures

Most policy analyses in the current literature on the COVID-19 pandemic differentiate between **short-term targets and medium- to long-term goals**.
In the **former case**, the objective is to address the immediate health situation, to protect income-generating opportunities and to safeguard the operation of critical supply chains, i.e. necessities and health supplies. In the **latter cases**, interventions to cushion the economic fallout emphasize measures to restore supply chains, recover demand and incentivize productive investment.

6.2 - Economic mitigation policy responses by countries

As the COVID-19 pandemic is spreading across the globe, most governments in developed and developing countries have deployed some type of policy response to curb the immediate human and economic effects.
The IMF, which is monitoring macro-economic policies (distinguishing between exchange rate and balance of payments measures; monetary and macro-financial measures and fiscal measures), has identified major differences across countries in terms of the breadth and scope of economic actions beyond those related to how strict or far-reaching the adopted social distancing and lockdown measures are (if any). The documented exchange rate adjustments and balance of payment measures can help policymakers in emerging and developing economies balance the difficult challenge of addressing capital flow reversals and commodity shocks.
Policy responses are revised in response to the deteriorating economic prospects triggered by the pandemic.
Governments across the world are increasingly resorting to economic policies in addition to containment measures already in place.
Impact evaluation exercises focusing on specific regions have further highlighted that the current economic crisis is likely to exacerbate pre-existing weaknesses, unless adequate measures have effectively been put in place.

6.3 - Policies to support manufacturing

PwC has mapped a host of challenges for industry in light of the ongoing crisis, including supply chains and the workforce's global mobility.
It identifies policy measures such as extending lines of credit, reducing infrastructure costs, providing short-term funding, lessening the tax burden and providing supply chain support that could assist manufacturers in responding to and anticipating necessary adjustments.
In addition to all of the above-mentioned measures to mitigate the immediate economic downturn associated with the COVID-19 pandemic, governments have also started to extend support to manufacturing companies, to alleviate the immediate economic damage caused by the pandemic, assisting severely hit businesses and promoting job retention.
A recent report prepared by the **Policy Links Unit of the Cambridge University Institute for Manufacturing (IfM)** reviewed policy responses aimed at mitigating the potential impacts of COVID-19 on manufacturing in 11 countries, plus the European Union.

Their study indicates that while macroeconomic mitigation measures are likely to impact the manufacturing industry, they are often combined with emerging measures in three distinct areas:

1. Safeguarding continued operation of manufacturing;
2. Mobilizing manufacturing towards critical supplies;
3. Supporting post-crisis manufacturing growth.

Table 1.6 below provides examples of concrete measures taken in each of these areas so far, that could be intensified in the mid- to later stages of the recovery phase with a view to shaping a new future for the manufacturing industry (i.e. government support to identify emerging markets and consumer needs, as well as direct funding to promote the internalization of production and the creation of new supplier networks) as explained by *Hartwich et al.*, 2020.

Table 1.6: Current international policies and measures to support manufacturing

Policy area	Examples of concrete measures	

Safeguarding continued manufacturing	• *Financial and fiscal support (loans, guarantees, subsidies, insurance, tax breaks, etc.)*
	  - *Cash flows to support firm survival*
	  - *Workforce retention and wage payments*
	• *Ensuring continued supply of production inputs/ addressing supply chain disruptions*
	• *Designation of critical workers and sectors*	

Mobilizing manufacturing towards critical supplies	• *Repurposing manufacturing towards critical supplies* • *Industrial consortia to produce critical supplies* • *Designation of critical medical supplies* • *Easing of regulations* • *Export controls and import facilitation* • *Direct government involvement in production and distribution*	
Supporting post-crisis manufacturing growth	*Supporting business resumption*	• *Guidance for business resumption, including workers' health and safety* • *Initiatives aimed at increasing manufacturing productivity*
	Supporting business reorientation	• *Support to identify future markets and sale channels* • *Support for investments in innovation and local production*

Note: Policies taken by central/national governments in Australia, China, France, Germany, India, Italy, Japan, Rep. of Korea, New Zealand, Singapore, the United States and the European Union as of 3 April 2020 are presented. The list of concrete measures combines newly established measures and previously existing ones that have been expanded and/or repurposed. It is non-exhaustive, and measures may not be exclusive to the manufacturing industry, but also benefit other sectors.

Source: *UNIDO based on Castaneda-Navarrete et al.* (2020).

Cross-sectoral policies and measures will likely impact the manufacturing industry, but uncertainty remains as to how specific sectors will be affected.

In its sectoral briefs series, the ILO discusses the likely impact of macroeconomic policies and other cross-sectoral measures on industries, noting, however, that it is still too soon to fully grasp how many of the current policy responses will effectively impact specific sectors.
The biggest uncertainties identified are “whether and how SMEs in the supply chains will be able to access financial assistance, and whether major producing countries will be able to benefit from their implementation”.

Seizing the opportunity to strengthen local manufacturing post-crisis.
In a recent opinion piece, Dani Rodrik (Professor of International Political Economy at Harvard University's John F. Kennedy School of Government) discusses the trends that will shape the global economy in the years to come. He identifies the rebalancing of state-market relations (with a greater presence of the former) and a rebalancing between hyper-globalization and national autonomy (to the benefit of the latter).
In fact, some governments are already considering the windows of opportunity these trends might offer to strengthen and develop their local manufacturing capacities.
The Indian government, for example, has announced a relief package for industry with an explicit view to achieving self-reliance while enhancing the country’s competitiveness in the global economy.

6.4 – Support for developing countries

Analyses focused on developing countries tend to agree that the economic stimulus necessary to mitigate the pandemic’s economic damage by and large exceeds the sums announced by governments so far, which further underpins the need for international cooperation.
The international community has certainly stepped up efforts.

Effective support measures, accompanied by coordinated efforts, could help least developed countries ride out the storm.
In light of the uneven government capacities to respond to the COVID-19 crisis, calls for the international community to coordinate efforts and provide effective support measures, especially for least developed countries (LDC), have increased. Given that such coordinated efforts have yet to materialize, businesses and governments in both developed and developing countries have been leading initiatives to mobilize scientific, technological and productive capacities towards critical goods.

In the context of developing countries, however, such initiatives appear insufficient to contain the impacts of the pandemic and to provide the necessary supplies.
In a recent policy brief, the UN Commission for Latin America and the Caribbean highlighted that the region is highly dependent on medical goods imports, with less than 4% originating in the region itself. Insofar as four of the top five suppliers in the region have restricted their medical supply exports in response to COVID-19, Latin America and the Caribbean remain vulnerable.
Nevertheless, public-private partnerships have developed in the region, providing evidence of the possibility to unite efforts towards a common goal and setting an important precedent for a medium- to long-term strategy to build resilient health industries.

Whether a consensus is beginning to evolve on the need to follow more inclusive and sustainable paths once the pandemic has been contained is not yet clear.
In this vein, export-oriented industrialization may be a less viable vehicle for recovery from COVID-19 and for longer term development, which should compel developing countries to rethink their growth models and strategies.
This means not only addressing emergencies, but also including policies aimed at expanding productive capacities, promoting economic diversification and technological upgrading, while ensuring social and environmental protection.
For that to become a reality, however, global coordination is key.
China, Europe and the United States have already initiated aggressive plans to reignite and bolster their productive capabilities and innovation.
Developing countries must also seize the opportunity and start preparing now to prevent the existing asymmetries from widening even further.

6.5 – Support for firms and jobs

Repurposing efforts can help tackle COVID-19 and save jobs but entails challenges that need to be overcome.
Business efforts to retool factories so traditional production lines can incorporate products for which demand is increasing (i.e. ventilators, masks and protective gowns) are underway in advanced economies and have started to emerge in the developing world (e.g. an apparel factory in Kenya shifted to producing masks within one week and is now producing 30,000 masks per day) (*Jayaram et al., 2020*).
Such efforts can simultaneously help address the health emergency and retain jobs.

Support for business survival is the key to curb the pandemic's immediate effects.

Governments' responses to the pandemic have focused primarily on the immediate health emergency and its economic effects, thus seeking to safeguard the provision of healthcare and support for individuals, households and businesses. Yet there is a huge disparity across countries and regions in terms of their capacity to mobilize the necessary fiscal and financial resources (developed and developing).

While crucial for business resumption after the crisis, providing clear guidance on issues such as **workers' health and safety** under high uncertainty is not trivial. As some economies are starting to reopen after economic lockdowns and are gradually resuming manufacturing activities, it is undisputable that workers' health and safety guidelines are instrumental in preventing a second wave of contagion.

The type of support that firms are receiving varies across countries, with tax deferrals being the most widespread measure.

The most common forms of support reported by firms are tax deferrals or reductions, cuts in utility costs, deferment of loan obligations, concessional financing for firms that do not lay off workers and other types of financial assistance.

The emphasis on deferrals of tax obligations seems to follow a global pattern. In their analysis of how OECD and G20 countries are responding to the COVID-19 crisis, Bulman and Koirala (The OECD COVID-19 Policy Tracker: What are governments doing to deal with the COVID-19 pandemic?) find that the deferment of taxes and social security payments is the most common fiscal instrument being implemented.

Accordingly, as of 13 May 2020, 96% of the 90+ countries covered by the OECD's COVID-19 Policy Tracker had adopted such measures, followed by credit subsidies to firms (93%), income support for households (91%) and wage subsidies (89%); cuts in taxes/social security and cash transfers/grants to firms were the least commonly used support measure (80% and 51%, respectively).

Firms are calling for tax cuts to respond to the crisis.

The vast majority of respondents participating in the UNIDO firm survey stated that reductions in taxes and rent or in utility costs are measures they would applaud.

The share of firms in favor of tax reductions ranged between 39% (Mongolia) and 76% (Afghanistan); the share of firms calling for reductions in rent and utility costs varied between 32% (Mongolia) and 63% (Afghanistan), as illustrated in **Table 2.6**.

Table 2.6: Policies governments should implement, as indicated by firms (%)

Source: *UNIDO*

The effectiveness of fiscal measures:

The **UNIDO firm survey** (covering Malaysia, Mongolia, Pakistan and Thailand) also asked firms to indicate how useful the support measures provided by the government have been. Not surprisingly, direct financial support was considered the most beneficial support measure (72% in Mongolia; 77% in Pakistan; 73% in Thailand). The OECD recently analyzed (*Corporate sector vulnerabilities during the Covid-19 outbreak: assessment and policy responses*) the expected impact of three types of government measures aimed at assisting businesses in coping with the financial fallout caused by COVID-19:

1. Deferral of taxes;
2. Financial support for debt payment;
3. Temporary support for wage payments.

Two scenarios were considered in the analysis which relied on firm-level financial data from the *Orbis dataset* (that is the most comprehensive source of comparable data on companies from around the world): **one scenario** in which government support for firms is abundant, and a **second scenario** in which no such support is in place. Supporting wage payments appeared to be considered particularly effective, while tax deferrals were found to have the least impact on firms' cash flow.

According to the same study, combining the three types of measures over two months would reduce the number of cash-strapped firms by 20%.

Larger manufacturing firms seem to be the primary beneficiaries of government support.

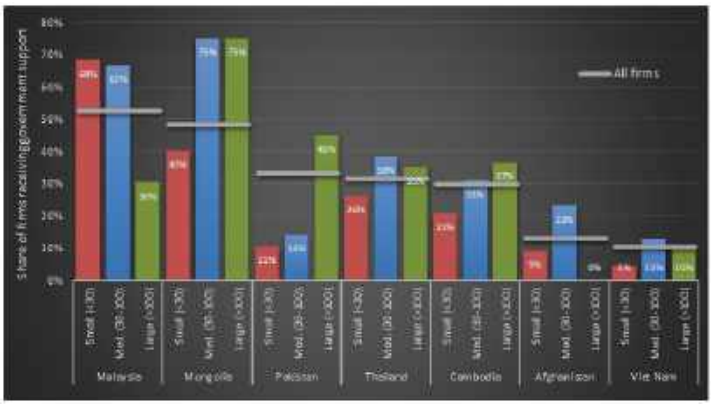
The results of the **UNIDO firm survey** also highlight the importance of government capacity for swift and effective responses to shocks.

By capturing some of the characteristics of the support currently being provided to firms as opposed to firms' expectations, it comes out options that could help governments design and adapt their industrial policy measures and packages.

It can be seen that the average share of firms benefitting from government support measures or stimulus packages ranges from around 10% (Afghanistan and Viet Nam) to 50% (Malaysia and Mongolia).

Overall, larger firms were more likely to receive support than smaller ones (**Figure 3.6**), which in "normal" times already tend to be more vulnerable and face more difficulties in accessing finance. A clear exception was observed in the case of Malaysia, where nearly 70% of small firms surveyed received some form of support.

Figure 3.6: Share of firms benefitting from government support by firm size (%)



Note: The criteria for classifying firms by size varies across countries. Figures for medium-sized firms in Malaysia and Mongolia include medium-large firms.

Source: *UNIDO*

6.6 – Trade policies

Trade policies could enable access to critical supplies and mitigate the effects of disruptions in global value chains.

In light of the challenges for local production and the current surge in protectionist measures, the recent literature on policy responses to the coronavirus pandemic emphasizes the importance of trade measures to keep supply chains and international commerce running, especially of medical supplies.
According to **UNCTAD**, this recognition is reflected in increased funding for international organizations to support trade facilitation efforts, which are deemed key to the implementation of the **WTO's Trade Facilitation Agreement (TFA).**

6.7 - Environment

Joint efforts could help pave the way towards a better future.
In a recent statement, UN Secretary General Guterres urged civil society, governments, businesses and international organizations to join efforts to turn the recovery from an ongoing health crisis into a real opportunity to build a better, greener future *(United Nations, 2020).*
City, state and national leaders are elaborating COVID-19 recovery plans that could also generate benefits for climate change mitigation and resilience, racial, gender and economic equity.

Amidst fears that recovery plans could undermine the achievement of environmental goals, the debate on the greening of manufacturing intensifies.
As documented in the past weeks, the halt in economic activities, while negatively affecting socio-economic conditions, has led to an improvement in the environment in terms of energy consumption and CO2 emissions.
Surveys show that climate change and sustainability are key concerns among manufacturing workers, which suggests that they would welcome a shift towards greener practices in the post-crisis period and beyond.

A shift towards conditionality:
The impact of COVID-19 on businesses and the subsequent recession have prompted many governments to explore the option of making businesses more conducive to inclusive, sustainable growth. For example, the *EU Recovery Plan for Europe* envisages that the EU Recovery and Resilience Facility, together with the Just Transition Mechanism, will focus on investments in line with Europe green and digital transitions. The IMF is calling on countries to implement green recovery plans when elaborating the structural reforms necessary for further macroeconomic development.

Individual countries are following a similar path: Republic of Korea, Germany and the United States, for example, are promoting the greening of the construction sector (*IISD*, on the article: *COVID-19 Stimulus Spending for Green Construction Means Building Back Better, 2020*). Others are using state funds allocated for COVID-19 recovery to build more resilient healthcare systems (*WHO,* on the article: *WHO and European Investment Bank strengthen efforts to combat COVID-19 and build resilient health systems to face future pandemics, 2020*) or to reduce their dependence on imports of essential goods. This implies that the funds governments are allocating to mitigate the effects of the pandemic have become more conditional, and could eventually lead to a **healthier, more resilient and productive economy**.

For this to become a reality, however, governments must restore their capacity to design, implement and enforce conditionality among the recipients of financial support.

6.8 - Innovation policies

Innovation policies can foster recovery from COVID-19 effects on the economy. Many companies have been forced due to containment measures to develop new business models and ways to organize production to survive in the short term and ensure long-term viability and growth.

Such changes may eventually benefit from the support of science, technology and innovation (STI) policies through grants, credit and tax breaks, among other instruments.

Yet as innovation features as one of the key drivers of economic growth, it is expected that STI policies should also contribute to fostering economic recovery in the medium- to long run by enabling economic restructuring, productive diversification and entry/repositioning in what is expected to be a changed landscape of global value chains once the pandemic has been controlled (*Santiago et al. 2020*).

CHAPTER 7 – REVIEW ON SECTORS IMPLICATIONS OF CORONAVIRUS PANDEMIC

In an attempt to understand the turmoil effect on the economy, it can be summarized the effect of COVID-19 on individual aspects of the world economy, focusing on **primary sectors**, which include industries involved in the extraction of raw materials, **secondary sectors** involved in the production of finished products and **tertiary sectors** including all service provision industries.

7.1 - Primary sectors

1) AGRICULTURE:
A global crash in demand from hotels and restaurants has seen prices of agricultural commodities drop by 20%. Countries around the world have imposed a number of protective measures to contain the exponentially increasing spread, including social distancing, avoiding unnecessary travel, and a ban on congregations. Advice on self-isolation upon contact with suspected carriers of the virus is likely to impact the number of available inspectors and delivery staff critical to ensuring verification and transportation of products.
This will have pronounced implications for perishable goods such as meat and vegetables. Furthermore, markets have gone a step further by shutting down floor trading which has impacted the ability to exchange commodities.
'Panic buying' is further complicating shortages beyond supermarket shelves. The American Veterinary Medical Association (AVMA) have expressed concern over low levels of animal pharmaceuticals from several large drug suppliers.

2) PETROLEUM AND OIL:
During a meeting at the Organization of the Petroleum Exporting Countries (OPEC) in Vienna on March 6th, a refusal by Russia to slash oil production triggered Saudi Arabia to retaliate with extraordinary discounts to buyers and a threat to pump more crude. Saudi, regarded as the de facto leader of OPEC, increased its provision of oil by 25% compared to February – taking production volume to an unprecedented level. This caused the steepest one-day price crash seen in nearly 30 years – On March 23rd, Brent Crude dropped by 24% from $34/barrel to stand at $25.70. Although a deceleration in the number of COVID-related deaths has caused some stabilization of oil prices, there is still much uncertainty. On the background of a viral outbreak already dampening the demand for oil, this oil-price war is predicted to have grave implications for the global economy.

In more ordinary times, cheap oil may have functioned as an advantage for economies, but savings on petrol are unlikely to be redirected into more spending as populations are instructed to practice social distancing and the working class are uncertain about job security. Furthermore, any increase to consumer activity is likely to be outweighed by damage caused to populations reliant on revenue from other forms of energy. Economic modelling from Imperial College's Centre for Climate Finance and Investment has suggested 'Carbon Dividends', with a £50/tons of CO2 tax could be channeled into UK households in order to stimulate consumer spending whilst keeping oil prices at the same level as February 2020. However, this relies on turbulence between Saudi Arabia and Russia, thus should not be considered sustainable for the long-term.

7.2 - Secondary sectors

1) MANUFACTURING INDUSTRY:

A survey conducted by the British Plastics Federation (BPF) explored how COVID-19 is impacting manufacturing businesses in the United Kingdom (UK).
Over 80% of respondents anticipated a decline in turnover over the next 2 quarters, with 98% admitting concern about the negative impact of the pandemic on business operations. Importation issues and staffing deficiencies stood out as the key concerns for businesses due to disruption to supply chains and self-isolation policies. Indeed, for many roles within a manufacturing company, 'working from home' is not a viable option. As the UK is adopting similar protective measures to the rest of the world, and due to the global overlap of supply chains, we can expect these anxieties to transcend borders.
The Chemical Industry is predicted to reduce its global production by 1.2%, the worst growth for the sector since the 2008 financial crash. Major chemical manufacturing companies such as BASF who were in the process of upscaling production in China have had to delay their activities, contributing to a slowdown in predicted growth.

7.3 - Tertiary sectors

1) EDUCATION:

COVID-19 has affected all levels of the education system, from pre-school to tertiary education.

Different countries have introduced various policies, ranging from complete closure in Germany and Italy to targeted closure in the United Kingdom for all but the children of workers in key industries. Additionally, over 100 countries have imposed a nationwide closure of educational facilities.
UNESCO estimates that close to 900 million learners have been affected by the closure of educational institutions (**Fig. 1.7**).

Figure 1.7: Global Impact of COVID-19 on school closures

Fig. 1. Global impact of COVID-19 on school closures. Figure produced by UNESCO [21].

Source: *UNESCO*

Whilst the intention of these closures is to prevent spread of the virus within institutions and prevent carriage to vulnerable individuals, these closures have had widespread socioeconomic implications.
COVID-19 has had an impact on social mobility whereby schools are no longer able to provide free school meals for children from low-income families, social isolation and school dropout rates. It has also had a significant impact on childcare costs for families with young children.
Additionally, there exists a wide disparity amongst populations with a higher income who are able to access technology that can ensure education continues digitally during social isolation.
In Dubai, 13.900 people have signed a petition to decrease independent school fees by 30%, as parents struggle to source these funds amidst recent pay cuts reaching as high as 50%, and high costs of living. Furthermore, parents are being asked to provide schools with confidential information such as bank statements and profit and loss company statements.
The impact of long-term school closure is yet to be seen.
However, a study by *Chen et al.* of a one-week closure of schools in Taiwan during the 2009 H1N1 outbreak found that 27% of families could not go to work with 18% losing income as a direct result.

A study by the Brookings Institution, modelling closures in major US cities and nationwide, suggested that there would be a median cost of $142 per student per week. This led to an estimate that a four-week closure of New York City would result in an economic cost of $1.1bn and that a nationwide closure for 12 weeks would cost 1% of GDP. Furthermore, this study looks at the direct impact of closures on the children of healthcare workers with an estimated 6–19% of healthcare workforce hours lost. An estimate in the UK suggested that protracted closures could cost 3% of UK GDP.

COVID-19 has also influenced the tertiary sector.
As well as the impact on undergraduate education, the most significant impact is on the postgraduate research community with research into many non-COVID related topics being placed on hold. In UK, the national funding body for health research has halted all non-COVID research in order to allow clinically trained staff who are normally on academic secondments to return to the frontline.
In the US, similar action has been taken by the National Institute for Health to shut down all non-critical research in order to free up staff and resources for 'mission-critical' research.
Outside of the healthcare research setting, several institutions have put research in fields such as the humanities and social sciences on hold with Harvard University closing all laboratories in the Faculty of Arts and Sciences.
Additionally, concerns have been raised regarding the number of scientific conferences that have been cancelled or postponed. These conferences are the key to scientific research in many disciplines, allowing dissemination of research as well as providing networking opportunities for collaboration and job-seeking. Many conferences have moved online, however these 'virtual conferences' are often not as amenable to networking and informal means of scientific communication.

2) FINANCE INDUSTRY:
COVID-19 has affected communities, businesses and organizations globally, inadvertently affecting the financial markets and the global economy. Uncoordinated governmental responses and lockdowns have led to a disruption in the supply chain. In China, lockdown restrictions significantly reduced the production of goods from factories, while quarantine and self-isolation policies decreased consumption, demand and utilization of products and services.
As COVID-19 has progressed to affect the rest of the world, China will begin to recover faster than the rest of the countries, strengthening its trade negotiating power against the US.

In fact, Chinese companies will be in the advantageous position to acquire their western counterparts, which are greatly dependent and will be inevitably affected by the stock market.

In addition to the disruption in the supply chain, the capital market sector has also been affected.
In the US, the S&P 500, a stock market index that measures the stock performance of 500 large companies on the US stock exchange, the Dow Jones Industrial Average and the Nasdaq fell dramatically until the US government secured the Coronavirus Aid, Relief, and Economic Security (CARES) Act, with the indexes raising by 7.3%, 7.73% and 7.33% respectively.
Furthermore, 10-year US Treasury bond yields have dropped to 0.67%.
In the Asian markets, the same pattern followed with China's Shanghai Composite, Hong Kong's Hang Seng and South Korea's KOSPI, initially dropping then followed by a rise in stocks after governmental support.
Japan's Nikkei was up 2.01%. Europe's bond yields mostly declined, reaching market stress hit levels faced in the eurozone crisis of 2011–2012.
Germany's DAX, the UK's FTSE 100 and the Euro Stoxx 50 were all down on March 23rd but rose significantly after the EU's rescue package was agreed.
Gold dropped against the dollar by 0.65%. The decline in global stock markets has festered a volatile environment with critical liquidity levels.
To combat these effects, Central banks globally have intervened to ensure liquidity is maintained and mitigate the economic shock, with several leaders embarking on a 'Whatever it takes' approach.

2.1) EUROPEAN RESPONSE:
Europe has pledged a €1.7tn rescue package in an attempt to dampen the economic effects of COVID-19 on the eurozone with contributions from all member states, the UK, as well as countries in the area which do not for part of the European Union. The European Central Bank (ECB) has announced a €750bn asset-purchase program with an aim of stabilizing and strengthening the Euro through the pandemic. Moreover, the European Commission has collated a €25bn investment fund for the cause and has agreed to a more relaxed policy on budget rules to encourage public spending and the support of affected businesses by their corresponding government. In Germany, the state development bank (KfW) is to provide €500bn in loans to aid companies affected by the pandemic, dubbed the 'biggest post-war aid package'.

The Kurzarbeitergeld, a subsidized scheme by the German Federal parliament (the Bundenstag), will look to compensate employees who fall ill or are unable to work due to the virus. France, Spain and Italy have also promised €345bn, €200bn and €25bn respectively, to help support businesses.

2.2) UK RESPONSE:

In the UK, Chancellor Rishi Sunak announced a £330bn package of emergency loan guarantees to help those in financial difficulty.

A further £20bn of fiscal support has been issued in attempts to save UK businesses. The package of measures includes:

- A Coronavirus Job Retention Scheme;
- Deferring VAT and Income Tax payments;
- A Statutory Sick Pay relief package for SMEs (Small and Medium sized Enterprises);
- A 12-month business rates holiday for all retail, hospitality, leisure and nursery businesses in England;
- Small business grant funding of £10,000 for all business in receipt of small business rate relief or rural rate relief;
- Grant funding of £25,000 for retail, hospitality and leisure businesses with property with a ratable value between £15,000 and £51,000;
- The Coronavirus Business Interruption Loan Scheme offering loans of up to £5 million for SMEs through the British Business Bank;
- A new lending facility from the Bank of England to help support liquidity among larger firms, helping them bridge coronavirus disruption to their cash flows through loans;
- The HMRC Time To Pay Scheme.

The Bank of England has cut interest rates to 0.1 pc, an unprecedented response, in an attempt to dampen the effects of COVID-19 as well as an attempt to maintain the confidence of unnerved investors.

On the March 20, 2020, the Chancellor announced that the government will pay up to 80% of the salary of staff (up to £2500 per month) who are kept on by their employer and has vowed to support approximately 3.8 million self-employed individuals with a £9bn support scheme.

2.3) US RESPONSE:

The US Federal Reserve has recently decreased interest rates by 0.5% in an attempt to soften the blow of the virus on the US Economy.

On March 23rd, it also announced that it would further aid the market by purchasing $125bn in bonds.

It will also offer a $300bn lending program for Main Street businesses as well as ensure that Asset Backed Loan facility which was used in 2008–2009 would be restarted. The Trump administration has managed to secure on the 27th March a $2 trillion 'virus-aid package'- the CARES Act, to support the economy through these times. This bill is to cover:

- $1200 to be given to every adult American with an income less than $75,000 or couples less than $150,000;
- $500 for every child under the age of 17;
- Increase unemployment compensation by 600$ per week, increase unemployment benefit support by 13 months and extend eligibility to the self-employed and independent contractors;
- $500bn in loans and loan guarantees to be issued by the US Treasury Department to small and large businesses. Businesses who receive such aid are obligated to keep 90% of their employees until September 30, must pay their loans back within five years and are prohibited to issue dividends for up to a year after the full amount of their loan is repaid;
- $377bn to provide small businesses with loans and grants, $10bn for emergency grants and $17bn will also be made available to enable deferral of existing payments;
- Student loan payments to be deferred until 30th September without penalty charges;
- Ban on foreclosures of federally backed mortgages until mid-May;
- Ban on evictions of tenants in federal housing program for four months;
- $25bn in food assistance;
- $100bn for healthcare;
- $45bn to be directed to the Disaster Relief Fund (which includes the supply of protective equipment);
- $29bn in grants and $29bn in loans, loan guarantees, excise and fuel tax relief;
- $17bn towards national security;
- $14bn to farmers.

2.4) CHINA AND JAPAN RESPONSE:

China and Japan took similar action with the People's Bank of China (PBoC) and the Bank of Japan (BoJ) providing the equivalent of $240bn and $43bn to maintain bank liquidity, respectively. Leaders from the G20 expect recovery from the economic crisis to take the form of a 'V' shaped curve, with a sharp and short-lived dip, followed by a rapid recovery and economic growth.

3) HEALTHCARE AND THE PHARMACEUTICAL INDUSTRY:

3.1) HEALTHCARE:

The risk to healthcare workers is one of the greatest vulnerabilities of healthcare systems worldwide. Considering most healthcare workers are unable to work remotely, strategies including the early deployment of viral testing for asymptomatic and/or frontline healthcare staff is imperative.
High healthcare costs, shortages of protective equipment including face masks, and low numbers of ICU beds and ventilators have ultimately exposed weaknesses in the delivery of patient care. In the US, there is concern regarding uninsured individuals, who may work in jobs predisposing them to viral infection which may lead to significant financial consequences in the event of illness.

3.2) PHARMACEUTICAL INDUSTRY:

Profound changes to the dynamics of healthcare are likely to ensue, leading to massive investment into disease prevention infrastructure, and the accelerated digital transformation of healthcare delivery. In the US, active pharmaceutical ingredients are imported largely from India (18%) and the EU (26%), while China accounts for 13%, that is also the biggest exporter of medical devices to the US, accounting for 39.3%. Production slow-downs and limitations in supply would inadvertently lead to revenue loss. In the UK, AstraZeneca have indicated that COVID-19 is likely to affect its 2020 revenue growth.
Conversely, opportunities for companies engaged in vaccine and drug development have simultaneously emerged, with US-based companies including Johnson & Johnson, Vir Biotechnology, Novavax and NanoViricides having announced collaborative plans to develop a viral vaccine. A Phase 1 clinical trial evaluating an investigational COVID-19 vaccine is currently underway and will enroll 45 healthy adult volunteers ages 18–55 years over approximately 6 weeks.

4) HOSPITALITY, TOURISM AND AVIATION:

4.1) HOSPITALITY:

The hospitality and travel industry have perhaps been most hard-hit, with hourly workers facing potentially devastating hardships. For example, Marriott International (approximately 174,000 employees) is poised to place tens of thousands of workers on furlough. Also, Hilton Worldwide has also notified lenders on March 5, 2020 that they would be borrowing a precautionary $1.75bn under a revolving loan to preserve money and to maintain flexibility “in light of uncertainty in the global markets”.

Hotel industry revenue per available room in the US fell 11.6% for the week ending March 7, 2020, whilst in China occupancy rates fell 89% by the end of January 2020. Other US hotel companies are seeking approximately $150bn in direct aid for employees due to an unprecedented fall in demand, along with an estimated $1.5bn loss since mid-February. Since March 1, 2020, hotel occupancy in Germany decreased by over 36%. Italian cities, including Rome, have been inadvertently affected with a current occupancy rate of 6%, whilst London remains the most stable with an occupancy rate of approximately 47%.

4.2) TOURISM:

The tourism sector is currently one of the hardest-hit by the outbreak of COVID-19, with impacts on both travel supply and demand. As a direct consequence, The World Travel and Tourism Council has warned that 50 million jobs in the global travel and tourism sector may be at risk.

In Europe, the European Tourism Manifesto alliance, encompassing over 50 European public and private organizations from travel and tourism sector, have highlighted the need to implement urgent measures. These include temporary state aid for the tourism and travel sector from national governments as well as fast and easy access to short and medium-term loans to overcome liquidity shortages, including funds made available by the EU through the Corona Response Investment Initiative, and fiscal relief. The alliance has also called for the launch of the European Unemployment Reinsurance Scheme.

Internationally, Vietnam received approximately 1.45 million Chinese visitors in the first quarter of 2019, dropping by 644.000 in January of 2020, and it is estimated that Vietnam's tourist sector will suffer a $5bn loss should the COVID-19 pandemic extend into the second quarter of 2020.

Moreover, the Philippines is projecting a 0.3–0.7% slowdown in the country's full year GDP. In US, restriction of all non-essential travel, US-Canada border closure, and the suspension of visa services may accelerate disruption of the American economy. In UK, many parks are now closing to further enforce social distancing as they have in Italy.

4.3) AVIATION:

The travel industry is grappling with an unprecedented wave of cancellations and a significant drop in demand, due to strict governmental instructions to implement social distancing and the restriction of unnecessary travel.

Globally, border closures are on the rise. In the US, all foreign nationals from China, Iran and certain EU countries are barred from entering.

This ban includes anyone who visited these countries within the 14 days prior to their US trip. The UK Foreign Office has also advised UK nationals against all but essential international travel.
In Europe, the president of the EU commission has proposed all non-essential travel from outside the EU be suspended for 30 days.
Travel suspensions have also been implemented across Asia and Africa.
In light of these events, Malaysia Airport reported a 30% decline in international passenger traffic for February. More recently, Airlines for America sought a government bailout encompassing $25bn in grants, $25bn in loans, and significant tax relief to ensure survival. UK airlines have also called for an immediate £7.5bn emergency bailout to prevent a widespread shutdown. Ministers in the Netherlands have also reported implementing strategies to ensure the continued operation of Air France-KLM and Amsterdam's Schiphol airport, whilst the Italian Government have been said to be close to taking full control of ailing airline Alitalia.

5) REAL ESTATE AND HOUSING SECTOR:
At an individual level, social distancing precautions have reduced house views, a key part of the selling process, and both buyers and sellers are having to reconsider their plans. Increasingly, sellers are looking for reassurance regarding the health of potential buyers coming to view properties.
Some brokers are offering house tours via Skype and FaceTime to minimize the risk of infection propagation, and, in United States, are also asking potential buyers to preregister for viewings in order to gauge their level of interest and likelihood of purchase. Additionally, thousands of workers around the world have been made redundant or have been placed on temporary, unpaid leave of absence. Inevitably this will have a significant impact on individuals' abilities to pay rent, mortgages and various household expenditures.
To tackle this, part of the £350bn lifeline the UK government has released will be used to allow mortgage lenders to offer a three-month mortgage holiday to those in financial difficulty. The government has also recommended that buyers and lenders delay negotiations during the lockdown, bringing transactions to a halt. Many are worried that we will face another financial crisis, similar to that of 2008 that will impact confidence in real estate.
Banks within the UK have begun to take precautions; high street lenders require up to 40% deposits for a new mortgage to be approved.

6) SPORTS INDUSTRY:

COVID-19 is having a substantial impact on sporting schedules as some of the world's largest sporting events come to view in 2020. Football's much anticipated Euro 2020 tournament has been postponed for 12 months, International Olympic committee was committed to staging the Tokyo 2020 Olympics this summer without delay, but they have made the decision to postpone the games to 2021, supported by athletes and their respective nations.

These are but a few examples; golf, tennis, athletics, basketball, rugby, cycling, boxing, snooker and ice-skating fixtures have all faced cancellations and delays in an attempt to curb the spread of disease.

7) INFORMATION TECHNOLOGY, MEDIA, RESEARCH & DEVELOPMENT:

With the WHO raising COVD-19's status to a pandemic, 35 companies and academic institutions are racing to develop an effective vac- cine.

Four potential vaccines are currently being tested on animals with the biotech firm Moderna entering human trials imminently.

The Coalition for Epidemic Preparedness Innovations (CEPI), is leading various efforts to finance and coordinate COVID-19 vaccine development. They have announced a $4.4m partnership fund with Novavax and University of Oxford to develop a viable solution.

The Gates Foundation, Wellcome and Mastercard have also committed $125m to find new treatments for COVID-19.

Social distancing precautions are paramount to the containment effort. Additionally, COVID-19 has left several hospitals in turmoil, having reached maximal capacity. As a result, various countries are turning towards technological solutions, to care for patients and at the same time, minimize the risk of person to person transmission.

In various cities across China, tele-response bots powered by fifth-generation wireless networks are being utilized that allow health care staff to communicate with patients, monitor their health and deliver medical supplies, even drones that deliver medication and work-from-home apps are also being adopted. Automation of services has been a major goal for China, and COVID-19 has helped to accelerate uptake and has taken them one step closer to this goal [94].

The demand for respiratory ventilators has skyrocketed due to the outbreak of the virus. However, it is clear that the current supply across the United States and Europe does not meet demand. It is estimated that the USA has 160.000 ventilators, and this is 580.000 short of what would be required in a severe pandemic.

Governments around the world are attempting to buy ventilators, as in the United Kingdom, the prime minister has asked companies such as Rolls Royce and Dyson to divert their manufacturing power to medical supplies.
However, industry leaders have stated that this is easier said than done as many of these companies do not produce medical equipment such as ventilators, and, in addition to this, production of ventilators requires strict regulation and testing to ensure their safety which can be a lengthy process.

8) FOOD SECTOR:

The food sector, including food distribution and retailing, has been put under strain as a result of people panic-buying and stockpiling food.
This has led to increased concerns about shortages of food products such as long-life milk, pasta, rice and tinned vegetables.
Panic-buying has resulted in an increase of £1bn worth of food in UK homes.
This high demand on food products has also affected online food delivery, as companies are struggling with excessive bookings, with deliveries arriving late or not at all. Moreover, food banks have also been affected by panic-buying and food stockpiling as donations have reduced, and concerns about food running out also means that vulnerable populations who cannot afford to stockpile, may not find food. In response to these concerns, UK government has made efforts to provide certain populations with food parcels and free meals to collect and take home, including high-risk vulnerable individuals such as the elderly who have no support network, and school children of low-income families.
The UK government has also reduced restrictions on delivery hours for retailers in order to allow stores to restock with basic food products.
Furthermore, the British Retail Consortium (BRC) has reassured the public that despite low inventory of certain food products in local stores, there are no such shortages of food. Similar statements have been made by the US Food and Drug Administration (FDA). In addition, despite reassurance by the government, stores have made drastic changes by restricting the amount of each product that an individual can buy, providing more than 30.000 new jobs to meet the high pressure of restocking shelves, and setting special shopping hours for the elderly, vulnerable populations and NHS stuff.
Further changes being implemented include a decrease in the range of products being made by manufacturers, with the aim of focusing on products that are in greater need. Independent supermarkets have also been affected by the high demand on food products.

Measures implemented by these local stores include free delivery of food products to customers to avoid panic-buying, putting restrictions on the number of customers allowed in at any given time to avoid overcrowding, and expanding on the number of suppliers whom they buy their products from to avoid food shortage. On the other hand, restaurants and cafes have been forced to close, and many of these stores are at risk of permanent closure and many of their employees have lost their jobs.

In conclusion, with fears of a new recession and financial collapse, times like these call for resilient and strong leadership in healthcare, business, government and wider society.
Immediate relief measures need to be implemented and adjusted for those that may fall through the cracks.
Medium- and longer-term planning is needed to re-balance and re-energize the economy following this crisis.
A broad socioeconomic development plan including sector by sector plans and an ecosystem that encourages entrepreneurship is also needed so that those with robust and sustainable business models can flourish.
It is prudent that governments and financial institutions constantly re-assess and re-evaluate the state of play and ensure that the ‘whatever it takes’ promise is truly delivered.

CHAPTER 8 - COVID-ABS TO SIMULATE HEALTH AND ECONOMIC EFFECTS OF SOCIAL DISTANCING INTERVENTIONS

Modeling and simulating the COVID-19 epidemic are a relevant and helpful way to understand the spread of the disease and the epidemiological effects of social distancing interventions.
For this purpose, many studies in the literature have developed or adapted equation-based models to simulate the COVID-19 epidemic, using the **Susceptible-Infected-Recovered (SIR)** model or the **Susceptible-Exposed-Infected-Recovered (SEIR)** model to characterize the dynamics.
Even **Agent-based Model (ABM)** is used to simulate the dynamics of the COVID-19 epidemic and the epidemiological and economic effects of social distancing interventions.
The proposed one aims to emulate a closed society living on a shared environment, consisting of agents that represent people, houses, businesses, the government and the healthcare system, each one with specific attributes and behaviors. A society living over a territory is a complex and dynamic system, that have many interacting variables, present nonlinear behavior and their properties evolve over time.
Agent-Based Simulations (ABS) are a good choice to simulate such systems, due to their simplicity of implementation and accurate results when compared with real data. Its main goal is to simulate the temporal evolution of the system, storing statistics derived from the internal states of the agents in each iteration and the global behaviors that emerge due to the interactions between the agents over the iterations. This approach allows the simulation of systems with intricate nonlinear relationships, complex conditions and restrictions that may be hard to describe mathematically. In fact, it is much easier to simulate these scenarios with an agent-based model.
The ABM proposed here not only simulates the epidemic dynamics but also models the economy in this society of agents, which can help to estimate the economic impact under different types of interventions and becomes a useful tool to assist politicians and health authorities in planning their actions against the COVID-19 epidemic.

RELATED WORK:

Some works used the SIR model to characterize the COVID-19 dynamics.
However, more precise simulations usually used an approach based on the SEIR model, given that this disease has a known incubation period.

Some authors added new states to refine the model, for instance, super-spreaders or isolated, hospitalized, and asymptomatic infected.
Equation-based models to simulate the epidemic represent the majority among those proposed in the literature, but some papers with agent-based models have also been proposed for it. For example, in a report released by *Ferguson et al*., an individual-based simulation model was used to explore scenarios for COVID-19 in Great Britain and USA and the impact of non-pharmaceutical interventions on the healthcare demand. Even another by *Bossert et al.* developed an ABM combining socio-economic and traffic data to analyze COVID-19 spreading in a South Africa city under social isolation scenarios.
The prediction suggests that lockdown strategy is useful to mitigate the disease, and another study using an ABM also analyzed several scenarios and highlighted that with 90% of the population in isolation, it is possible to control the disease within 13 weeks when joined with effective case isolation and international travel restrictions, considering the Australian context.

An appealing characteristic of agent-based modeling is the easiness to simulate different scenarios. For instance, the scenario that considers universal use of masks integrated with social distance is the recommended one to control the pandemic according to *Braun et al. and Kai et al.*
Given the flexibility of the agent-based approach, previous works have employed this method to simulate specific topics in the COVID-19 context, such as testing policies, strategies for reopening public buildings, hypothetical effective treatments, and a spatio-temporal strategy for vaccination.
Few works in the literature used agent-based models to simulate the economic impacts of the COVID-19. For instance, *Inoue and Todo* quantified that a possible one-month lockdown in Tokyo would lead to a total production loss of 5.3% in Japanese annual gross domestic product (GDP). *Dignum et al.* proposed a tool to analyze the health, social, and economic impacts of the pandemic when the government implements a number of interventions, such as closing schools, requiring that employees work at home, and providing subsidy for the population.

In this work it is used a SEIR agent-based model to simulate the health and economic impacts of the COVID-19 epidemic, and perform analysis to seven possible scenarios:

1) Do nothing;
2) Lockdown;
3) Conditional lockdown;

4) Vertical isolation;
5) Partial isolation;
6) Use of face masks;
7) Use of face masks together with 50% of social isolation.

The data are from Brazil for all scenarios considered.

COVID-ABS: PROPOSED AGENT-BASED SYSTEM MODELING

The agent-based approach aims to emulate a closed society living on a shared finite environment, composed of humans, which are organized in families, business and government, which interact with each other.

The agents, their attributes and possible actions are described in **Table 1.8.**

Table 1
Types of agents and their attributes and actions.

A1: Person	
Description	*A1* is the main type of agent. Its dynamic position varies according to the environment and may be associated with *A2*, or not (homeless) and *A3*, or not (unemployed).
Attributes	Position (dynamic), Age, House (*A2*), Employer (*A3*), Epidemiological status, Infection status, Wealth, Income and Social Stratum
Actions	Walk freely (daily), Go home (daily), Go to work (daily), Personal contact (hourly), Business contact (hourly), Go to the hospital
A2: Houses	
Description	*A2* represent the families. They share a house and financial bills.
Attributes	Position (static), Social stratum, Housemates (group of *A1*), Wealth, Incomes and Expenses
Actions	Homemate check-in (daily), Accounting (monthly)
A3: Business	
Description	*A3* are the economical agents, e.g. industries, shops or markets. It interacts with *A1* by paying a salary or selling a product.
Attributes	Position (static), Social stratum, Employees (group of *A1*), Wealth, Incomes and Expenses
Actions	Accounting (monthly), Business contact (hourly)
A4: Government	
Description	*A4* is a singleton agent that receives taxes from *A2* and *A3*, provide funds to *A5* and insurance for homeless and unemployed *A1*.
Attributes	Position (static), Wealth
Actions	Accounting (monthly)
A5: Healthcare System	
Description	*A5* is also a singleton, which represents the health system that ideally should be able to serve the entire population.
Attributes	Position (static), Wealth

In the model, T represents the number of iterations.

The model takes an input parameter set P and produces a response Yt (observable variables), related to epidemiological or economic effects of the pandemic. Its internal state Ot (t = 1 . . . T) consists of the union of the internal states of the agents θti, where i=1...n and n are the number of agents, such that Ot = Ui^n=1 θt^i. The model is described in **Algorithm 1.8:**

Algorithm 1 General procedure of the proposed agent-based approach.

Require: P the parameter set, T the number of iterations
$\Theta_0 \leftarrow$ `initialize`(P)
for $t \leftarrow 1$ to T **do**
  for all agent $a_i \in \Theta_t$ **do**
    $\theta_t^i \leftarrow a_i$.`execute_actions`$(t, P, \Theta_t)$
    if type of $a_i = A1$ **then**
      for all agent $a_j \in \Theta_t | i \neq j$ **do**
        if distance$(a_i, a_j) \leq \delta$ **then**
          a_i.`contact`(a_j)
        end if
      end for
    end if
  end for
  $Y_t \leftarrow$ `summarize`(Θ_t)
  $\Theta_{t+1} \leftarrow \bigcup_{i=1}^{n} \theta_t^i$
end for

The initialization of internal states in line 1 creates the agents, the simulation dynamics starts in line 2, and depends on the type of the agent, the parameter P and the current iteration t (discrete time).
Each type of agent has its own set of actions in different time frames (hourly, daily, weekly or monthly). At each iteration, it checks if there was contact between any pair of agents. A contact happens when the distance between any two agents is less than or equal to a threshold δ defined in P.
The contact can be **epidemiological (if the agents are of type A1) or economical (A1 and A3).**

PARAMETER ESTIMATION

Table 2
Definitions of the parameters of the proposed ABS model.

Variable	Domain/ Unit	Current value	References and Observations
Social and Demographic			
w_1 – Height	$\mathbb{N}^*$	500	Defined empirically. Each unit corresponds to 7 m.
w_2 – Width	$\mathbb{N}^*$	500	Defined empirically. Each unit corresponds to 7 m.
w_3 – Population size	$\mathbb{N}^*$/people	300	Defined empirically.
w_4 – Age	[0, 100]	$\beta(2, 4)$	[43]
w_5 – Average family size	$\mathbb{N}^*$/people	3	[44]
w_6 – Mobility	$\mathbb{N}^*$	10	Defined empirically. Each unit corresponds to 7 m.
w_7 – Homeless rate	[0, 1]	0.0005	[45]
Epidemiological			
β_1 – Contagion distance	$\mathbb{R}^+$	1	[46]
β_2 – Contagion probability	[0, 1]	0.9	[46]
β_3 – Incubation time	$\mathbb{N}^*$/days	5 – 6	[47,48]
β_4 – Transmission time	$\mathbb{N}^*$/days	8 – 10	[49]
β_5 – Recovering time	$\mathbb{N}^*$/days	28	[50]
β_6 – Hospitalization rate per age	[0, 1]	Table 6	[46]
β_7 – Severe cases rate per age	[0, 1]	Table 6	[46]
β_8 – Death rate per age	[0, 1]	Table 6	[46]
β_9 – % initial infected	[0, 1]	0.01	Defined by the authors.
β_{10} – % initial immune	[0, 1]	0.01	Defined by the authors.
β_{11} – Critical limit of the Health System	[0, 1]	0.05	The proportion of ICU beds to the population
Economical			
γ_1 – Income distribution		Table 4	[51,52]
γ_2 – Proportion of businesses	$\mathbb{R}^+$	0.01875	Considering the number of businesses per 100k inhabitants [53]
γ_3 – Total GDP	$\mathbb{R}^+$/R$	1.000.000,00	Defined by the authors.
γ_4 – Public GPD rate	[0, 1]	0.01	Defined by the authors.
γ_5 – Business GPD rate	[0, 1]	0.05	Defined by the authors.
γ_6 – Personal GPD	[0, 1]	0.04	$\gamma_6 = 1 - \gamma_4 - \gamma_5$
γ_7 – Minimum income	$\mathbb{R}^+$/R$	900,00	
γ_8 – Minimum expenses	$\mathbb{R}^+$/R$	600,00	
γ_9 – Unemployment rate	[0, 1]	0.12	[54]
γ_{10} – Proportion of informal businesses	[0, 1]	0.40	Informal economy [54,55]
γ_{11} – EAP age group			16 < EAP < 65

Table 3
Response variables.

Variable	Description
Epidemiological	
S_t	Percentage of Susceptible agents in population
I_t	Percentage of Infected agents in population
I_t^A	Percentage of Infected Asymptomatic agents in population
I_t^H	Percentage of Infected Hospitalized agents in population
I_t^S	Percentage of Infected Severe agents in population
R_t	Percentage of Recovered and Immune agents in population
D_t	Percentage of Dead agents in population
Economical	
W_{St}^{A1}	Percentage of Gross Domestic Product owned by the people (A1 agents) at time t under scenario S
W_{St}^{A3}	Percentage of Gross Domestic Product owned by businesses (A3 agents) at time t under scenario S
W_{St}^{A4}	Percentage of Gross Domestic Product owned by government (A4 agent) at time t under scenario S

Some parameters in **Table 2.8** were empirically estimated, in a way that the epidemiological response variables present in **Table 3.8** correspond to those produced by a SEIR model.

For that purpose, the Epidemic Calculator was employed – this is an open-source SEIR implementation and visual tool for epidemic simulations.
The initial **percentage of infected (β9)** and **immune (β10) agents** were chosen in order to represent the complete epidemic dynamics.
The **population size parameter, α3**, is particularly concerning because it affects the execution time of the simulation. On the other hand, the **Population density**, defined as **α3/(α1α2)**, follows the population density of the area under study which is 24 people per km2. The **mobility parameter α6** was empirically estimated as the average range that a person walks randomly in his free time.
The **Total GDP**, parameter **γ3**, and the **percentage rates by kind of agent (γ4, γ5 and γ6)** are abstractions of closed local economy. The **minimum income γ7** represents the minimum net salary, the nominal income after taxes, and the **minimum expense γ8** represents the approximate market value of a basic needs' grocery pack.

INITIALIZATION
The simulation is performed in a squared bi-dimensional environment shared by all types of agents. Ai agents, i ∈ {2, 3, 4, 5}, are randomly initialized inside this environment given by **Eq. 1.8** below:

$$Ai_{pos} = \begin{cases} x \sim \mathcal{U}(0, \alpha_1) \\ y \sim \mathcal{U}(0, \alpha_2) \end{cases}$$

where **U (a, b)** is a **sample from a uniform distribution in the interval [a, b).**
Agents A1 are initialized in their A2 location, following Eq. 2 below, where **σk** is the **variability of the position inside the house.**
For homeless agents, **Eq. 2.8** is used.

$$A1_{pos} = A2_{pos} + \mathcal{N}(0, \sigma_k)$$

where **N (μ, σ)** is a **sample from a normal distribution with mean μ and standard deviation σ.**

The number of A1 agents is controlled by the **variable population size**, that is **|A1| = α3.** The **number of houses (A2 agents)** is calculated using **Eq. 3.8** below, considering the **average family size α5**:

$$|A2| = \left\lceil \frac{\alpha_3}{\alpha_5} \right\rceil$$

The number of A3 agents is calculated according to **Eq. 4.8** below, considering the **population size α3**, the **proportion of formal and informal businesses, γ2 and γ10, respectively**.

$$|A3| = \lceil \alpha_3 \gamma_2 + \alpha_3 \gamma_{10} \rceil$$

When a **person, A1** type, is created, it is assigned to a **randomly chosen house**, type **A2**, or it is considered homeless according to the **Homeless Rate, α7.** Parameter **γ9** defines the **probability of an A1 to be unemployed**.
If a person is employed and belongs to **Economical Active Population (EAP) (controlled by γ11)** an employer is randomly chosen among the available A3s.
A single instance of A4 and A5 agents are created.
The **age distribution of A1 agents** is given by **α4 parameter**, such as A1age ~ β(2, 5), where **β(a, b) is the beta distribution with shape parameters a, b**.
The **social stratum of A1, A2 and A3** is represented by the **income distribution γ1**, listed in the **Table 4.8**, meaning the **slice of the wealth** represented by the **GDP parameter γ3**. The social stratum of agents is sampled such that Ai*stratum* ~ U(1,5), for i = {1,2,3}. The **total wealth of the simulation**, represented by **γ3**, is shared among agents, according to **public, business and personal percentages** defined by **γ4, γ5 and γ6**. After the creation of all agents the simulation model starts its iteration loop, which represents the time dynamics.

Table 4
Income distribution (γ_1). Adapted from World Bank [52].

Quintile	Social Stratum	% of GDP Share	Cummulative % of GDP Share
Q1	Most Poor	3.62	3.62
Q2	Poor	7.88	11.50
Q3	Working Class	12.62	24.17
Q4	Rich	19.71	43.88
Q5	Most Rich	56.12	100.00

SIMULATION DYNAMICS
Each iteration represents one hour when the agents are invoked to perform actions that depend on their type and behaviors, as shown in **Fig. 1.8** for A1 agents.

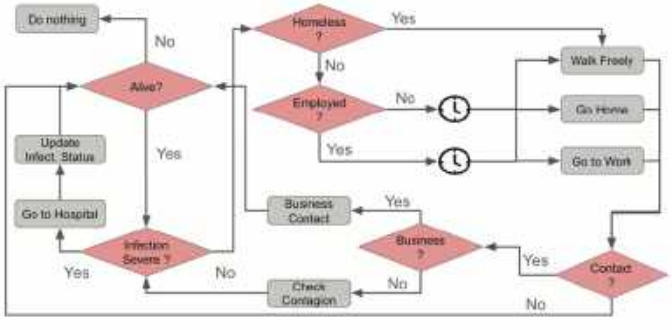


Fig. 1. A1 agent activity cycle.

During its movement, an A1 agent may get in the proximity with other A1, A2 or A3 agents.

A1 MOBILITY PATTERNS

The distribution of A1 agents' work, rest and leisure hours is shown in **Table 5.8** and it is based on the Universal Declaration of Human Rights.

Table 5
A1 agent movement routines considering a full day and different activities.

Start Time	End Time	Activity	Action
0	8	Rest	If *A1* is not homeless: Go home (Eq. (5)) Otherwise: Walk freely (Eq. (7))
8	12	Job	If *A1* is not unemployed: Go to work (Eq. (6)) Otherwise: Walk freely (Eq. (7))
12	14	Lunch	Walk Freely (Eq. (7))
14	18	Job	If *A1* is not unemployed: Go to work (Eq. (6)) Otherwise: Walk freely (Eq. (7))
18	0	Recreation	Walk freely (Eq. (7))

Basically, it is the standard deviation of a Gaussian distribution with average μ = 0, representing the variability of the movement amplitude of A1 in its free time or, in other words, how far the agent can walk from its actual position.

The actions "Go home", "Go to work" and "Walk freely" occur according to the **Eqs. 5.8, 6.8 and 7.8.** Besides these ordinary actions, all the agents that are infected and have infection severity equal to hospitalization or severe execute the "Go to hospital" action, according to the **Equation 8.8.**

All the dead agents have their positions set to zero.

$$A1_{pos} = A2_{pos} + \mathcal{N}(0, \sigma_k) \quad (5)$$

$$A1_{pos} = A3_{pos} + \mathcal{N}(0, \sigma_k) \quad (6)$$

$$A1_{pos} = A1_{pos} + \mathcal{N}(0, \alpha_6) \quad (7)$$

$$A1_{pos} = A5_{pos} + \mathcal{N}(0, \sigma_k) \quad (8)$$

where **σk = 0.01** is the **random noise variance for "Go to..." actions**, and the **mobility parameter α6** is the **random noise variance for "Walk freely" action**, representing the amplitude of movement the A1 agents have in their free time.

CONTAGION SPREADING

Following the SEIR model, in each simulation, there is an **initial percentage of infected and immune people (β9 and β10, respectively)**, and the remaining population consists of susceptible individuals.

There is also a Dead status, since part of the population dies due to the disease and its complications.

The possibility of contagion happens by the interaction of the agents by proximity or contact, so, the higher the mobility of a person, the greater the probability that he/she approaches an infected person and gets infected.
Each simulation considers a **contagion distance threshold β1**, which is the minimal distance that two agents have to be to occur the viral transmission, and a **probability of contagion β2** in case of contact.
Once an agent is infected, it can be in one of these sub-states:

a) asymptomatic, which includes mild symptoms without hospitalization;
b) hospitalization;
c) severe, used in cases of hospitalization in intensive care unit (ICU).

These states and their transitions are illustrated in **Fig. 2.8.**

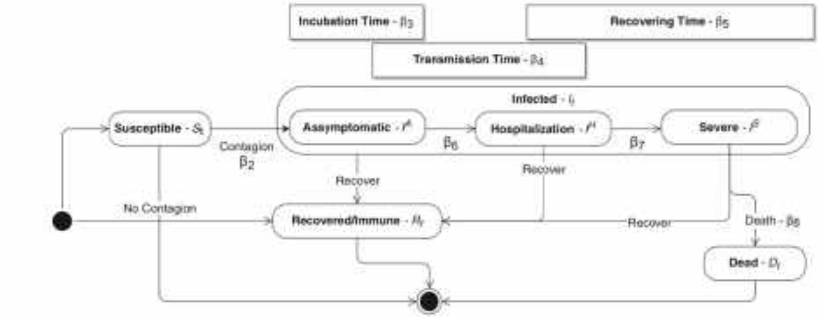


Fig. 2. Epidemiological and infection state diagram for A1 agents based in SEIR model, with the corresponding population response variables and parameters of their transition probabilities.

The **evolution of the medical condition** is stochastic and follows the probabilities summarized in **Table 6.8**, represented by the **parameters β6, β7 and β8, respectively**.

Table 6
Rates of medical conditions considering hospitalized (β_6) and severe (β_7) and death (β_8) cases grouped by age. Adapted from Ferguson et al. [6].

Age-group (years)	β_6 - % symptomatic cases requiring hospitalization	β_7 - % hospitalised cases requiring critical care	β_8 - Infection Fatality Ratio
0 - 9	0.100	5.000	0.002
10 - 19	0.300	5.000	0.006
20 - 29	1.200	5.000	0.030
30 - 39	3.200	5.000	0.080
40 - 49	4.900	6.300	0.150
50 - 59	10.200	12.200	0.600
60 - 69	16.600	27.400	2.200
70 - 79	24.300	43.200	5.100
80+	27.300	70.900	9.300

In each simulation, **limit β11** is considered, that represents the **percentage of the population that the healthcare system is capable to handle simultaneously.**
As a consequence, if the number of hospitalizations and severe cases increase above this limit, there are no beds in hospitals to manage the demand.

ECONOMIC TRANSACTIONS

The secondary goal of this study is to simulate the impact caused in the economy by the different types of mobility restrictions imposed by the authorities.

Fig. 3.8 shows the transactions by which agents exchange wealth in the simulation.

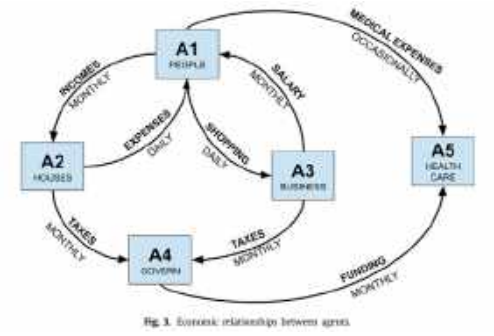


Fig. 3. Economic relationships between agents.

The **"business contact"** action happens hourly, when an A1 agent in its free time gets in contact with an A3 and occurs the transference of wealth from A1 to A3. These economic transactions are the most sensitive to the A1 agents' mobility (the more the agents move, the more they spend) and affects the A3 agent income. In pandemic times, that can happen in almost all scenarios, since the population tends to leave their houses just to buy essential items or to solve a problem which could not have been solved over the Internet.

The values exchanged in "business contact" depend on the social stratum of the A1 agents, and the higher the quintile the higher the spending following the wealth distribution γ1. In each day, the wealth of A2 and A3 agents is decreased by its minimal fixed expenses, proportional to the sum of the expenses of housemates and employees, respectively.

The **"accounting"** actions happen monthly for A2, A3 and A4 agents. Accounting is the payment of taxes from A2 and A3 agents to A4, and it represents the major income of A4. During accounting, A3 agents also pay salaries to their A1 employees determined in the initialization by the social stratum. Finally, A2 agents transfer money to a random A3 agent, representing supplier payments. The accounting of the government agent, A4, transfers funds to A5 agent, equivalent to its fixed expenses and the daily expenses of the hospitalized agents. Eventually, the A4 agent pays aids for unemployed and homeless A1 agents.

EXPERIMENTAL METHODOLOGY

To evaluate the proposed approach, seven different scenarios that reflect adopted and/or hypothetical social distancing interventions have been formulated. Each one simulates the impact of a given social distancing policy, considering the values of the parameters in **Table 2.8**, on the response variables, summarized in **Table 3.8.**

For each scenario 35 executions were performed, each one with T = 1.440 iterations and each corresponds to one hour, each execution covers exactly 2 months and one complete accounting cycle for houses, government and business, with one salary and tax payment, which occur in the 30th day of the month. The monthly "accounting" event is important for A2, A3 and A4 agents due to its severe cash impact and wealth transfers among agents.

The main goal of social interventions is to minimize the **death curve Dt** and to flattening the **infection curve It**, in order to keep the **hospitalization (It^H)** and **severe (It^S) cases** below the critical **limit of the healthcare system β11.**

Flattening the It curve means minimizing the **infection peak IP**, defined in **Eq. 9.8,** and extending the **time TIP spent to reach this peak**, defined in **Eq. 10.8.**

$$I_P = \max\{\, I_t \mid t = 1 \ldots T \,\} \tag{9}$$

$$T_{IP} = \min\{\, t \mid I_t = I_P \,\} \tag{10}$$

The economic analysis aims to assess the evolution of wealth, represented by the Ws,t response variables. To allow the economic comparison among scenarios with respect to the same reference, a baseline scenario (B) without a pandemic was designed. For comparison among scenarios, the increase in wealth, ∆WSi, for the group of agents, i ∈ {A1, A3, A4}, in scenario S is computed as follows:

$$\Delta W_S^i = \frac{W_{S,T}^i - W_{B,T}^i}{W_{B,T}^i} \tag{11}$$

where WB,T^i is the wealth of the group of agents, i, at the final simulation time step, T, of B.

RESULTS AND ANALYSIS

1) BASELINE (B): NO CORONAVIRUS PANDEMIC

This scenario simulates the economic behavior without a pandemic, used as baseline for comparison with all the other scenarios, and it is based on projections before the pandemic outbreak.

To generate it, they set parameters to β9 ← 0 and β10 ← 1.

The evolution of GDP is illustrated in **Fig. 4.8.**

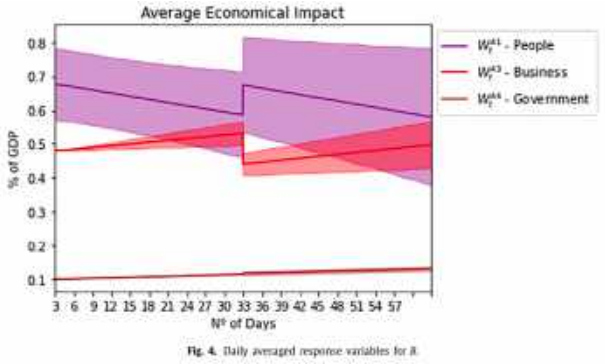


Fig. 4. Daily averaged response variables for B.

The GDP indicates a recession chart where the population (A1) and government (A4) is losing wealth and the businesses (A3) are floating at the equilibrium point (when the incomes and expenses are equal).
Initially the A3 are profiting but, in the accounting day, the profits are settled by the labor and tax expenses. The baseline scenario is consistent with the economic predictions of stagnation in Brazil.

2) SCENARIO 1: DO NOTHING

This one represents what could happen if politicians decided not to take any actions to avoid the increase of the number of people infected by the virus and, usually, this decision only targets the economic point of view.
Fig. 5.8 shows the epidemiological and economical average curves of this scenario and their variances.

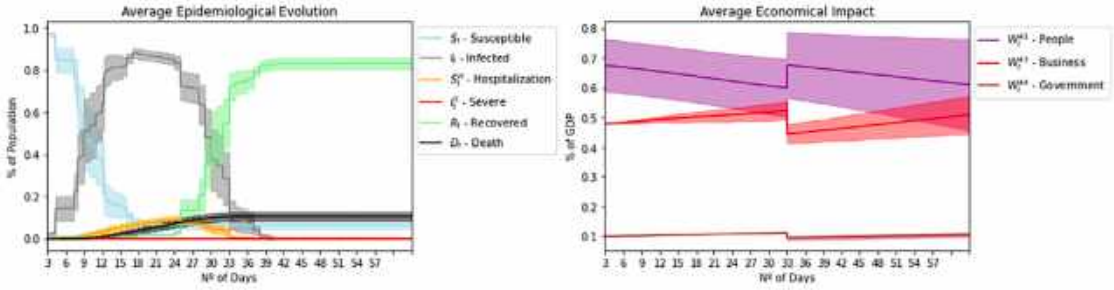


Fig. 5. Daily averaged response variables for scenario "Do Nothing".

It can be seen that the economic curves look closer to the ones of the baseline, confirming the economic motivation of keeping the environment without interventions. However, when the contagion curve (It) is considered, it is possible to note how the Healthcare System critical limit β11 was trespassed, pushing the death curve (Dt) up. The high number of lost lives makes this the most catastrophic scenario, despite its economic resemblance with B.

3) SCENARIO 2: LOCKDOWN

This one represents the complete social isolation, following the WHO recommendations, during a well-defined date range.

All A1 agents are kept in their houses, and the “walk freely” and “go to work” routines are suppressed. Even α6 ← 1, reducing the mobility amplitude of all A1 even the homeless. It is highly conservative in healthcare terms, and the main goal is to save as many lives as possible by minimizing viral spreading.

The entire population stays in lockdown for a predefined period of time, the infected agents only have contact with their housemates and the It (and especially It^S) stays below the healthcare critical limit β11, and the deaths Dt ← 0, meaning that the health-care system could handle effectively all cases, using its available resources.

Considering the economic point of view (**Fig. 6.8**), this scenario is the worst for the industry because the A1 agents cannot generate wealth, but keep receiving their labor incomes, A3 does not have income, but keeps paying taxes to A4 and labor expenses to A1.

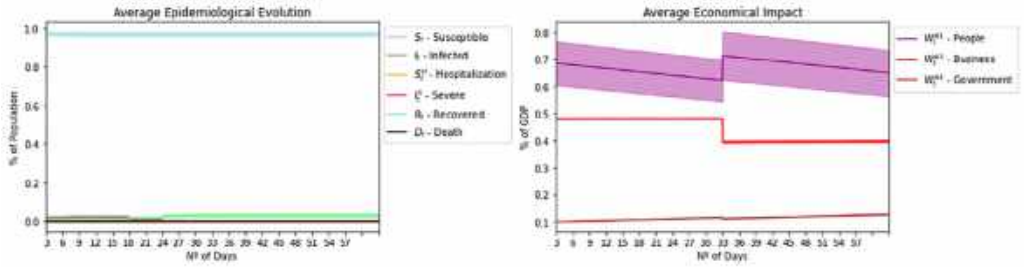


Fig. 6. Daily averaged response variables for Scenario 2.

In this scenario, after two months, the businesses lost 20% of its GDP share (see WS,T^A3 in Fig.6). The key point for the success of lockdown policy is staying at home (voluntarily or under laws).

Economical countermeasures to its harm can also be adopted by A4, as tax exemptions and universal income, in order to minimize the wealth losses.

In the impossibility of implementing this scenario, another one that considers protective and distance measures should be evaluated.

4) SCENARIO 3: CONDITIONAL LOCKDOWN

This one imposes the same restrictions on A1 mobility presented in scenario 2, but conditionally.

In the system, when the infection curve grows above a certain threshold, It ≥ 0.05, the lockdown restrictions are activated, being released when It ≤ 0.05.

As we can see in **Fig. 7.8**, the viral spreading represented by the infection curve It is controlled, not allowing the explosion of Dt curve.

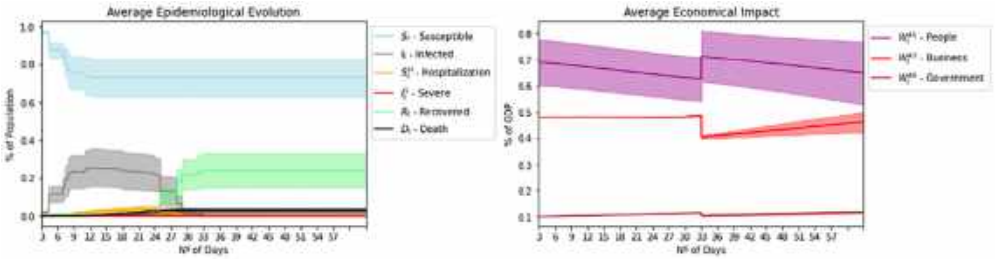


Fig. 7. Daily averaged response variables for Scenario 3.

Economically, recession can be observed during the lockdown period, W3,t^i lower than WB,t^i ∀i, but as soon as the restrictions are released the business performance is recovered.
W3,t^A3 remains below WB,t^A3 but above the complete lockdown curve W2,t^i. Less conservative than scenario 2 (and also less efficient in terms of Dt), it was implemented in New Zealand, and it depends on an effective healthcare system that is capable of carrying out the necessary tests in the population, granting reliability in It estimates and, as in scenario 2, the governmental ability to enforce the social isolation.

5) SCENARIO 4: VERTICAL ISOLATION

Vertical isolation is the name given to the social intervention policy where the known infected people and the known risk groups – elderly and people with pre-existent diseases – are kept in social isolation, whereas young people and adults are allowed to work regularly. This policy has, for instance, been advocated by the Brazilian president. In terms of the proposed model, over 65, below 18 years old and symptomatic regardless of the age stay at home, thus all the people outside the risk groups would not develop the severe cases of the disease.
But it was proved to be fragile and showed to be ineffective by *Duczmal et al.,* and the results shown in **Fig. 8.8** are in accordance with the literature and produced almost the same epidemiological and economical results of Scenario 1 of doing nothing.

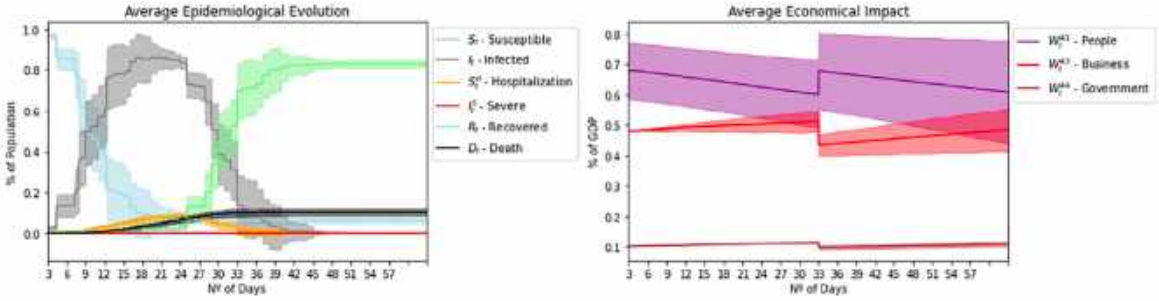


Fig. 8. Daily averaged response variables for Scenario 4.

6) SCENARIO 5: PARTIAL ISOLATION

When restrictive public policies are non-existent or are not taken seriously by the entire population, partial isolation levels are reached.

The **partial isolation level IL ∈ [0, 1]** means the percentage of the population that is fulfilling the isolation, while the remaining (1−IL) is not.

Then, it is possible to define that in the lockdown IL ≥ 0.9, considering that essential services and a few industries cannot stop in order to avoid supply breakdown. On the other hand, the scenarios 0 and 1 have IL ≤ 0.1, and the scenario 4 has IL ≈ 0.2, because of the age distribution and the definition of risk groups. This scenario aims to assess the effects of intermediate ILs, and it was simulated by randomly choosing agents A1 with probability IL ← 0.5 to stay at home. Observing the results in **Fig. 9.8**, although the It curve is flattened when compared with scenarios B and 4, it is still less efficient than scenarios 2 and 3. The Dt still grows exponentially before reaching the peak.

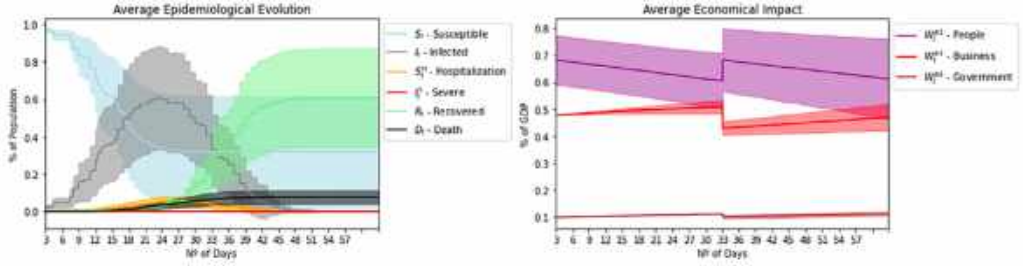


Fig. 9. Daily averaged response variables for Scenario 5.

For the economic perspective, this scenario behaves similarly to the baseline, proving that IL ← 0.5 is not enough for effective epidemiological control, and a level of isolation greater than that is recommended.

The impact of different isolation levels can be seen in **Figs. 10.8 and 11.8,** for IL ∈ [0.3, 0.9], which represents the response of epidemiological and economical curves for increasing IL.

In Fig. 10 it is possible to see how the infection curve It flattens as the isolation level increases from no isolation towards lockdown.

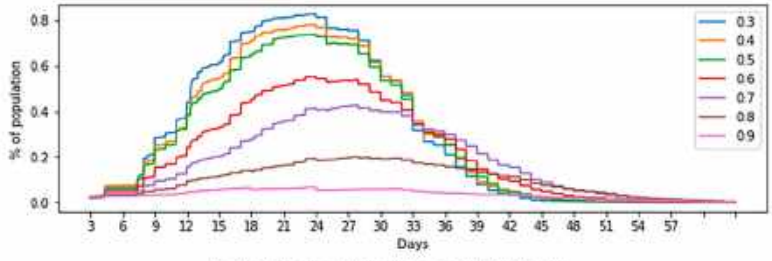


Fig. 10. Infection curves by varying values of partial isolation level (IL).

Fig. 11.8 shows that as the value of IL increases, wealth loss of the A3 agents is higher, represented by WS,t^A3 curve, showing the importance of agent's mobility in the economy.

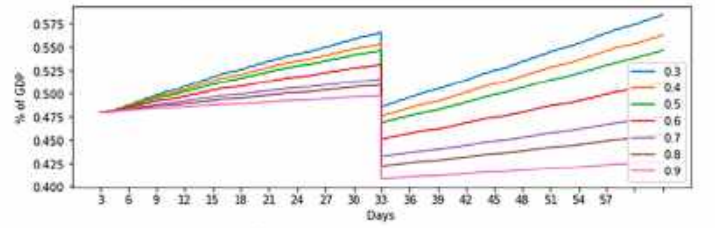


Fig. 11. $W_{S,t}^{A3}$ curves by varying values of partial isolation level (IL).

7) SCENARIO 6: USE OF FACE MASKS

This one represents the policy of mandatory usage of face masks and physical distancing, but without imposing restrictions on the mobility of agents, and it was implemented by reducing the contagion distance β1 = 0.5 and the contagion rate β2 = 0.3 as the effect of the policy. **Fig. 12.8** shows a flatter It curve when compared to scenario 5 while still keeping economic performance close to B.

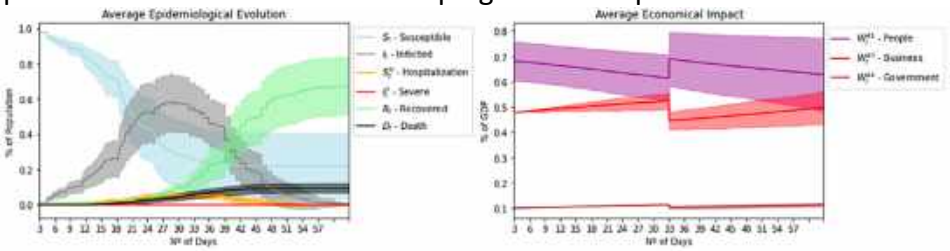


Fig. 12. Daily averaged response variables for Scenario 6.

Notice, however, that Dt is significantly higher when compared with scenarios 2 and 3.

8) SCENARIO 7: USE OF FACE MASKS AND 50% OF SOCIAL ISOLATION

This one combines the policies used in the scenarios 5 and 6, granting the necessary use of face masks plus partial isolation of the population, and it was implemented by using β1 = 0.5, β2 =0.3 and IL=0.5.

Fig. 13 shows its dynamics.

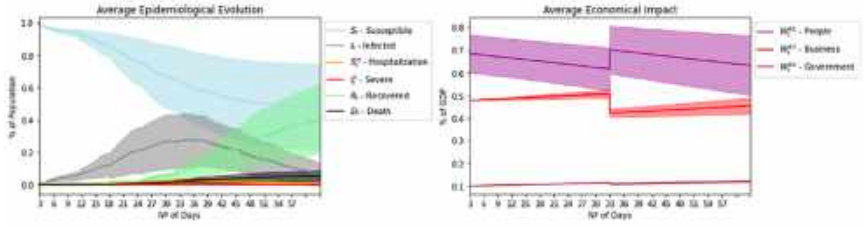
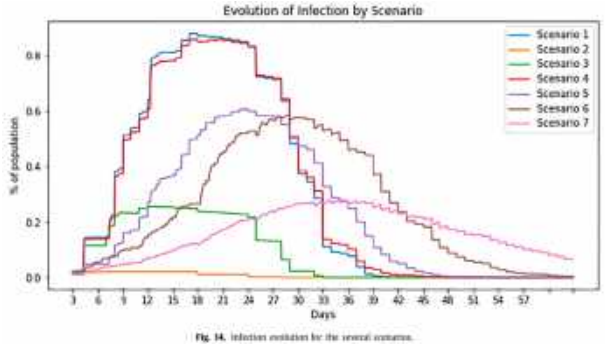


Fig. 13. Daily averaged response variables for Scenario 7.

Although the Dt is still above the values of scenarios 2 and 3, it presents less resistance from the general population. The It is flattened, and the economy, despite the downturn, suffers less than it would in scenarios with lockdown.

COMPARISONS AMONG SCENARIOS

The It curves (averages) of each scenario are shown in **Fig. 14.8.**



There, the effects of each intervention policy in flattening the curve can be observed and contrasted.

The epidemiological effectiveness of the scenarios is shown in **Fig. 15.8**, which compares the infection peak IP reached in each case, the number of days TIP to reach the peak IP and the max number of deaths Dt (as a proportion of the population).

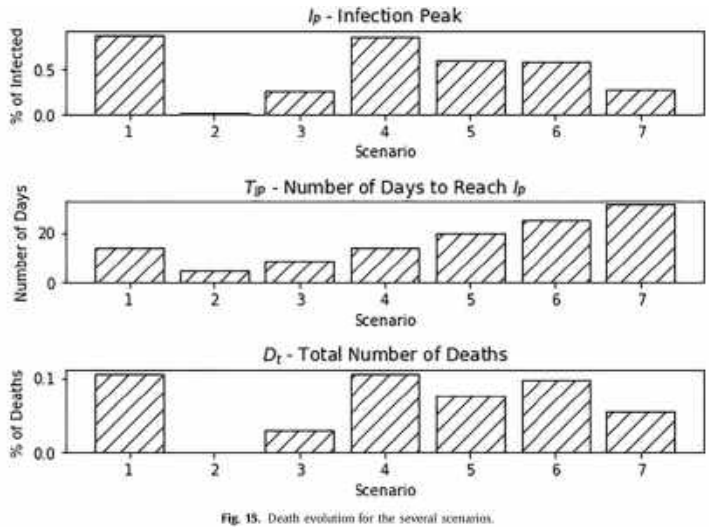


Fig. 15. Death evolution for the several scenarios.

As expected, scenarios 2 and 3 have the best epidemiological values followed by scenario 7. **Fig. 16.8** shows the economic result of each scenario for the agent types A1, A3 and A4.

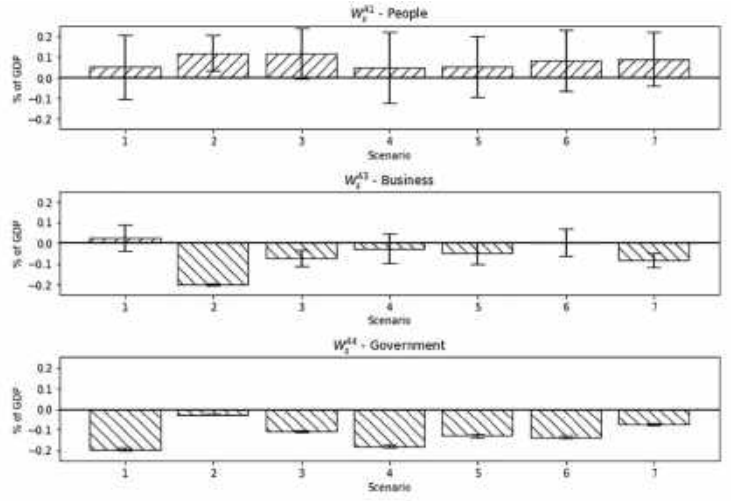


Fig. 16. Economical result of each scenario compared to Scenario 0 by response variable.

Assuming that businesses are not firing anyone, from the point of view of the citizen, scenarios 2 and 3 are not economically damaging, but the same ones are the worst from the business perspective.

It is important to explain that the expenses of government in the simulation are related with the costs of the healthcare system.

Thus, in scenarios with a high number of deaths, such as 1 and 4, the cost of maintaining the healthcare system is increased which demands an increase of public expenses. **Fig. 17.8** shows the scatter plots of the wealth increase (with respect to the baseline) of each type of agent by the percentage of deaths in the populations.

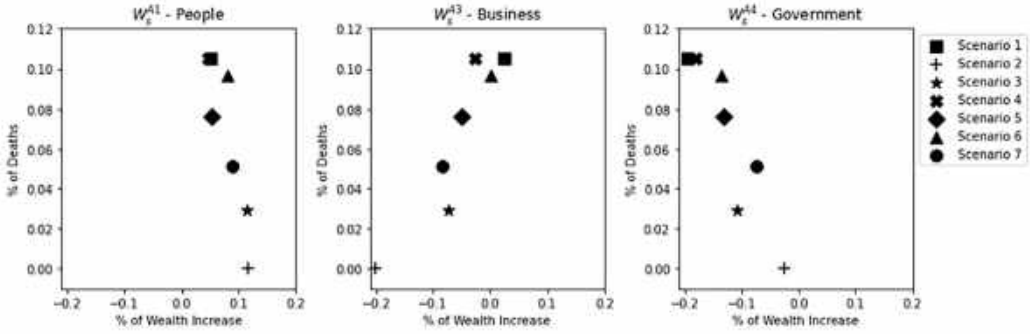


Fig. 17. Percentage of deaths versus percentage of GDP variation.

Source: *COVID-ABS: An agent-based model of COVID-19 epidemic to simulate health and economic effects of social distancing interventions*
Petrônio C.L. Silva, Paulo V.C. Batistaa, Hélder S. Limab, Marcos A. Alvesc, Frederico G. Guimarãesc, Rodrigo C.P. Silva (July 7, 2020) (as also all the other Images, Tables and Equations)

It can be seen that, from a life preservation perspective, there is no better policy than the lockdown (scenario 2). Furthermore, in the simulated model, scenario 2 Pareto dominates all the scenarios for both people and government.
On the other hand, it represents the worst case, financially, for businesses.

In the impossibility of enforcing a lockdown (discarding scenarios 2 and 3), which may happen in underdeveloped countries, the best solution is represented by scenario 7, that from the remaining Pareto optimal solutions for businesses is the one with lowest number of deaths, and becomes the best solution for government and people in both wealth and number of deaths.

In conclusion, the results showed that policies adopted by some countries, for instance US, Sweden and Brazil, are ineffective when the objective is to preserve lives.
Governments that chose to preserve the economy by not using severe isolation policies, fatally reached a situation with a high cost in human lives, and still embittered economic losses.
The evidence provided by the simulation model shows that there is a false dichotomy between healthcare and the economy.
In the scenarios where it was tried to save the economy by not taking hard social isolation policies, consequently, the social costs ended up impacting negatively into the economy.
So, the best way to manage this situation is to reach a situation with physical distancing, use of face masks, and make them match with everyday work, in order to not spread the virus, but at the same time keep running the economic system.

CHAPTER 9 - ECONOMIC RESILIENCE DATASET IN FACING PHYSICAL DISTANCING DURING PANDEMIC

The dataset was collected using the survey method with an electronic questionnaire, using Google form platform, in order to reach many respondents during the physical distancing caused by the COVID-19 global pandemic. Questionnaire distribution was conducted on April 12–20, 2020, two weeks after the government call of the Republic of Indonesia to carry out Physical Distancing to anticipate the COVID-19 Global Pandemic, and 1096 responses were collected. The entire data is then screened and filtered so that it only leaves the data with respondents who are domiciled in Medan City, so remained 846 data ready for analysis. In order to make more informative data, researchers conducted a descriptive statistical analysis, ANOVA, Kruskal Wallis, and the Spearman's rank correlation. Analysis of the data provides valuable information related to the interrelation of each item and the pattern of economic resilience that the urban city community has as a data of the COVID-19 global pandemic.
Researchers can then further analyze the data with more advanced analytical tools to produce more valuable information in the development of science and in developing strategic policies related to anticipating the economic vulnerability of the household due to the global pandemic disaster.
Descriptive statistics indicate that each sample category represents the observed conditions, such as physical distancing patterns, sources of family income, and estimates of the duration of economic resilience.

Table 1
Cross-Tabulation between Marital Status and Number of Family Member.

Marital Status	Number of Family Member					Total
	0	1–2	3–4	5–6	>6	
Married with Children	0	18	89	45	12	164
Married	0	74	125	79	20	298
Single	27	71	102	147	39	386
Divorce	0	4	1	0	0	5
Divorce with Children	0	5	6	3	0	14
Total	27	171	323	274	71	867

From **Table 1.9** emerges that:

- Marital status is dominated by respondents that are singles, married, and married with children.
- Number of family member is dominated by 1-2, 3-4 and 5-6.
- Only 27 respondents who are single and have no family members other than himself.
- A lot of respondents who have a single marital status probably happen because he or she is a member of the family as children instead of parents.
- The level of analysis was household instead of the individual and respondent not represents himself but his family.

Table 2
Descriptive Statistics of Characteristics Respondent

	Gender		Age	Marital Status					Educational Background					
	Male	Female		Married with child/ children	Married	Single	Widow/ Wid-ower	Widow/ Widower with Child/ Children	Primary School	Junior High School	Senior High School	Diploma/ Bachelor	Master Degree	Doctoral
Pattern of Physical Distancing														
Implement Social distancing strictly (N = 248)	N = 81 % = 32.7	N = 167 % = 67.3	Mean = 31.45 SD = 11.50	N = 49 % = 19.8	N = 87 % = 35.1	N = 109 % = 44.0	N = 0 % = 0.0	N = 3 % = 1.2	N = 0 % = 0.0	N = 3 % = 1.2	N = 98 % = 39.5	N = 82 % = 20.6	N = 51 % = 20.6	N = 4 % = 1.6
Social/Physical Distancing with Outdoor/Outside Activity (N = 194)	N = 200 % = 43.8	N = 134 % = 38.2	Mean = 32.40 SD = 11.81	N = 101 % = 18.7	N = 283 % = 34.2	N = 290 % = 44.8	N = 3 % = 0.5	N = 11 % = 1.9	N = 12 % = 2.0	N = 15 % = 2.5	N = 146 % = 41.4	N = 226 % = 38.0	N = 87 % = 14.8	N = 8 % = 1.3
Do not apply Social distancing (N = 25)	N = 5 % = 64.0	N = 14 % = 56.0	Mean = 29.24 SD = 10.03	N = 4 % = 16.0	N = 8 % = 32.0	N = 11 % = 44.0	N = 2 % = 8.0	N = 0 % = 0.0	N = 1 % = 4.0	N = 3 % = 12.0	N = 12 % = 48.0	N = 7 % = 28.0	N = 2 % = 8.0	N = 0 % = 0.0
Source of the family's main income														
Monthly salary as a civil servant, military, police, pensioner, or private employee (N = 467)	N = 187 % = 40.0	N = 280 % = 60.0	Mean = 32.68 SD = 11.07	N = 101 % = 21.6	N = 161 % = 34.5	N = 199 % = 42.6	N = 1 % = 0.2	N = 5 % = 1.1	N = 2 % = 0.4	N = 4 % = 0.9	N = 125 % = 26.8	N = 203 % = 43.5	N = 123 % = 26.3	N = 10 % = 2.1
Business or Entrepreneurship (N = 144)	N = 56 % = 38.9	N = 88 % = 61.1	Mean = 28.20 SD = 9.83	N = 22 % = 15.3	N = 45 % = 31.3	N = 73 % = 50.7	N = 2 % = 1.4	N = 2 % = 1.4	N = 1 % = 0.7	N = 1 % = 0.7	N = 82 % = 56.9	N = 51 % = 35.4	N = 8 % = 5.6	N = 1 % = 0.7
Workers with daily/uncertain income (Informal workers) (N = 170)	N = 71 % = 41.8	N = 99 % = 58.2	Mean = 34.23 SD = 13.55	N = 30 % = 17.6	N = 61 % = 35.9	N = 74 % = 43.5	N = 1 % = 0.6	N = 4 % = 2.4	N = 7 % = 4.1	N = 11 % = 6.5	N = 103 % = 60.6	N = 43 % = 26.5	N = 2 % = 1.2	N = 0 % = 0.0
Workers with weekly income (N = 41)	N = 17 % = 41.5	N = 24 % = 58.5	Mean = 31.00 SD = 12.37	N = 7 % = 17.1	N = 15 % = 36.6	N = 18 % = 50.0	N = 1 % = 2.4	N = 2 % = 4.9	N = 3 % = 7.3	N = 4 % = 9.8	N = 28 % = 68.3	N = 5 % = 12.2	N = 0 % = 0.0	N = 1 % = 2.4
Workers with project-based income (N = 45)	N = 21 % = 46.7	N = 24 % = 53.3	Mean = 30.29 SD = 10.05	N = 4 % = 8.9	N = 16 % = 35.6	N = 24 % = 53.3	N = 0 % = 0.0	N = 1 % = 2.2	N = 0 % = 0.0	N = 1 % = 2.2	N = 30 % = 95.6	N = 13 % = 48.7	N = 7 % = 15.6	N = 0 % = 0.0
If Physical Distancing will continue to apply, how long will you and your family survive economically														
< 2 weeks (N = 190)	N = 62 % = 32.6	N = 128 % = 67.4	Mean = 31.90 SD = 11.39	N = 32 % = 16.8	N = 71 % = 37.4	N = 82 % = 43.2	N = 3 % = 1.6	N = 2 % = 1.1	N = 4 % = 2.1	N = 10 % = 5.3	N = 96 % = 50.5	N = 68 % = 35.8	N = 11 % = 5.8	N = 1 % = 0.5
2 – 4 Weeks (N = 262)	N = 113 % = 43.1	N = 149 % = 56.9	Mean = 31.81 SD = 11.89	N = 43 % = 15.2	N = 99 % = 35.3	N = 135 % = 47.9	N = 1 % = 0.4	N = 4 % = 1.5	N = 7 % = 2.5	N = 9 % = 3.2	N = 131 % = 46.5	N = 98 % = 34.8	N = 36 % = 12.8	N = 1 % = 0.4
4 – 12 Weeks (N = 204)	N = 94 % = 46.1	N = 110 % = 53.9	Mean = 31.48 SD = 10.07	N = 40 % = 19.6	N = 71 % = 34.8	N = 88 % = 43.1	N = 0 % = 0	N = 5 % = 2.5	N = 1 % = 0.5	N = 1 % = 0.5	N = 97 % = 32.8	N = 93 % = 45.6	N = 36 % = 18.0	N = 4 % = 2.0
> 12 Weeks (N = 99)	N = 83 % = 83.8	N = 108 % = 56.5	Mean = 33.00 SD = 11.82	N = 49 % = 25.7	N = 57 % = 29.8	N = 81 % = 42.4	N = 1 % = 0.5	N = 3 % = 1.6	N = 1 % = 0.5	N = 1 % = 0.5	N = 52 % = 52.5	N = 66 % = 34.6	N = 55 % = 28.8	N = 6 % = 3.1

From **Table 2.9**, created from the cross-tabulate of number of family income with marital status, emerges that:

- The demography of respondents on gender shows that female is dominant respondents.
- Marital status is dominated by respondents that are singles, married, and married with children.
- Educational background of respondents was dominated by the Senior High School Education and Diploma/Bachelor.
- These conditions seem to bias to gender and marital status, but actually, the level of analysis was household instead of the individual and respondent not represents himself but his family.
- The respondents mostly did the physical distancing in level strict and moderate, while very few respondents did not carry out physical distancing.
- On the aspect of the source of the family's main income, the group of respondents who have the monthly salary as a civil servant, military, police, pensioner, or private employee represent half of the respondents, while the rest are scattered in other groups, namely business or entrepreneurship, workers with daily/uncertain income, workers with weekly income, and workers with project-based income.

- This distribution is in general divided into two categories, that is employee workers, and non-employees.
- In the estimation of economic resilience during the physical distancing period, the sample was evenly distributed from each of the offered schemes, namely <2 weeks, 2–4 weeks, 4–12 weeks, and> 12 weeks.

Table 3
Comparative Analysis Related to Pattern of Physical Distancing, Source of the Main Income and Economic Resilience.

	Pattern of Social/Physical Distance		Source of the family's main income		If Physical Distancing will continue to apply, how long will you and your family survive economically	
	F-test; Chi-Square	Sig	F-test; Chi-Square	Sig	F-test; Chi-Square	Sig
Income and Food Access						
Income	0.462	0.630	4.238	0.002**	14.249	0.000**
Number of Family Members	1.242	0.289	13.367	0.000**	0.794	0.497
Income Per-capita	2.561	0.078	223.092	0.000**	21.247	0.000**
Shopping pattern in accommodating the daily food needs under normal circumstances	2.581	0.275	42.581	0.000**	16.174	0.001**
Shopping patterns during Physical Distancing	20.213	0.000**	46.926	0.000**	42.187	0.000**
Access to Basic Services						
Type of health services	3.639	0.162	76.363	0.000**	41.270	0.000**
Quality of health services	8.674	0.013*	42.787	0.000**	13.523	0.001**
Quality of the Education System	4.568	0.102	47.639	0.000**	6.002	0.048*
Mobility disrupted during Physical Distancing	4.006	0.135	27.471	0.000**	10.253	0.017*
Transportation restrictions during Physical Distancing	18.661	0.000**	10.917	0.028*	5.309	0.151
Access to clean water during Physical Distancing	2.538	0.281	13.015	0.008**	9.274	0.026*
Ability to pay water bills during Physical Distancing	6.768	0.034	111.489	0.000**	191.291	0.000**
Increasing water bill during Physical Distancing	2.619	0.270	4.851	0.303	1.322	0.724
Getting water bill subsidy during Physical Distancing	0.668	0.719	38.920	0.001**	7.001	0.072
Access to electricity during Physical Distancing	5.518	0.077	7.391	0.117	34.339	0.000**
Ability to pay electricity bills during Physical Distancing	2.513	0.285	304.385	0.000**	123.387	0.000**
Increasing electricity bill during Physical Distancing	6.568	0.037*	16.113	0.003**	7.221	0.065
Getting electricity bill subsidy during Physical Distancing	1.120	0.571	15.667	0.004**	10.462	0.015*
Access to the internet during Physical Distancing	0.480	0.786	45.059	0.000**	44.569	0.000**
Ability to pay internet bills during Physical Distancing	1.117	0.572	86.062	0.000**	106.940	0.000**
Increasing internet bill during Physical Distancing	5.424	0.066	1.045	0.903	9.771	0.021*
Getting internet bill subsidy during Physical Distancing	2.288	0.319	11.208	0.024*	7.003	0.072
Social Safety Nets						
Access to cash or non-cash loans or assistance	0.294	0.683	9.958	0.041*	6.403	0.094
Assistance or loan help meet the needs of our family	4.602	1.000	7.347	0.100	4.346	0.226
Having a side job during Physical Distancing	0.501	0.779	17.115	0.002**	10.001	0.018*
Additional income from side job able to meet the needs of our family	1.833	0.400	12.849	0.012*	8.098	0.028*
Asses						
Status of residence	3.993	0.136	14.816	0.005**	20.856	0.000**
Savings	5.498	0.064	84.533	0.000**	205.177	0.000**
Valuable assets (gold and silver)	2.551	0.279	53.159	0.000**	43.532	0.000**
Immovable assets (land and buildings)	6.553	0.038*	16.250	0.003**	44.653	0.000**
Vehicle for daily activities (motorbikes or cars)	15.312	0.000**	12.348	0.015*	12.526	0.006**
Adaptive Capacity						
I have more than one source of income	6.393	0.041*	29.885	0.000**	32.775	0.000**
I have other skills that will be useful to get economic benefits during this Physical Distancing	6.687	0.035*	16.479	0.002**	8.930	0.818
Stability						
Numbers family members worked before Physical Distancing	1.444	0.237	2.352	0.054	1.701	0.165
Number family members lost their jobs/income during the Physical Distancing	1.753	0.174	15.961	0.000**	11.085	0.000**
Income condition during Physical Distancing	1.042	0.594	131.133	0.000**	11.791	0.000**
Spending conditions during Physical Distancing	8.338	0.015*	20.430	0.000**	6.635	0.888
Having health assurance	25.675	0.000**	92.300	0.000**	65.661	0.000**
Having insurance for assets (Motorbike, Car, House and others)	7.012	0.029*	43.222	0.000**	15.568	0.001**
Having debts	6.133	0.047*	18.843	0.001**	10.418	0.015
One of your family members have a credit card	1.209	0.549	31.341	0.000**	26.016	0.000**

** Significant at the 0.01 level; * Significant at the 0.05 level.

Table 3.9 shows the difference in responses that the group of respondents had from the resilience variables analyzed. The significance of differences is indicated by the number of p-values <0.05, and analysis of this data was carried out with ANOVA and Kruskal Wallis. Based on the number of p-values of each item, the data indicate that:

- The group of respondents who conducted physical distancing in a strict, moderate manner, and did not carry out physical distancing did not differ in aspects of income and access to food, access to basic services, social safety nets, and assets.

- Groups of respondents who were differentiated based on the source of main income and the estimated duration of economic resilience showed a significant difference almost across items both in income and food access variables, access to basic services, social safety nets, assets, adaptive capacity, and stability.
- The increase in the water bill, access to assistance, and the number of families did not show significant differences either in respondents who are distinguished based on physical distancing patterns, sources of income, and the estimated duration of economic resilience.
  This indicates that the water consumption pattern is relatively constant in any community conditions.
- The number of families does not become a differentiator, perhaps because of the large number of family members followed by a large number of economically productive families.

So, data shows the attractiveness of patterns and characteristics of the Medan community in terms of their economic resilience.

Table 4
Correlations Analysis of Economic Indicator to Pattern of Physical Distancing, Source of the Main Income and Economic Resilience.

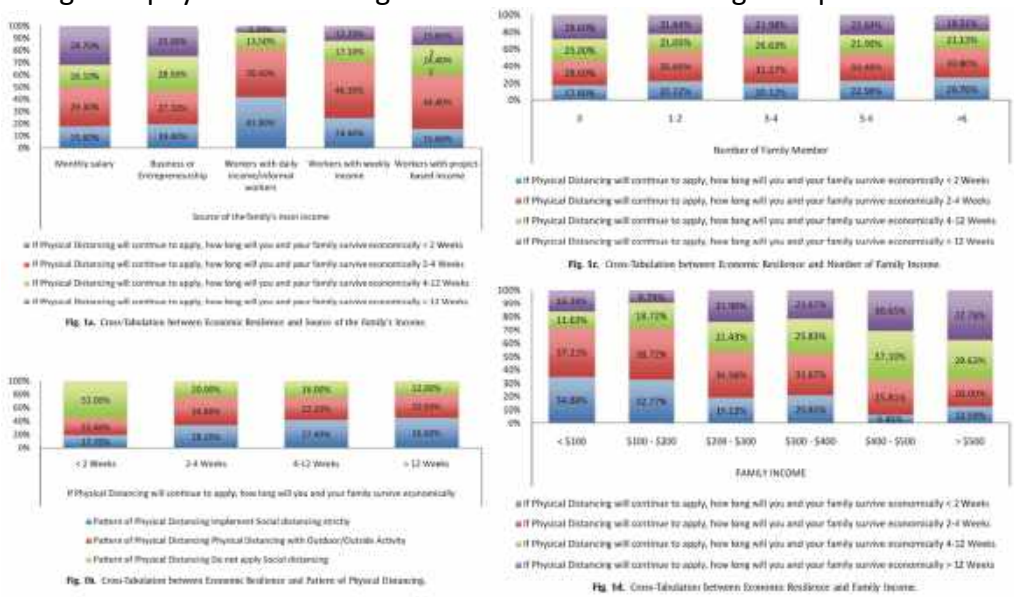
	Pattern of Social/Physical Distance	Source of the family's main income	If Physical Distancing will continue to apply, how long will you and your family survive economically
Income	0.173	0.000**	0.000**
Income per-capita	0.066	0.000**	0.000**
Access to cash or non-cash loans or assistance	0.611	0.806	0.026*
Having a side job during Physical Distancing	0.481	0.566	0.001**
Status of residence	0.000	0.645	0.000**
Savings	0.170	0.000**	0.000**
Valuable assets (gold and silver)	0.203	0.000**	0.000**
Immovable assets (land and buildings)	0.613	0.003**	0.000**
Vehicle for daily activities (motorbikes or cars)	0.997	0.009**	0.002**
I have more than one source of income	0.249	0.000**	0.000**
I have other skills that will be useful to get economic benefits during this Physical Distancing	0.391	0.794	0.358
Income condition during Physical Distancing	0.339	0.000**	0.000**
Spending conditions during Physical Distancing	0.145	0.001**	0.707
Having health insurance	0.000**	0.000**	0.000**
Having insurance for assets (Motorbike, Car, House and others)	0.018*	0.001**	0.001**
Having debts	0.105	0.004**	0.092
One of your family members have a credit card	0.288	0.000**	0.000**

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 4.9 presents the data of the spearman rank correlation between each item of financial aspects of economic security with a sample grouped in physical distancing patterns, sources of income, and estimated duration of economic resilience.
As Tables 2 and 3, it indicates the significance of the relation between variable using the number of p-values <0.5.
The data indicate that:

- There were almost no items significantly related to physical distancing patterns except for health insurance and insurance on movable property items.
- There is a significant relationship between all items and family income sources except access to assistance/loans, having side jobs during physical distancing, the status of residence, and other skills that are economically useful.
  The same thing also happened in the estimated duration of economic resilience.
- Almost all items have a significant relationship with the estimated duration of economic resilience except for other skills items that are economically useful, spending patterns, and debt ownership.

These findings indicate interesting characteristics of the people of Medan in dealing with physical distancing in the face of a COVID-19 global pandemic.



In conclusion, **Figure 1a-1b-1c-1d** shows all the cross-tabulation between the variables analyzed and shows clearly all the consequences of Physical distancing on the households.
From the first one (**Fig. 1a**) emerges that Workers with daily income/informal workers are those who suffer most Physical distancing, because of their type of work contract, that in this period is the most afflicted one.
Even Workers with weekly income and Workers with project-based income, but less than daily one.

The safest types of income are Monthly salary and Business/Entrepreneurship, in equal percentages, that evidence the fact that this type of contracts can save families for a longer period of difficulties like the present one, but also in normal circumstances.

As regards **Fig. 1b**, the more the weeks increase, the more people prefer to do Social distancing strictly, but also Outdoor activities, that remains in constant percentage.

In **Fig. 1c** it's relevant the fact that the more family members you have, the more Physical distancing and uncertainty in income weighs on your economic situation, because of family expenses, not only in food, but also in services, home and so on.

Even in the last picture (**Fig. 1d**) is clear that the more income a family perceive, the more they can survive to these kind of situations, because, as the previous Figure clears out, households have to incur continuous costs, from shopping goods (food, beverages) to taxes (home bills, insurances).

And all of these pictures reflects the effects on all the world's families and households during the coronavirus outbreak.

CHAPTER 10 - PERSONALITY AND INDIVIDUAL DIFFERENCES: PERSONAL ECONOMIC ANXIETY IN RESPONSE TO COVID-19

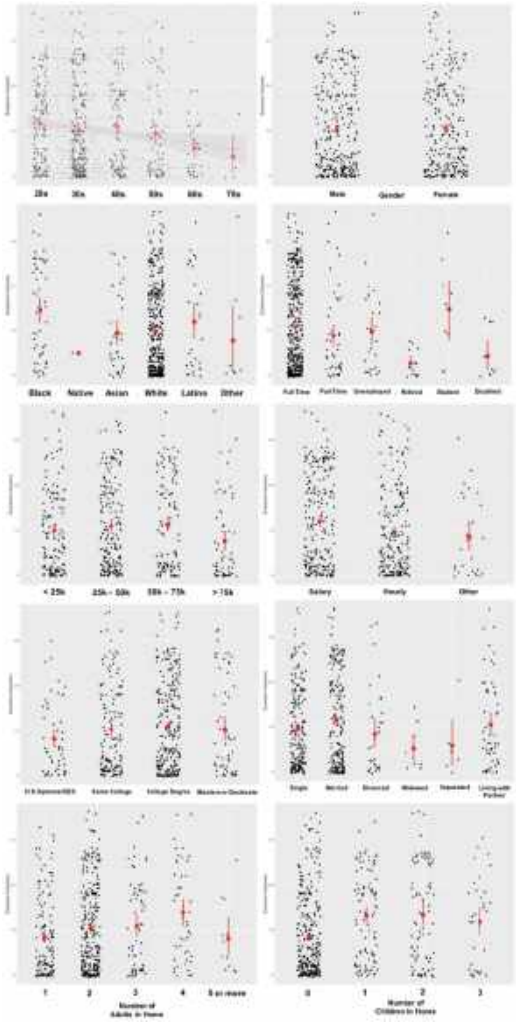
Economic anxiety is a pernicious form of psychological distress associated with deleterious outcomes, in this case of economic nature, that can lead to mental disorders and suicidal behavior.
Using a sample of adults from the United States (n = 513), the study examined demographic and individual correlates of anxiety about financial hardship on March 17th, 2020, the day after historic stock market drops in response to the emerging COVID-19 crisis. The current study sought to test specific individual differences as correlates of economic anxiety, above and beyond demographic factors, and the possibility that it may highlight the characteristics of those who may be most likely to experience mental and behavioral health sequelae of economic hardship. The study focuses on individual differences related to basic personality traits and group-related proclivities in the domains of health, social evaluations, and social connection, assessing **perceived disease vulnerability**, **collective identity**, **social belongingness**, and the **Big Five personality domains**.

- **Perceived disease vulnerability** taps people's concerns that they may be susceptible to illness and take action to avoid contagions.
  Not only this one has a strong connection to health concerns, beliefs that one is susceptible to pathogens also may generalize to heightened threat detection more broadly.
  So, it is predicted that perceived disease vulnerability would be associated with heightened economic anxiety.
- **Collective identity** was measured using the race/ethnicity version of the collective self-esteem scale. Literature reviews have concluded that a benefit of self-esteem is to confer resiliency in the face of setbacks and threats, which may bear on people's perceptions of their economic prospects in the context of their racial or ethnic groups.
  The scale measures self- perceptions of being a worthy group member (**membership self-esteem**), the esteem that one has for one's group (**private self-esteem**), beliefs about others' evaluation of one's group (**public self-esteem**), and the extent to which people's personal identity is influenced by their group membership (**identity self-esteem**).
  They had the strongest predictions that lower scores on the first three measures of self-esteem were thought to predict more economic anxiety, whereas the link to the inclusion of racial/ethnic identity in one's self-image (identity self-esteem) was uncertain.

- The degree to which people derive **social belongingness** from being part of large group activities was measured using the effervescent collective assembly measure. This concept, originating from *Durkheim (1912*), pertains to feelings of solidarity and connectedness from fun-filled large group events (e.g., festivals, concerts), as well as somber public events (e.g., public memorials).
  So, is a form of social connection that is now threatened by social distancing guidelines. Hence, we predicted that people who report stronger collective effervescence motivations, who are thus deprived of opportunities to fulfill this form of social connection, would feel more anxious about potential financial hardships.
- **The Big Five domains of personality** capture fundamental organizing axes of variation in affect, behavior, and motivation.
  People with a tendency to experience high levels of neuroticism were predicted to experience high levels of economic anxiety due the COVID-19 crisis.
  Therefore, we predicted that high levels of neuroticism would be associated with economic anxiety.

An online survey was collected from a sample of 513 adults using the Amazon's Mechanical Turk Prime platform. Data collection began on March 17th and participants were notified of an opportunity to “provide your evaluations on multiple measures such as demographics, risk perceptions, and thoughts about COVID-19. The study should take about 10 minutes to complete".
All study participants had IP addresses from the United States and were compensated $ 1.00. From the sample emerges these generalities about the participants (**Figure 1.10**):

Fig. 1.10: Demographics of economic anxiety in response to COVID-19.
Notes: Black dots indicate individual observations. Red dots indicate arithmetic means. Red bars indicate 95% bootstrapped confidence intervals.



Economic anxiety was measured using an adapted version of an economic hardship scale.

Participants rated the **extent to which they were concerned about economic hardships** that may befall them due to the COVID-19 crisis; **Deriving belongingness from participating in large groups**, measured using the tendency for effervescent assembly scale; **Racial/ethnic identity**, measured using the race-specific version of the collective self-esteem scale;

Personality traits, measured using the extra-short form of the Big Five Inventory, which uses three items to capture variation in each of the **Big Five domains: conscientiousness** (e.g., "tends to be disorganized"), **agreeableness** (e.g., "is compassionate, has a soft heart"), **neuroticism** (e.g., "worries a lot"), **openness to experience** (e.g., "is original, comes up with new ideas"), and **extra- version** (e.g., "is dominant, acts as a leader").

Descriptive statistics from **Table 1.10** shows that 15% of adults reported no economic anxiety, and 10% reported they were only "somewhat concerned" about a single financial hardship.

Table 1
Descriptive statistics for individual differences and economic anxiety.

n = 513	k	M	SD	Min	Max	Skew	Kurtosis	α	ω
Conscientiousness	3	3.33	0.50	1.67	5.00	−0.37	0.47	0.71	0.73
Agreeableness	3	3.21	0.67	1.33	5.00	−0.39	0.46	0.42	0.50
Neuroticism	3	2.53	1.04	1.00	5.00	0.18	−0.83	0.67	0.70
Openness to experience	3	3.75	0.94	1.00	5.00	−0.59	−0.17	0.67	0.68
Extraversion	3	2.93	0.96	1.00	5.00	0.00	−0.46	0.58	0.60
Membership self-esteem	4	5.10	1.09	1.00	7.00	−0.28	−0.36	0.69	0.81
Public self-esteem	4	4.85	1.08	1.00	7.00	−0.26	0.11	0.66	0.80
Private self-esteem	4	5.17	1.18	1.75	7.00	−0.20	−0.84	0.76	0.87
Identity self-esteem	4	3.94	1.51	1.00	7.00	0.00	−0.55	0.84	0.89
Perceived disease vulnerability	13	3.96	0.89	1.47	6.73	0.04	0.29	0.80	0.88
Propensity for collective assembly	11	4.19	0.86	1.33	6.24	−0.33	0.06	0.86	0.92
Economic anxiety	18	10.3	9.74	0.00	36.00	0.68	−0.73	0.95	0.96

Note. k = number of items per measure. M = mean. SD = standard deviation. Min = minimum observed score. Max = maximum observed score. α = Cronbach's alpha. ω = McDonald's omega.

It emerges that:

- Age was negatively correlated with economic anxiety (r = −0.13, SE = 0.04, p = .002).
- The difference between men and women was small (β = 0.07, SE = 0.09, p = .462).
- Black respondents reported more economic anxiety than did others (β = 0.49, SE = 0.16, p = .002) and White respondents less anxiety compared to others (β = −0.22, SE = 0.11, p = .035).
- Being retired (β = −0.80, SE = 0.09, p < .001) or disabled (β = −0.80, SE = 0.09, p < .001) were negatively associated with economic anxiety. Pairwise comparisons across categories of employment using Tukey's range test indicated that retired adults reported less economic anxiety than employed adults (Cohen's d = 0.83, p = .038) and students (Cohen's d = 1.69, p = .048).
- Adults who earned greater than $75.000 a year reported less economic anxiety than adults who earned less (β = −0.33, SE = 0.13, p = .014).
- Economic anxiety was not significantly different across other income brackets.

- Source of income was significantly associated with economic anxiety, such that earning a salary was associated with greater anxiety (β = 0.26, SE = 0.09, p = .004), and earning an hourly wage was associated with less anxiety (β = −0.21, SE = 0.09, p = .022).
- Using Tukey's range test, pairwise comparisons (salary vs. hourly vs. other) indicated that adults who were paid hourly reported less anxiety than adults who earned a salary (Cohen's d = 0.25, p = .025).
- Average economic anxiety was lower for those who did not have any children living in their home (β = −0.47, SE = 0.09, p < .001).
- Compared to having one child, economic anxiety was lower for those who had no children living at home (Cohen's d = 0.52, p < .001).
  Compared to having two or more children, economic anxiety was not significantly different from those with only one child (ps > .05).
- Economic anxiety was not significantly different across levels of educational attainment, marital status, or number of adults living at home (ps > .05).

Pearson's correlations and Kendall's tau are reported in **Table 2.10.**

Table 2

Zero-order correlations between individual difference variables and economic anxiety about the COVID-19 crisis.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1.Conscientiousness	1.00	.00	-.40***	.23***	.24***	-.16***	.27***	.19***	.03	-.02	-.02	-.15***
		(-.02, .15)	(-.54, -.41)	(.15, .31)	(.16, .32)	(-.25, -.08)	(.19, .35)	(.10, .27)	(-.12, .06)	(-.12, .06)	(-.10, .07)	(-.23, -.08)
2.Agreeableness	.07*	1.00	-.15***	-.29***	.04	.03	.05	.09*	.11*	.11*	.17***	.03
	(.02, .12)		(-.25, -.06)	(-.37, -.21)	(-.02, .13)	(-.06, .11)	(-.03, .14)	(.01, .18)	(.02, .19)	(.02, .20)	(.08, .23)	(-.07, .12)
3. Neuroticism	-.40***	-.12***	1.00	-.21***	-.44***	.24***	-.40***	-.17***	-.02	-.02	.14**	.28***
	(-.45, -.35)	(-.18, -.07)		(-.29, -.13)	(-.51, -.37)	(.14, .33)	(-.47, -.33)	(-.25, -.08)	(-.11, .06)	(-.11, .06)	(.04, .23)	(.18, .38)
4. Openness	.21***	-.15***	-.18***	1.00	.24***	-.10*	.15***	.10*	-.01	-.01	.13**	-.12**
	(.16, .27)	(-.25, -.13)	(-.24, -.12)		(.16, .32)	(-.18, -.01)	(.17, .33)	(.01, .19)	(-.10, .07)	(-.10, .07)	(.03, .22)	(-.24, -.01)
5. Extroversion	.20***	.07*	-.31***	.17***	1.00	-.09*	.24***	.06	.10***	.10***	.23***	.00
	(.14, .25)	(.01, .13)	(-.37, -.26)	(.11, .23)		(-.17, -.00)	(.20, .30)	(-.02, .13)	(.03, .24)	(.03, .24)	(.15, .31)	(-.08, .09)
6. Disease Vulnerability	-.12***	.01	.19***	-.07*	-.04	1.00	-.07	-.13**	-.10*	-.10*	-.26***	.25***
	(-.18, -.07)	(-.05, .07)	(.13, .25)	(-.13, -.01)	(-.11, .02)		(-.16, .01)	(-.22, -.05)	(-.02, .19)	(-.02, .19)	(-.32, -.21)	(.17, .33)
7. Membership CSE	.22***	.06	-.30***	.22***	.15***	-.05	1.00	.45***	.25***	.35***	.08*	-.28***
	(.16, .27)	(.00, .12)	(-.36, -.25)	(.16, .28)	(.09, .20)	(-.12, .01)		(.38, .52)	(.17, .32)	(.27, .42)	(.02, .13)	(-.34, -.23)
8. Public CSE	.16***	.08**	-.15***	.12***	.03	-.11***	.45***	1.00	.18***	.18***	-.07	-.24***
	(.09, .22)	(.02, .14)	(-.21, -.09)	(.06, .18)	(-.03, .09)	(-.17, -.05)	(.39, .49)		(.11, .24)	(.11, .26)	(-.13, -.02)	(-.32, -.16)
9. Private CSE	-.02	.08**	-.01	.00	.13***	.07*	.39***	.33***	1.00	.43***	-.05	-.34***
	(-.07, .04)	(.02, .14)	(-.08, .05)	(-.06, .06)	(.07, .19)	(.01, .14)	(.33, .45)	(.27, .39)		(.34, .49)	(-.14, .03)	(-.42, -.26)
10. Identity CSE	-.02	.08*	-.01	.00	.13***	.07*	.35***	.33***	.21***	1.00	.25***	.05
	(-.07, .04)	(.02, .14)	(-.08, .05)	(-.06, .06)	(.07, .19)	(.01, .14)	(.30, .32)	(.27, .39)	(.25, .36)		(.18, .33)	(-.03, .14)
11. Collective Assembly	.02	.13***	.19***	.08**	.17***	.40***	.07*	-.06*	.04	.17***	1.00	.32***
	(-.04, .04)	(.07, .18)	(.02, .15)	(.02, .14)	(.12, .23)	(.34, .46)	(.01, .17)	(-.12, .00)	(-.02, .03)	(.11, .23)		(.24, .39)
12. Economic Anxiety	-.13***	-.02	.23***	-.24***	.00	.29***	.21***	-.20***	-.20***	.04	.22***	1.00
	(-.18, -.07)	(-.07, .04)	(.17, .28)	(-.29, -.18)	(-.06, .06)	(.24, .34)	(.17, .26)	(-.25, -.14)	(-.25, -.14)	(-.01, .10)	(.16, .28)	

Notes. Pearson's correlations and Kendall's rank-order correlations are reported above and below the diagonal, respectively. 95% confidence intervals are reported in parentheses below point estimates. One, two, and three asterisks indicate $p < .05$, $p < .01$, & $p < .001$.

Semi-partial associations with economic anxiety were estimated by regressing economic anxiety simultaneously on demographic variables and each individual difference variable.

These regressions tested whether individual difference variables were associated with economic anxiety after accounting for demographic differences (**Fig. 2.10; Table 3.10**).

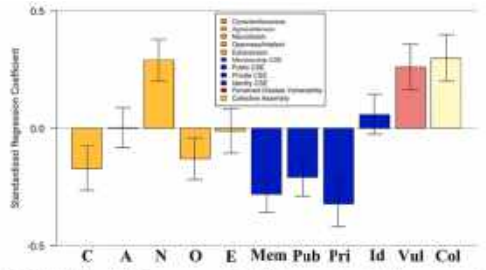


Fig. 2. Individual differences associated with economic anxiety in response to COVID-19 controlling for demographic differences.
Notes. Bars depict the direction and size of multiple standardized regression coefficients. Bars depict 95% bootstrapped confidence intervals.

Table 3
Results of multiple regression models predicting economic anxiety from individual difference variables controlling for demographic factors.

	Economic anxiety: Observed scale			Economic anxiety: Latent factor		
Predictors	β	*SE*	*p*	β	*SE*	*p*
Conscientiousness	−0.16	0.05	<.001	−0.17	0.05	<.001
Agreeableness	0.00	0.04	.973	0.00	0.05	.987
Neuroticism	0.26	0.04	<.001	0.29	0.04	<.001
Openness to experience	−0.12	0.05	<.001	−0.13	0.05	.006
Extraversion	−0.01	0.04	.782	0.01	0.04	.831
Membership self-esteem	−0.27	0.04	<.001	−0.28	0.04	<.001
Public self-esteem	−0.20	0.04	<.001	−0.21	0.05	<.001
Private self-esteem	−0.30	0.04	<.001	−0.32	0.05	<.001
Identity self-esteem	0.05	0.04	.241	0.06	0.05	.222
Perceived disease vulnerability	0.23	0.04	<.001	0.26	0.05	<.001
Propensity for collective assembly	0.26	0.04	<.001	0.30	0.05	<.001

Notes. Demographic factors were included as exogenous covariates. β = standardized multiple regression coefficient. *SE* = standard error. *p* = probability of the estimated coefficient if the null hypothesis is true.

Most central to the hypotheses were the two individual differences that related most directly to the pandemic itself — perceived vulnerability to disease and belongingness from collective assembly.
Controlling for demographic factors, both still positively predicted economic anxiety (**Table 2; Fig. 2**). Moving to collective self-esteem, which also may bear on the economic outcomes of the COVID-19 pandemic:

- Racial/ethnic membership esteem was negatively associated with economic anxiety, as were the public and private self-esteem subscales.
- Collective identity self-esteem was not significantly associated with economic anxiety.
- Three personality characteristics were associated with economic anxiety after controlling for demographic variables.
- Conscientiousness and openness to experience negatively predicted economic anxiety whereas neuroticism was a positive concurrent predictor.

In order to assess the unique contributions of individual differences in explaining economic anxiety due to COVID-19, a final model regressed economic anxiety on all demographic and individual difference variables simultaneously.
In this way, the demographic and individual difference variables must compete with one another to explain variation in economic anxiety.

In that model, belongingness from collective assembly (β = 0.23, SE = 0.06, p < .001), racial/ethnic membership self-esteem (β = −0.16, SE = 0.07, p = .016), racial/ethnic private self-esteem (β = −0.21, SE = 0.07, p = .002), and neuroticism (β = 0.15, SE = 0.05, p = .007) continued to be significant concurrent predictors of economic anxiety.

So, only these four individual differences variables are predictors of economic anxiety. It emerges that younger adults tended to report greater anxiety than older adults, because of the work position, as younger probably have started to work not long time ago or have already a work career to face.

Black respondents reported significantly more anxiety, whereas respondents without children living at home reported less anxiety, for the fact that they have less expenses and less concerns at home.

Low collective self-esteem, low conscientiousness, and low openness to experience were associated with greater economic anxiety, because of psychological reasons, as well as high neuroticism, perceived vulnerability to disease, and belongingness stemming from large group activities, they too associated with greater anxiety.

In conclusion, these results can be explained by connecting socioeconomic status with self-esteem, so between the position you have in the society and your mental status.

CHAPTER 11 - ECONOMIC, SOCIAL AND POLITICAL ISSUES RAISED BY PANDEMIC

The adverse economic consequences of new forms or types of diseases can be severe given the high degree of interdependence in economic activity in modern economies. For example, the absence of workers from work due to such infections, or the risks of these infections, can disrupt production at the workplace level. As well, supply chains are liable to be broken or disrupted by these pandemics, and in addition, they usually have negative effects on the aggregate demand for commodities.
This is evident from the COVID-19 outbreak which has resulted in a major worldwide economic depression.

Contagious diseases capable of becoming pandemics can take varied forms and therefore, appropriate policies for controlling them often differ.
Determining appropriate economic policies to respond to the outbreak and human-to-human spread of COVID-19 has proven to be extremely challenging because major measures to stem the level of infections and death rates from the disease involve a high economic cost in terms of the levels of income and economic production forgone. These control measures have included the isolation of individuals, restrictions on gatherings and on travel.
They were seen as necessary to flatten the upward trend in the curve of infections and reduce the increase in deaths and to enable hospitals to increase their capacity to provide for patients requiring hospitalization.

Fig. 1.11 is helpful for conceptualizing one of the economic problems, namely those involved in flattening the infection curve.

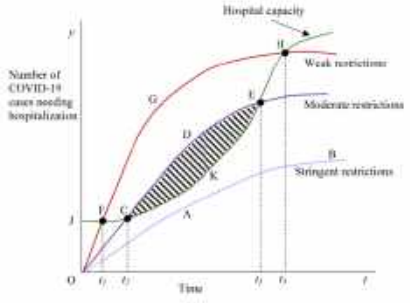


Fig. 1. This figure is used to illustrate a choice problem involving COVID-19 patients needing hospitalization.

Curve JKEH represents the capacity of the hospital system to admit and care for patients requiring hospitalization for COVID-19.

It might be of a logistic form because the initial expansion of this capacity takes time and once physical capacity ramps up, increasing scarcity of qualified staff to operate hospitals can become a major constraint.
Three different hypothetical functions correspond to the number of persons requiring hospitalization due to COVID-19 infections — the higher the curve, the greater the number needing to be hospitalized.
Each also corresponds to different levels of social restrictions imposed by the government to limit the spread of COVID-19.
Curves OAB, ODE and OGH correspond respectively to substantial, moderate, and weak social restrictions to limit the spread of this disease.
As a result of the most severe restrictions, the hospital system would be able to accommodate all COVID-19 patients requiring hospitalization. Indeed, in this case hospital over capacity occurs.
In the other two cases, hospital capacity is exceeded for a period of time and to a greater extent, the weaker are the social restrictions and precautions designed to reduce the transmission of the disease.
In the case of moderate restrictions, hospital capacity is exceeded between t2 and t3 with the number of COVID-19 patients in need of hospitalization but unable to be admitted is equal to the difference between the segment CDE of the curve of COVID-19 patients requiring hospitalization and the segment CKE of the capacity of the hospital system to accommodate these patients.
If weak restrictions and precautions are taken to limit the occurrence of COVID-19, then the period for which hospital capacity is exceeded increases to t4–t1. Consequently, the number of needy cases unable to be hospitalized rises from an amount indicated by the eye-shaped hatched area bounded by CKED to that enclosed by FKHG. This raises the question of how should COVID-19 sufferers be prioritized for admission if the capacity of hospitals to accommodate them is exceeded?
One possibility is to give priority to admitting those COVID-19 sufferers to hospital who have the largest increase in the expected value of their lives if they recover from COVID-19 as a result of being hospitalized.
This can be formally analyzed as follows:
Vi = expected value of the life of the ith sufferer from COVID-19 if this patient does not die; **PHi** = the probability of the ith COVID-19 sufferer recovering from the virus if admitted to hospital; **PNHi** = the probability of the ith COVID-19 sufferer's recovery if not admitted to hospital.
Then the expected increase in the value of admitting the ith COVID-19 sufferer to hospital is **ΔE[Vi] = (PHi – PNHi)Vi**

A challenging moral and valuation issue is how to determine Vi.
Also, in many circumstances, the change in the probability of survival as a result of hospitalization can be uncertain.
Sometimes, hospitalization may actually increase the probability of death, and it is best avoided in these cases. Several different possibilities exist for determining Vi. One criterion for prioritizing health (frequently used by health professionals) is based on the **quality of life years (QALYS)** available to patients.
It requires to estimate the quality of life years each sufferer is likely to have left if the individual recovers from the disease.
On this basis, other things being equal, the fewer are the number of years a sufferer is predicted to survive for after recovery from the virus, the lower would be the sufferer's Vi-value. But this approach could discriminate against the elderly and those with chronic health conditions, that are more prevalent in some ethnic minority communities also and so this criterion could also discriminate against these groups.
It is necessary however, to bear in mind that not all individuals in these groups have an equal chance of recovery if they are provided with hospital care and the remaining QALYS of individuals of the same age can be difficult to determine and can vary considerably.
Furthermore, it should be kept in mind that COVID-19 victims belonging to some groups (such as the young) have a high chance of recovery without hospitalization (or treatment) and on average, hospitalization may do little to increase their probability of recovery.
Consequently, even though their Vi-values are high, the change in their expected Vi-values could be much lower than for those patients (such as the elderly or those with underlying health problems) who contract COVID-19.
This lowers their priority for hospitalization given the previous equation.
Therefore, it is probably rational for doctors to monitor individual patients and to be more ready to recommend admission to hospital of those patients who are likely to have the greatest possibility of benefiting from hospitalization.
Possibly, elderly patients (and those with underlying health problems) should be admitted early when they contract this disease whereas others could be monitored with admission only being recommended when it becomes evident that they will succumb to this disease in the absence of hospitalization.

Another approach to prioritizing hospital admissions of those infected by COVID-19 is to make these admissions dependent on their **willingness (and ability) to pay**.

Therefore, this approach discriminates against the poor, and other socially disadvantaged groups. Many of these are poor or comparatively poor, for example, many of those who are elderly and those belonging to particular ethnic groups. They are also more likely than the remainder of the population to have chronic health problems. So, there is a high probability that this economic criterion (as well as the use of QALYS) will disadvantage the elderly and some ethnic communities, or more generally the poorer members of society in gaining access to medicine and hospital services.

Looking back at Figure 1, in the absence of mitigation measures, it is believed that the number of active cases of COVID-19 rises initially at an exponential rate (as a function of time) but eventually reaches a maximum (once a large proportion of the population has been infected).
It can then be expected to decline at a slower rate than in the upsurge of cases. Consequently, the curve of infections exhibits kurtosis, the initial exponential growth rate in the incidence of COVID-19 is very high and the doubling time of infections is very short. If containment or mitigation is not started early after an initial outbreak, it is very hard to contain the virus because small numbers of infected persons rapidly infect a very large number of individuals, and tracing active cases becomes difficult, making the disease very hard to manage socially. It is also the case, that early relaxation of mitigation measures can allow a rapid resurgence of the disease. Control measures need to be kept in place to ensure that the basic reproduction rate of infections is less than unity if the number of infections is to be lowered. An infection rate of unity corresponds to an approximate stationary state, so, if less than an existing stationary state is desired, a hard lockdown may be needed to reduce the numbers infected, that is the adoption of a suppression strategy, but the economic and psychiatric costs of this are likely to be high.

Given that unemployment rises and aggregate economic activity falls when social restrictions to reduce the occurrence of COVID-19 are more stringent, governments have been faced with a difficult trade-off problem; namely how much reduction in employment and economic activity to accept as a result of allowing more liberal opportunities for social interaction.
However, solving such a problem is difficult because of the uncertainty about many of the dimensions of a new pandemic, and the problem of devising a widely or universally acceptable social welfare function.
Despite this, exploring the potential trade-offs and opportunity costs involved in such measures remains important as a basis for rational decision-making.

Social choice is complicated by the fact that collective responses to new pandemics, such as COVID-19, are significantly influenced by prevailing political systems and by the diverse objectives of rulers.
In the case of COVID-19, this has resulted in noticeable disparities in the methods adopted by different governments to manage the occurrence of COVID-19 infections and in the stringency of their precautionary social restrictions.
Furthermore, especially in democratic countries, controls seem to be subject to political seesaw of public opinion.
When death rates are high, government action to adopt measures to reduce them become commonplace but once death rates fall, then there are usually strong demands to ease social restrictions. This can set off a new wave of infections with the process repeating itself once again, like in some countries (e.g. Spain and France).

Figure 2.11 shows a hypothetical relationship between the number of COVID-19 cases and the level of economic activity and supposes that the number of cases rises as the stringency of social controls on the spread of the virus are weakened.

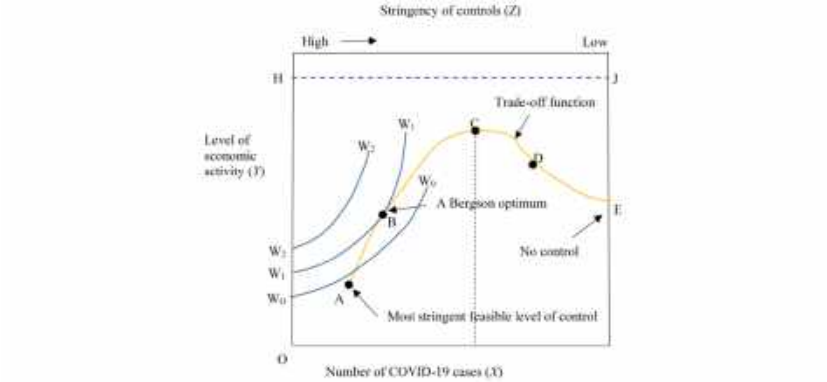


Fig. 2. A theoretical illustration of social choice and the trade-off between a higher number of COVID-19 cases (less stringent social restrictions) and the level of economic activity.

The relationship ABCDE represents the assumed relationship between the stringency of controls (Z) as well as the number of COVID-19 cases (X) and the level of economic activity (Y).
Stringent controls result in a low level of economic activity due to the closure of many businesses and restrictions on the mobility of individuals.
Weak controls are also likely to depress production due to absences from work in those cases where production requires employees to be at a workplace, as crowding in workplaces also tends to increase the risk of COVID-19 infections.
The line HJ represents the assumed level of economic activity that would prevail in the absence of COVID-19.

The trade-off nature of curve ABCDE can be correlated between the loss in output (GDP) and the number of COVID-19 deaths, which in turn is related to the severity of social controls designed to limit the occurrence of the disease.
Output loss is also related to the incidence of the disease, and number of deaths are positively related to the number of COVID-19 cases, so if:

- m = mortality from the disease;
- X = number of COVID-19 cases;
- Then: **m = f(X)**

This equation can vary in every country, depending on health care available and healthiness of different groups.

The loss in output due to the disease showed in Fig.2 is equal to the difference between line HJ and the trade-off function ABCD.
If the relationship ABCDE in Fig. 1 is represented by the function: **Y =g(X)**, then the loss in output (L) due to COVID-19 can be represented by: **L=Y0 –g(X)**, where Y0 represents the level of output in the absence of COVID-19.
It is rational to suppose that there is a social preference for fewer COVID-19 cases and for a higher level of economic activity. So, it is irrational to choose a combination on the segment CDE of the trade-off function, ABCDE, and the optimal choice will depend on the nature of the preference function adopted. Given the Bergson-type of preference function represented in Fig. 2 by the indifference curve W0W0, W1W1 and W2W2, the optimal choice corresponds to point B, that will reflect the preferences of a nation's political leaders.
This function may alter during the course of the pandemic as political pressures change. In fact, in extreme cases, their indifference curves are almost horizontal and social restrictions are adjusted solely to maximize the level of predicted economic activity with no regard being given to the number of COVID-19 cases and deaths. At the opposite end of the spectrum, their indifference curves are almost vertical, giving the priority to avoiding COVID-19 cases and deaths.

Acemoglu et al. (2020) develop a model from which they conclude that the isolation of individuals belonging to particular social groups is an effective means of limiting the number of deaths from and the incidence of COVID-19 and the economic loss from the virus. They claim that a policy of isolating the elderly from other age groups (which they describe as ''group distancing'') is a very efficient means for approaching the trade-off frontier between the incidence of COVID-19 and the loss in output due to the disease.

Their modelling focuses on three age groups: those aged 20–49 years, 50–64 years and 65 and over which they describe respectively as young, middle-aged and elderly. They estimate that the corresponding fatality rates for each of these groups is 0.001, 0.01 and 0.06 respectively.
All these data are derived from South Korea, where standard of facilities is high, but in other countries with poorer hospital facilities the death rate is higher.
The modelling only focuses on the economic impact of fatality rates and does not take specific account of economic losses which occur when individuals are affected by the virus but do not die, and this is another limitation of their technical analysis.
Acemoglu et al. also suggest that in addition to targeting the elderly for lockdown, it would be beneficial to target other social groups that are vulnerable to COVID-19, like those with co-morbidities.
In this case there is a discrimination, because economically the poor may not be able to survive a lockdown unless provided with financial support by the state, and morbidity tends to increase with poverty and chronic illness is also often a source of poverty. In the absence of government financial support, most of the poor have little option but to work (if they can) even if they have COVID-19 or are awaiting the results of testing for it. They are also more likely than the well-off to be employed in occupations where they are unable to work from home, for example in cleaning or as taxi and bus drivers.
In fact, there is a case for government income support to be given for all those infected by COVID-19 or those awaiting test results if they do not have sick leave entitlements. Otherwise they may fail to remain in isolation or quarantine and spread the virus.

There are two aspects to be considered in restricting liberty:

1. The extent to which individuals should be able to decide the degree of risk they want to take in contracting the virus.
2. The ability of an individual to spread the occurrence of the virus, that is the negative external effects arising from the individual being permitted liberty.

Although some restrictions on liberty may be defensible on social grounds, others could be difficult to defend.
The latter include restrictions in cases where the behavior of individuals poses little or no risk to others, but which heighten the risk of those granted greater liberty being infected with the virus.
In these cases, it might be argued that taking this extra risk could pose a burden to society if the individuals involved become infected with the virus.

If they need medical care or hospitalization as a result of being infected, this would put extra strain on the medical and hospital system.
If the state subsidizes or provides free medical care or hospital services, this will add to the costs that have to be met by taxpayers.
In addition, if the contacts of an infected person are quarantined for a time, this adds to external costs as does the cost of tracing their contacts.
Furthermore, an extra economic burden can be placed on family members if one of its members is infected by COVID-19.
Any society which allowed complete personal liberty would be lawless and lacking in order, that would have negative economic repercussions due to individuals being allowed to act (without limitation) in ways which have negative effects on others. So, excessive personal liberty poses a threat to the stability of societies and to the maintenance of social and economic welfare.

To control COVID-19, for example, some restrictions on the freedom of individuals involve little cost and loss of freedom, such as the wearing of masks in crowded places but the social benefits may be considerable, but also some types of blanket lockdowns involve a considerable restriction on personal freedom and the social gains might be small. The costs to individuals of restrictions on their liberty appear to vary with the social structure, nature of economies and the stages of their economic development. In fact, higher income countries are in a better position to provide social safety nets to their citizens to support them if they are restricted in their ability to work as a result of COVID-19, but there is little scope for cushioning these effects in low-income countries such as India. In these countries, stringent social measures to control COVID-19 imposed a heavy burden on the poor who need to work to earn enough income for their survival. The choice of government policies to control COVID-19 are significantly influenced by political pressures. Initially, many governments were slow to impose social restrictions to limit the occurrence of COVID-19, but, as infections and the death rate rose, political pressure to impose social restrictions to limit the occurrence of the disease mounted.
However, political pressure subsequently intensified to ease these restrictions in order to reduce the economic cost of the virus, and, as a result, many governments responded by altering their Bergson-type preference functions (Fig.2) to take account of these political pressures.
In addition, with better knowledge about COVID-19 and of the means to treat it, greater hospital capacity and the occurrence of fewer cases, shifts in the trade-off function ABCDE favored less stringent control measures in some countries.

The speed and nature of recovery from the pandemic will be hampered both by supply-side and demand-side factors.
On the supply-side, many manufacturers and other businesses depend on international supply chains for sustaining their economic activity, and this raises a synchronization problem.
Nations that are ready to and want to resume production of commodities (but rely on international supply chains for their production) may find that their ability to do so is restricted because their international suppliers cannot meet their demands due to continuing closures or because of their reduced output as a consequence of COVID-19, and international deliveries may also be limited by disruption in transport services, e.g., air services.
The disruption of supply chains, however, appears to have been more severe in the earlier stages of the pandemic than later.
Just-in-time international supply chains have had to be replaced by others or by increases in domestic production.
On the demand-side, aggregate consumer expenditure is likely to recover slowly due to lower disposable incomes and because consumers do not purchase commodities that increase their risk of contracting COVID-19 or purchase lots of these commodities.
Similarly, many individuals will continue to avoid activities (for some time) that involve mass gatherings.
Demand is only likely to recover slowly for the commodities produced by those industries that sell discretionary commodities and for which their purchasers face increased risks of contracting COVID-19.
Consequently, the economic recovery of some industries will be constrained by both of these factors, that is, by reduced discretionary buying and by risk-avoidance in purchasing commodities.
So, those industries that recover slowly after the end of the period of socio-economic hibernation designed to control COVID-19 will also retard the recovery of those industries with which they have a high degree of economic interdependence.
Many nations may begin to adopt protectionist policies to counteract a reduction in their level of economic activity and employment brought about by the pandemic, delaying global economic recovery, and disadvantage countries (such as Australia and Germany) which depend heavily on exports to generate their level of economic activity and employment.

In conclusion, as regards the moral and ethics, the modelling of *Acemoglu et al.* give to the lives of the elderly and those of low-income earners (the poor) a low value compared to the lives of others.

How we can value the lives of humans based on how much they contribute to economic production?

Even the QALYS and the willingness to pay approaches tend to assign a lower value of life to the elderly, and possibly to those who are poor and have serious morbidity problems.

However, the lives of those individuals may have value for others.

Should that be ignored?

Furthermore, in the case of the elderly, should their earlier contribution to the welfare of others be ignored in considering the value of their lives?

It must be careful not to smother the economic analysis in technicalities that cause the lose sight of ethical issues of this kind, and its ethical implications and limitations should be made clear and debated.

How should we value human life? To what extent are economic valuations of it morally and socially acceptable?

In relation to this matter, it would be useful to have further studies of the extent to which individuals would be willing to save the life of others and why.

The value placed on the lives of different social groups, e.g. the aged, probably varies in different societies, may alter with the passage of time and could weaken as societies become more individualistic, for instance, due to increased pervasiveness of the market system and the greater geographical mobility of individuals.

CONCLUSIONS

This work focused on everything that this pandemic has brought to our world.
As for the economy, the coronavirus has affected us deeply from all sides and most of those who had a business or who worked for it, but in general all of us, have not been able to prevent it from dragging us into the dark, some more, some less.
For example, all those jobs that require the physical presence of workers have been hit hard by the pandemic, as they could not use the new working method called "smart-working".
On the other hand, those who were able to use it certainly experienced "better days", despite the salary and subsidy issues, which affected most businesses.
Smart-working, together with the entire digital world, has been a salvation for many, as it represented a turning point in the world of work, capable of allowing people to earn their salary from home, in safety, especially while outside the world was crumbling to pieces.
From now on, certainly many companies, in the sectors that allow it, will use this working method more and more widely.

Regarding the government system, this pandemic has taught us that we must be ever more ready for such situations and, above all, we must respond more quickly to them.
We spend a lot of money preparing for war, military budgets are large and new weapons get created, but outbreaks belong right there with war.
So, we need to invest on our healthcare system, we need to do more to prevent pandemics from happening in the first place, because when they comes out, we always look back and wish we'd invested more on it, but very quickly our memory fades and other priorities are getting the resources.
Also, live animal markets are remained popular in China and other countries, giving animal viruses all kinds of opportunities to mix, mutate and jump to humans, but this is only one problem among the thousand that there are.

We should have been more prepared, but when it comes to technology, science, and coordination, we've also never been more prepared.
In fact, all the world is working constantly and making progresses every day, in order to find the solution to this situation, and all together we will win the race against COVID-19.
We know what it takes, because we've been in this race since life on Earth began, and a virus hasn't beaten us yet.

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