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Making Sense of the Covid-19 (SARS-CoV-2) Pandemic

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Abstract

This monograph is a compilation of multiple research I made conducted during the first wave of the Covid-19 pandemic, from March to May 2020 included. The research is on going, and has evolved through times along the diffusion of the virus, and along the new discoveries around the epidemiology of the disease and its impact. By design, this has been work- in-progress, with inevitable shortcomings, errors, but with a purpose of "80-20", and with a view to share possibly important insights as long as the "covid 19 crisis" evolves. I am grateful to a long list of people who provided feedbacks as well encouragements along the way. I hope that some of the ideas and the fact base expressed herein have been useful to the current debate on how to control this pandemic.

Keywords: Covid-19, pandemic, crisis, social distancing, lockdown, new normal.

JEL: A19, B55, D62, D69, E27, I19, I31

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1. Three key Covid-19 indicators to curb a potential of 20 million human fatality

March 2. Today's major headline across the globe is the spread of the new coronavirus, Covid 19, soon to affect 100,000 persons in the coming weeks since its start by December 2019 from a market in the Hubei province, in China. The concern is high among the population as to how Covid-19 will unfold, given health and economic consequences. The number of Google searches increased 100-fold in the last six weeks, across the planet and many stock marketplaces went down significantly with loss of more than 10% from their peak during the last week of February, as a likely fear that the Covid 19 may become a ajor pandemic.

In this article, I focus on three main indicators whose current ranges **may imply a most probable case of a world pandemic with a power to be affecting in the range of 20 million humans under no interventions** . Of course, figures are early and may change, for the better (but also for the worst). The better may evidently come out **from an active and rapid management of actions at global level to curb those three main indicators of the Covid-19**. **Such actions are today patchy;** a **more synchronized way to reflect our globalized world** is a more promising route to date to curb the pandemics and re-route the world for a better life and growth economics.

An history of viruses

Viruses and their outbreaks are part of our life. But some outbreaks can indeed become significant, mutating to pandemics with extensive and exponential attack on human society, causing major societal disruptions. The plague of Athens caused by typhus started by about 430 years BCE, and led to the fall of the Golden Age of Athens. The Antonin Plague (at about 180 years CE), caused by measles or smallpox, devastated the Roman Empire (see *Hurbin, 2011*).

Not that far away from us, the Spanish Influenza broke out by 1918, and killed between 40-70 million people worldwide in 10 months, when it finally retracted. Ebola had a series of outbreaks in the last decades, mostly in Africa. Excluding the outgoing one in Congo, the last one outbreak between 2003 to 2006 killed between 50% to 70% of those infected (*Vogel , 2014*). The same fatality rate was visible for HIV infected persons, before antiretroviral drugs were found to contain the speed and attack of the infection. Yet, more than 20 million people out of 40 million sufferers have passed away due to HIV in

20 years according to UNAIDS. HIV/AIDS might be the main cause of death in some sub-Saharan countries such as Zimbabwe or South Afrika (*Mboup et alii,2006*).

Viruses outbreaks are also not rare. They may have multiple short waves, like the 3 waves of the Spanish flu in 1918-19. They may have much longer cycles and may can come back with vengeance—as the bubonic plague did in multiple cycles from 1300 CE to the 18th century; the Cholera, with just less than 10 cycles since the pandemic of 1820.

What about influenza ?

The above viruses examples are the long tail of human damages—they are many other cases where viruses outbreaks had of course much narrow impact. Geographically, Ebola was contained in Africa for 99% of cases and largely within 6 African countries, and particularly, Guinea. The total fatalities were about 11,000 people at the time the World Health Organization (WHO) called the end of the outbreak. Guinea witnessed the largest fatality rate (66% of all infected people).SAR,S which broke out by November 2002, reached 37 countries by end of July 2003, killed less than 1000 people, while the center of gravity was mainly China and Hong Kong (70% of the total fatal cases worldwide). By 2012, the MERS-Cov virus centered more about the Middle East even if it reached 27 countries, and the number of fatalities was less than 1000 in the range of SRAS death outcomes worldwide.

While the Influenza family, to which Covid 19 belongs, is usually less lethal than many other viruses, it is also more contagious, and its attack rate is often extensive, that is, it is affecting a significant larger amount of people (see Table 1). Large attack, even with low fatality rate may still make big number. Hence, typically, the flu seems to kill between 300,000 to up to 700,000 people every year according to most estimates published[2] or roughly up to 0,01% of population worldwide.

Some cases are also stronger than this average. About 6 cases seem to prevail with excess mortality rates in the range of 0,03% to 0,1%, since the 1700s according to the WH. This would lead globally to 2 to 7 million a year of people passing away due to influenza (*Fan et al., 2018*). The Asian Flu (H2N2) in 1957 killed a proportion between 0,04% and 0.27% of the population, while it was 0.01% to 0.07% in the case of the Hong Kong population during years 1968-1969.

[2] *https://www.pbs.org/newshour/health/cdc-says-more-people-die-of-influenza-worldwide-than-who-estimated*

Table 1 : High level influenza driven fatalities, estimates

Year	Virus	USA	Worldwide
1918	H1N1	between 500k to 1 million	between 40 million to 70 million
1957	H2N2	150,000	> 2 million
1968	H3N2	70,000	> 2 million
2009	H1N1	15,000	300,000

For reference:

Norma flu	30,000 to 80,000	300,000 to 700,000

Source : Author's own computation based on WHO, Lancet, Wikipedia, CDC

Note: Numbers readjusted to current 2019 population, as per IMF data

The three key figures that matter for Covid-19

Regarding Covid-19, the question is whether it would be a replica of a « normal » (call it mild) flu, or will it more like the ones with excess fatality rates (call them a serious flu), or worse, like a *black swan type of the Spanish flu*. There is still lots of uncertainty as how this will play out.

Three key figures, as given by **the average reproduction rate, its variance, and the fatality rate** are critically important to watch out, as their combinations will provide the likely ranges of how Covid 19 will affect our lives and our economies. Based on current range of figures, it looks like the Covid 19 might indeed be what we might call a *serious influenza* pandemic, -hopefully unlikely to be a reproduction of the Spanish influenza, but we are afraid, enough to become a major cause of death worldwide, if nothing is done to limit the pandemics.

Key figure 1. Fatality rate : Enough to take notice (range 0,5% to 2%)

High fatalities by influenza standard

Out of a population of 60 million in-habitants in the Hubei province, more than 0,1% has been infected to date and the fatality rate is in the north of 2 %, based on (possibly understated) official figures. Looking at Wuham, a city of about 11 million habitants according to Chinese statistics, which is the epicenter of the disease origination, and which concentrates 85% of the cases in the region, the contamination is 0,4% and the fatality rate is slightly higher at 2,5 to 3%.

Those statistics are rather crude, and likely inflated if the reporting rate is low, even not intentionally, because 80% of Covid-19 cases seem to be mild cases, as reported by WHO. Adjusting from those factors say 50% of the mild/ asymptomatic cases are un-noticed, the fatality rate becomes more like 0.5%, a significant figure by influenza standard.

An early benchmark South Korea, which went for an extensive random testing of this population witnesses such a range of fatality rate (0.5%), while 1% of infected people on the Princess Cruise boat has been passing away to date. This higher figure may be linked to the fact that people were stuck in a rather confined space, and there is ad is proportionate weight of older people enjoying cruises. In fact, the early data on fatality rate linked to Covid-19 show that the virus has possibly mild effect for the population aged below 40 years, but the rate then doubles for every extra decade of life, reaching more than 10% for those adults above 70 years old. **This fatality rate, above 70 years, is as large as what has been observed in the pandemic of the SRAS by 2003**. But let us remember that the SRAS remained confined (37 countries affected in its total course, versus already close to 60 countries to date for the covid-19). As well, it went dormant in just above 6 months, - below the typical time span, **of 9 to 11 months, it usually took for other influenza epidemic cases across the centuries to die out**.

All in all, we conclude that, using the standards of the WHO, this virus can be qualified more like a “serious” disease- in need of watch out and actions to preempt.

Key figure 2. Reproduction rate: More a wide pandemic than a niche (adjusted R0 between 1.3 to 2, with mean at 1.9)

You said R-nought (R0)

A typical metric to determine how broadly people can be infected and whether we have a strong or weak pandemic dynamic is the basic reproduction rate at the start of the pandemic (patient “zero”), called R0. If R0<1, this means that on average, the early infected person passes the virus to less than one other person, and thus the attack is not exponential and dies out. The reverse is obviously true, when R0>1; further, the spread is faster the higher R0. Rt is the reproduction rate along time t, and obviously declines below one when converging to the end of pandemic, when people have been infected, or when people develop a natural immunity to the system. Rt can also be influenced by medical and no medical interventions though times, such as the containment put in place in Wuhan by late January.

One should also note, that **given the early start of the pandemic as an exponential curve, a very high R0 creates a health challenge or deploying enough resources to sustain the care of infected individuals**. R0 typically above 3 are really challenging if typical incubation and illness periods are more than one week. Looking at benchmarks, the Covid 19 reproduction rate computed by multiple studies is relatively imprecise but implies a fast rate of diffusion.

a) At the start of the 2002 SARS (a proxy for R0), SARS RO was computed to be in the range of 2.2 to 3.6; Rt declined to 1.6 to 1.8 before the peak in Asia. The average Rt was quickly at about R0=0.95 worldwide, which limited the outbreak to the East. The MERS-Cov, which broke out in the Middle East by 2012 had a low R0, at less than 0 .5 in Saudi Arabia and Middle East at large. Ebola by 2014, is said to have a reproduction rate, R0 between 1.5 to 2.3, shifting in later stage, Rt, to about 0.7. Regarding 2009 H1N1, the average R0 started at 2.5 to 3, to quick go down to Rt= 1.5. The 1918 Spanish influenza R0 during its growing phase was 1.8 to 4, and declined after peak, rather quickly with Rt- 0.5.

b) There is today a large variety of estimates for the Covid 19, from about ten recent academic studies recently published. The range remains rather large given early days, and the imprecise figures of contaminations. The R0 estimates nevertheless range between 1.5 to 6.5, with a mean of R0=3 depending on geographical scope and time. Specifically, R0 estimate for Wuhan varies by a factor of 2, between 1.5 to 3; likewise for China and overseas with estimate between 2.2 to 3.7—"world" R0 is between 3 and6, but it is likely biased given robustness of data and that main driver to date in terms of cases outside China, is Iran).

c) However, we note from other epidemics, that the average range of R0 when computed, after knowledge of the full cycle, has been typically, adjusted downward, up to 40% lower than in the early phase estimates of the outbreak. Making the adjustment to Covid 19, this would imply that the range for China and world is likely to be in between 1.3 to 2, with a mean at 1.9.

Key figure 3. Variance of reproduction. Superspreaders likely the rule (Top 20% accounts for between 40% to 70% of secondary infections).

Everyone spreads equally in the Kermack and McKendrick formula

As just said, we observe an epidemic with sufficient level of sustained transmission, R0 > 1. The computation of R0 is not possible bottom up, but is usually derived through a formula pioneered by Kermack and McKendrick close to one century ago (*Kermack and McKendrick,1927).* Under some key assumptions, an epidemic with a given R0 will infect a fixed fraction R(∞) of the susceptible population by solving their formula :

$$R(\infty) = -1/R0 * \ln[1-R(\infty)] \quad (1)$$

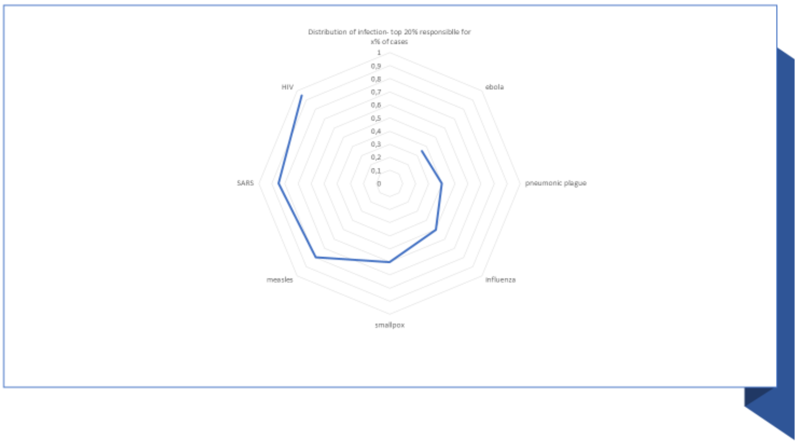
Equation (1) indeed shows that when R0<1, the final outbreak size converges to 0 but the outbreak is increasing as 1−exp(−R0) when R0 >1, and in the limit, infects the entire population. **One key assumption beyond this mathematical approach may however to be adjusted, as if not, may provide a bias towards *too large pandemics*. The formula above is indeed based on the restrictive idea that all individuals are *equally* susceptible to transmit the virus**.

Accounting for super-spreaders versus limited spreaders

If the heterogeneity in infection is large, the outbreak may actually weaken as the strength of the influence may be lower as some points of the diffusion. SARS, as we mentioned, has solid average R0, except worldwide, and a large fatality case, but there seems to have been a large heterogeneity in secondary infections, making possible to quickly containing the outbreak.

Usually, the world of interaction and influence behaves more like a Pareto distribution (where the top 20% of individuals, called the super)spreaders, are responsible for 80% of the connection/influence), rather than an uniform distribution. Regarding viruses, the same holds true, eg Measles infection is a Pareto distribution (see *Lloyd Smith et al, 2005, "Superspreading and the effect of individual variation on disease emergence," Nature*). The top 20% typically contribute like 85% for SARS, while the figure is 95% for HIV, creating a distribution even more skewed than a Pareto distribution. The distribution is much less unequal for smallpox (top 20%=60%) and for Ebola (top 20%= 35%). (See Figure 1).

Figure 1 : Heterogeneity in disease spread, indicative estimates



Source: Author's own, Lloyd Smith et al., Lit search

Getting the distribution skewness right for a disease has significant impact on the potential estimate of diffusion. For example, moving from a distribution such as observed for Measles to one observed for Ebola, will more than double the number of infected cases by with super-spreaders (respectively, under-spreaders) achieve 2.3 (resp. 2) lower (resp.higher) infectious reach (see Brauer, *2019*).

A scan of literature for Covid-19 has been unsuccessful, at this time of writing, that provides an assessment of the distribution type of secondary infections for the virus. Benchmarks for influenza suggest a skewed distribution, in the range of top 20% being accountable for 65% of secondary infections (*Lloyd Smith et al. above*). Using other cases, the distribution may be more homogenous, top 20% contributing 40% of secondary cases (*Hebert-Dufresne et al. , 2020*). Using those ranges, **this means that compared to the mean R0, we may have to discount the total diffusion by a correction factor,** in the range of 40% and up to 70% if the distribution is skewed and (hopefully) closer to Pareto.

The emerging best guess picture for Covid 19: potential without control of up to 20 million fatalities worldwide

Four clusters of viruses

Table 2 provides a high level picture of epidemic difference per virus and injects the current range estimates for Covid 19. Four clusters emerge when looking at the table:

a. The "**niche killer**": one notes that MERS, despite high fatality rate, for instance was a small outbreak, confined to Middle East, and with low and unequal reproduction rates among infected.

b. The “**confined killer”**: The Ebola outbreak was much more powerful but controlled to Africa.

c. The “**global hitter”**; The H1N1 virus has been typically spreading worldwide, …

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d. The “**serial killer”**: but the 1918 flu had much lethal effects on infected and was more consistent in spreading towards secondary infections than the 2019 outbreaks.

Table 2 : three « KPI » Metrics for different viruses (high level)

Year	Virus	scope	mean RO	top20% contribution	Fatalities
1918	H1N1	worldwide	1.8 to 2.2	40%	2%
2002	SARS	Asia	1.6 to 1.9	85%	9/10%
2003	Ebola	Africa	1.5 to 2.5	35%	55%
2009	H1N1	Worldwide	1.5	65%	0.2%
2012	MERS	MiddleEast	0.5	70%	30%
2019	**Covid 19**	**Worldwide**	**1.3 to 2.0**	**40% to 70%**	**0.5% to 2%**

Source : Author’s own computation based on WHO, Lancet, wikipedia, CDC, Nature,

Covid-19: a global hit to control

If we look at the three figures on Covid 19, the virus falls into a solid global hitter. The mean range is similar to the low range of the 1918 H1N1 –but can be higher than in the 2009 outbreak ; the fatality rate is likely half that of the 1918 outbreak but also at least twice the one to date o the 2009 pandemics. The evidence regarding the disparity of secondary contamination is not known to date, but taking the average of range for other influenza virus, we might be mid -way to H1N1 in 2009 and the Spanish flu by 2018.

Using all figure ranges as displayed in Table 3, and assuming an independent normal distribution of each KPI, we infer that the mode just below 20 million fatalities, with a standard deviation of about 5 million less or more casualities

Table 3 : three « KPI » Metrics impact on likely covid 19 evolution

Range				
From	R0 *	skewness	* fatality rate	= total world pop (million)
Low	19%	0.3	0.5%	0,03% (2.5million)
Mean	35%	0.5	1.2%	0,21% (18 million)
High	40%	0.7	2%	0,56% (48 million)

Source- derived from above figures, author's computation

Note the crucial element of this table: this is the **potential of the virus**, **if left freely to attack** (of course unlikely, given the fatalities implied). But this is roughly more than *20* times the traditional burden of the normal, seasonal, flu at potential of 650,000 individuals, (R0 of flu is 1,3; and fatality rate is tyipcally 0,1% as said earlier), and roughly 5 to 10 times, recent pandemic H1N1, in 2009, with R0 at 1,5 and fatality rate at 0,2% (potential of 2 millions).

This potential in million deaths is caused among others by the **multiplier nature, R0, of contagion**. But this is the reason why it is useful powerful to have active intervention by population and by government, to curb the spread the disease, with a mix of medical (antiviral and vaccine) and of non-medical actions (containment; border control, etc). **The multiplier in this case plays the other way round; in the case of for instance H1N1 in 2009, the WHO has finally evaluated a total death toll of just below 300,000, that is, 15% of full potential.**

As another example, the potential of SARS, despite high fatality rate, was restricted by its variance of contagion, and a pandemic restricted mainly to China (and some imports to US an Canada), at 6 million inhabitants worldwide. The final death case is less than 10,000, or a reduction of 99% of the potential. What made the case more controllable in the case of the SARS is three two things: symptoms like fever coincided with period of contagion, making people easily identifiable of being contaminated, and thus be put in quarantine. Furthermore , the high rate of fatality made people naturally afraid of the virus, and hence, used a large plethora of self-protective behavior. In the case of Covid 19, it looks like the latency period before symptoms are revealed may be at least 5 days, while many cases may be mild, even asymptomatic, **making the pandemic much more challenging to control**.

This potential is not to be neglected and is to be the largest cause of deaths in the world for 2020 (see Table 4), or in the top of the list, under history of controlling pandemic influenza in the past.

Table 4 -ranking of casualties, per 100,000 pop, worldwide estimates

1. **Estimated mode Covid 19 (under no action) 210**

2. Ischaemic heart disease, **126**

3. Stroke, **77**

3bis. **Estimated mode Covid 19 (success rate control H1N1 , 2009) 31**

4. Alzheimer's disease and other dementias, **27**

5. Trachea, bronchus, lung cancers, **23**

6. Diabetes mellitus, **21**

7. Diarrhoeal diseases, **19**

8. Tuberculosis, **17**

Source : author's computation, wikipedia

Note: covid 19 fatalities are higher among co-morbid patients, with diabetis, hearth diseases, etc. Thus, it has also extra effects on top diseases, not shown here

In our simulation, and taking the range of our estimates on the three parameters studied, we find that there is further only 1% chance that i will be « as low » as the 1957 H2N2, which already has *double* the number of fatal casualties of what has been seen from the worst normal flu epidemia. The « only good » news is that Covid 19 has only 1% chance to be as lethal as the Spanish flu, but a possible Black Swan is not to be excluded, as part of our range of scenarios, to define the danger of the disease.

A coordinated global action plan may be required

As the epidemy continues its course, it is thus critical to act in order to avoid the predictions set by the three current figures.

Multiple actions can be undertaken, like average social distancing measures of closing frequent and large interaction environments (reducing R0), like spotting superspreaders (playing the skewness-, or still by attempting to find good care and protection (playing on fatalities-), with retrovirus might be more timely and a promising route.

As the world is more and more connected, all levers may have to be playing in the same time, and across the globe. If those levers play each to reduce 50% of the burden, the Covid 19 will look like a 1957 disease—an important pandemic, **enough to remember that global management to contain lethal diseases is both necessary and successful.** Hence, it is thus time to scale and synchronize efforts, versus too much wait. **In a subsequent article, we will look at the likely economics of the pandemics, showing that economics add further fuel to the idea of correctly manage as scale against the spread of those types of viruses.**

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<u>Written March 02; revised March 21. All errors are mine. References listed as they are found in the text</u>

2. A « 20 million lives » pay off : How to curb the effects of the Covid-19 pandemic

March 3. In yesterday companion paper, I have mixed the ranges of values of three key fundamental drivers of pandemic development, based on data collected from academic studies and international health organizations such as the WHO to derive a possible distribution of global fatalities arising from the diffusion of Covid-19 virus.

The outcome is that the **potential** of fatalities has a mode at 20 million people worldwide, with 5 million standard deviation, or a pandemic more than ten-fold the severity of a flu pandemia, **if covid 19 is able to continue its curse freely.**

Nevertheless, history of self protection and health policy has usually been able to curb pandemic, even if more difficult with viruses like new forms of H1N1 influenza. Assuming same success rate of pandemic control success as in past (full pandemic being roughly 20% of potential), the current pandemic may thus take a toll of 2 to 4 million lives worldwide.

A casualty of 4-20 million lives lost remains a large figure, adding**, about 5% to 25% additional increase to the world crude number of deaths per year**(*Riou et al, 2020*). This article introduces some methods to limit the diffusion of the virus, with in background the question as to how to limit its spread to become more like a severe flu (>10 times fewer casualties).

We look at the case example of China, as this was the first country affected. In fact, after underestimating the virus and signals given by some of their doctors in Wuhan, China has taken many measures, from focused measures (building additional care capacity, or sending enough doctors), to more radical measures such as the requirement of large containment of the population in the main Chinese provinces around the Huwan epicenter. The good news at this stage is that those active strategies seem to have flattened the spread of the disease, even if the epidemy is still ongoing. Early reproduction rate, Ro, inferred from the free outbreak were above 3, with the effective reproductino rate, Rt , to come down significantly. The messages we wish to convey, from a review of cases and from own model simulation, are as follows.

a) **It is still *plausible* to confine the disease** and make it become more like a severe flu

b) This **however requires *agility, speed and massive scale actions***

c) **Consistent adjusted social behaviors are key**, meaning that population may have to cooperate without panic for success

Two other side messages are also in order :

a) **Vaccines have been important to limit the reproduction of new outbreaks**. Similarly here, the size of the pandemics may be large enough to sustain a search for it, but **looking at past experience, it might be that any vaccine may not play a role in this first cycle of this virus outbreak,** given long time, possibly more than one year, to develop secure its use as well as to execute the logistics of vaccination worldwide.

b) This **is a global phenomenon**- meeting the three messages above will **be most effective if the approach is coordinated, rather than segmented**. This is especially important as the world continues to be more and more connected.

Do not play small- this is a "scale" game

Curbing a pandemic is a game of scaling actions. Consider that in the case of the current drivers of Covid-19, the actual R0 is indeed like 1,9, as per our high level simulation in the previous post. At this level, a vaccine that protects the population is easily to compute as (1) :

$$V=1- 1/R0 \qquad (1)$$

Thus V **will have to be administered to <u>about 50%</u> of population to hope contain the virus outbreak**, a not small number of the population worldwide (3 to 4 billion of individuals) to fully eradicate the disease [34]. Likewise, the total mortality rate (fatality per pop) needs to come down manyfold for Covid 19 to behave more like a severe flu. As the mortality rate is driven by the product of three key drivers

[3] Using estimates from Gavi and WHO, a highly indicative fully loaded cost of producing, packaging and distributing the vaccine per year would like be in the range of likely 10 to 30 billion USD, at purchasing power parity, but this may be a small investment versus the disruption costs in health and economics. See http://www.gavi.org/library/gavi-documents/supply-procurement/. According to audit reports, and industrial data for reference, the top three vaccine blockbursters today include Pfizer's Prevenar 13 against pneumococcal virus, (5.5 billion USD), Gardasil by Merck(3,5 billion USD) for papillovirus, and Shingrix by GSK agianst zona (2,2 billionUSD). Those costs do not include cost of distribution, etc—and usually have yet to cover the globe, especially developing countries.

[4]

(reproduction rate, skewness of social contagion, and fatality rates),each of them may have also to be cut by half (50%) to meet the aggregate objective.

Controlling the outbreak: scale + agility and speed.

Consider each of the three key drivers of the virus diffusion.

Reducing the fatality rate. When it comes to the fatality rate, the rate is typically dependent on the institutional quality of healthcare, which is rather « given » in the short-term. The main scale play is then concerned with enough capacity of health units and doctors. China, furthermore, has shown how agile they could be in building additional capacity in matters of weeks in the epicenter of the virus development. China quickly redirected many doctors to support enough capacity to handle severe contaminated cases.

An important driver of the fatality rate evolution is how well one manages to limit the false negatives, that is patients with not enough discriminative symptoms to be diagnosed, and sent back outside hospital confinement. Not only this person is at risk, but may lead to large secondary contagion. **In general, reducing the false negative is not easy** : **in the case of the Covid 19, tests used have a 90% specificity success** (they are able to identify you as not being contaminated when you are not), **but with only a 40% sensitivity** (ability to identify you as contamined, when you reallyuare) (see *Chen, 2020*). **At this level of sensivity**, **one might need up to 8 tests for uncertain patients to find out whether they are or not contaminated, with 95% certainty** (versus 50%/50% for any new patients).

Producing and executing such a number of tests is obviously really intense and scale consuming game. It is likely impossible to maintain in periods of early explosion of the pandemics. Agility is then the name of the game, - in this case finding quickly new ways to improve the poor rate of sensivity. Doctors in the Hubei regions went on a systematic agile testind, and discovered that sensitivity score has been usually low because of their reliance on typical CT machines for diagnosis. They experimented successfully with a combination with genomics and other scanning machines that improve the effectivenleaseess of the sensivity diagnosis, (even if a multiple diagnostic sequence remains necessary to limit risk of false négatives).

Regarding tests, South Korea is also an example of agility. When realized the human transmission of Covid-19, **South Korea's CDC approved and released a « beta »- series of their country lab companies' diagnostic tests**, even if not sure if they were fully effective, in the hope to better grasp the extent of contamination. The idea was not to be perfect ,but to reduce the asymetry of information with the disease, and act fact, with quick checking on how tests work and adjust accordingly. In effect, South Korea has been the country with the largest number of population testing, and with one of the best flattening of their pandemic curve.

Spotting and controlling superspreaders

Consider now the super-spreaders. As said in my previous article, superspreading is a natural outcome of many viruses. Typically, superspreaders in the population obey a power law like Pareto where the top 20% of population accounts for 80% of the contamination.

In the case of influenza viruses, we have a less skewed distribution of contribution, where the top 20% is more likely accountable for 40% to 65%, average 55% of the contamination. In such an average case, an individual in the top 20% of the population will be about 7 times more amenable to social contagion than someone in the other 80% of population. With a population average of reproduction rate at R0=1,9 (our best case for covid 19 to date), the contribution rate of the top 20% is 6 (each person contaminates 6), while it is more like 0,9 for the bottom 80% (each person contaminates less than 1).

The good news here is that the covid-19 long tail of contamined individuals does not have an exponential propensity to contaminate, which kills the outbreak. Yet, the bad news is that the top 20% are the real contributors to a fast exponential contagion. Given how contagious they are, simple maths show that **one needs to spot and contain 75% of them to have the average population reproduction rate fall below : R0<1**[5]. Alas, a reduction of 50% of the top 20% still make R0 decline from 1.9 to 1.3, and we remain still in a situation of not controlling the pandemic, but we are cobnverging to the R0 of a typical flu.

In practice, itw il lbe rather difficult to spot as many of those superspreaders. But multiple agile methods may be pursued to identify at least a good portion of them. The first is to trace people who may have come into contact with an infectious individual. By mapping the origin of the individual, one is better informed about the size of secondary cases caused by a single individual. The mapping of online social networks of individuals may lead to clue as to who might be superspreader. Second, viral genome sequences may provide information on both the timing of the outbreak and structure of secondary cases (see https://www.medrxiv.org/content/10.1101/2020.02.10.20021725v1.full.pdf)

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[5] Alas, a reduction of 50% of the top 20% still make R0 decline from 1.9 to 1.3, and we remain still in a situation of not controlling the pandemic, but we are converging to the R0 of a typical flu.

Third, logic may be used if one can not spot personally identify superspreaders. Superspreaders will be a fortiori dangerous when they are in close social contacts with others. "**Super-spreading" events, with long time contacts, such as concerts, fares, etc can be cancelled, as a way to limit the risk. Further, for major non controllable outbreaks, one can go broader, limiting locations of high frequency contacts such as schools or work**. While indeed costly for the economy, a few weeks closure should be the rule, and be just longer than the incubation and contamination time of the virus. **If the total is 20 days, and contamination R0-2, we should possibly go for some smart shutdown, of 40 days (hence, « quarantine »), in the case of Covid-19.**

Limiting reproduction rate via control of contamination and susceptible pop

Independently of the superspreaders, **tracing contact is an important play, and a vey powerful response strategy, epsecially when the transmission of viruses appears after the onset, -or concurrent-, to symptoms**. It is claimed that this is how the SARS was finally controlled as the virus contagion appeared after the onset to symptoms for SArS, providing a easy case of spotting effectively any infected person. The same is true as well for the Ebola and MERS outbreaks (see *Hellewell, et al. 2020, Feasibility of controlling Covid 19 outbreaks byisolationof cases and contacts, The Lancet*).

Tracing contact must be critically important and large, at least spotting as many of the superspreaders ; thus again a scale game. But this is also a matter of agility and speed. Leveraging simulations published in the Lancet (see above), to a population with a reproduction rate estimated to be at R0=1.9 for Covid 19, (as per our base case of RO to date for ther Covid-19), a 50% chance to control the pandemics for 50% of contacts is achieved only when : a) intervention before isolation is **done in 1 to 2 days** b) disease transmission before symptoms, happens in less than 10% of cases, and c) social distancing is launched at the very early stage of the epidemy, w**hen they are less than a few tens of contaminated cases**.

In most of times, the condition c) is difficult, at least when it comes to a new virus. In such a case,the containment tactics to be successful must be even larger and **must target not only the contaminated person, but the *susceptible* person.** China after missing its start, constrained quarantine for all symptomatic ndividual . (see *Maier, 2020,*)

Ensure an active and appropriate role for the population

The above set of levers can curb the epidemy, but can be socially disruptive, especially when it comes to affect less and less targeted sub populations, and affect a broader part of population. In general, also levers that limit social contacts or use personal information may be seen as contrary to freedom and privacy.

The role of population is nevertheless critical and also is a matter of scale. Covid 19 infection mechanisms require people to wash hands, limit contacts, and generally behave to protect others in case of sneezing, caughing, etc**. Those behaviors are not that difficult and challenging, and work very effectively to the extent everyone does it, as proclaimed by the concept of herd immunity**. Hence, it is critical to communicate more and clearly about those small changes, versus the case of necessary confinements if eradication becomes more and more difficult.

A global play, please

Viruses are unaware of borders, so it is important to coordinate among connected routes. Likewise, this is also about international aid in the form of best practice sharing, capabilities and capacity support to regions and countries will lower resources, like developing countries. **An ability to play a coordinated role will be a proof that globalisation may be an asset, not a risk to our society**.

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Written March 03 . Comments more than welcome. All errors are mine. References listed as they are found in the text

3. What could be the Return on Investment of curbing the Covid--19 pandemic ?

March 4. My two recent articles have tried to make the case that

a) **The Covid-19 outbreak might be serious**. The Covid-19 looks like it behaves as a **global hitter**, -- not a serial **killer** like the 1918 Spanish influenza pandemics that killed tens of millions of people, but likely a bug that is an order of magnitude, - more than ten times-, what we know from the flu.

b) **There is a plausible scenario for reducing its risk, but a way to curb it to level of a severe flu will require a significant set of actions at scale, delivered with speed and agility, and with cooperation to population**.

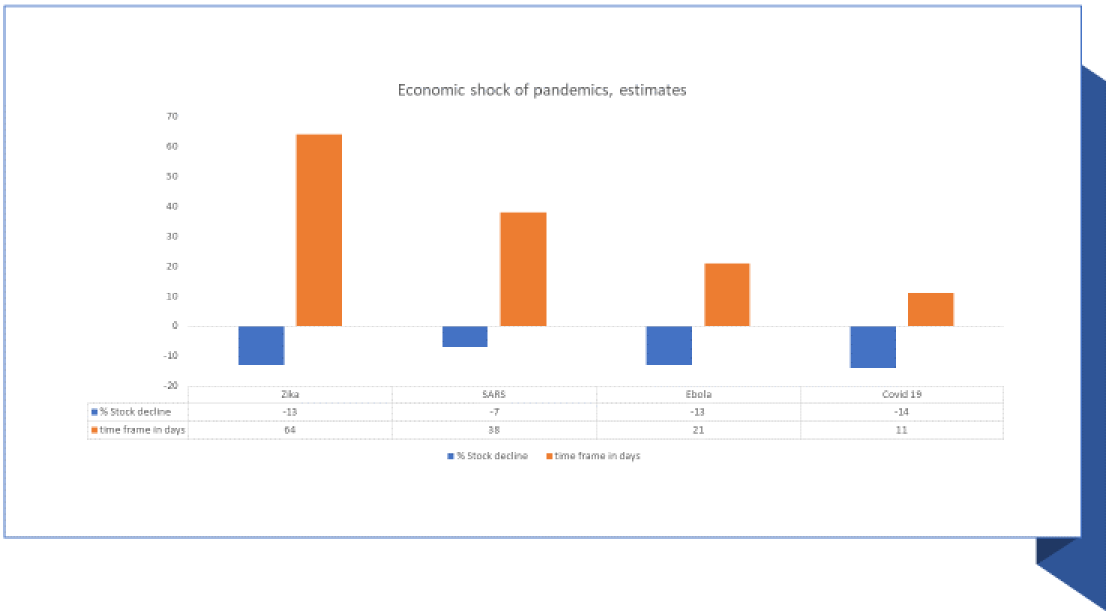
The typical question that arises now is what is the **economic consequence of the action plan—and can the world afford it ?**

At current, the stock markets has given a first high level data point. They have been under large pressure – and may be continue their drop, when they came to realize that contamination was not confined to Asia but was moving quickly into the Western world. They lost an estimate of US 6 to 7 trillions by end of february in the worst week since the 2008. This is equivalent to **9% decline of the equity value by end of 2019 worldwide, and up to 10% from peak achieved in late Jan 2020**[6] . The first week of March is on going with furher decline reaching -14%, with an interquartile range of -19,7% to -7,9% (*Ramelli and Wagner, 2020*)

The size of the drop is **not exceptional, except that it happened much quicker than in the case of other recent high profile outbreaks (Figure 1)** . Ebola outbreak by 2013 shaved around 13% of the S&P 500 in 21 trading days, (for the same cut but in three times more sessions for the Zika virus, from November 2015), while SRAS did decline the S&P by 7% in about 38 sessions, according to Citibank analysts (see https://www.cnbc.com/2020/01/28/market-reactions-to-major-virus-scares-show-stocks-have-more-to-lose.html).

[6] see https://www.cnbc.com/2019/12/24/global-stock-markets-gained-17-trillion-in-value-in-2019.html, for a Deutsche Bank estimate of the value of the global equity markets

Figure 1- Market reaction to diseases outbreaks (source : Citibank, Ramelli & Wagner, 2020)



The good news, says the past, is that stock markets quickly recovered when the outbreak was mastered, - a « V like » recovery. But will it be different this time?. Reviewing multiple models and channels by which the virus may affect the macroeconomics and social systems, and doing own « high level » back-the-enveloppe calibration, the early high level conclusion is that

a) **(Even) a controlled outbreak is a material negative headwind**,

b) ..which may **be turning into a global recession, if Covid 19 maintains the same curse globally, or if actions must be massive to stabilize the curse**.

By our early estimates, the return on investment on acting fast and at scale is sufficient to have economic agents incentivized to put a break on the pandemic, as it is for citizens to maintain welfare. The two critical question are whether actions being undertaken by governments and through the support of the WHO are sufficiently pervasive and cost-effective (from what we know, **a coordinated, and traced infection is yet to be deployed seamlessly),** as well as whether the actions are well balanced around socio-economic groups **(early evidence suggests there is no one size fits all).**

The macroeconomic burden of influenza pandemics

There are multiple channels by which a pandemic may affect the economies. The most obvious one is through reduction of production through affected labor, then a supply side disruption, and possibly a series of demand side effects, such as inflation, depressive wealth effect, risk aversion, etc. We first look at a typical influenza, then w escale the macroeconomic burden to a potentially more severe pandemic like covid 19.

The GDP impact from human capital

Most influenza has arisen from China, Russia and Asia*, (Shortridge and Stuart Smith, 1982)*. There seems to have been 10 influenza pandemics since the 17th century, killing a large number of people, due to generally high attack rates. We consider the average of those cases of the archetype of a strong flu, which would typically affect 1 to 2.0 billion people, kill 300,000 to 700,000 people out of 7,8 billion humans, if left do its curse freely.

A simple macroeconomic, labor supply-side, costing exercise would be to take the mortality rate, and the average age of those who fell victims to compute a recurring effect on GDP, due to depletion of human capital. It would also add the days of unproductive works for each time of the outbreak.

A typical flu would kill individuals at both extremes of the age structure, as a « U-type » curve, eg younger and older individuals. The average age of casualties would be around 45 years old, creating a opportunity cost of half their work life. Given that labor stands for 50 to 60% of total added value, and considering that human capital depreciates at 3-5% a year, while real labor productivity growth has been in the range of 1.5% a year[7] (see https://stats.oecd.org/), the yearly impact would be up to 0,1 % and 0,2% of GDP of the year of occurrence, and recovery afterwards.

Now let us look at the days lost at work of the 1 to 2 billion people. Assume that one out of 60 contaminated people needs hospitalization and loses 10 days of work, while days lost for other affected people is one week out of 48, then the total effect ends up to be 0,2% to 0,4% of GDP, on each year of the pandemics. If the flu comes back every year, - but this will pandemic only every 10-20 years, and will thus more like the seasonal flu, at possibly 25% effect of the current archetype, the total value effect is 0,2 to 0,3% carved out of the long-term GDP path.

Extending to more channels /effects

The above only accounts for the « labor supply » disruption. They are many more channels by which the disruption may happen :

[7] see https://stats.oecd.org/),

Demand effects

For instance, there is likely a depressive demand effect, that is, the size of the health risk makes inhabitants decide to reduce consumption, eg in retail (non food), in external entertainment services, or travel/transportation [8], while the significant (fear of) a lower wealth may lead to additional reduction in spending (McKibbin and Fernando, 2020). Surveys made at the time of the SARS outbreak in Asia confirm that people in Asia were willing to pay a premium to prevent risk of infection, demonstrating a risk aversion in the context of high fatality rate pandemics, with a 3% decline in demand during the quarter of the SARS acute phase (Bloom et al. 2004, Lee and McKibbin, 2003,).

A second demand effect is through export and import—according to the degree of country connectivity. Given the fact that about 20% of world GDP is related to both import and export globalisation, one talks about an additional 40% pressure effect inflating the private consumption effect (as private consumption is possibly 50% of GDP).

Extra supply effects

On the supply side, there are the costs of hospitalization and treatment, but we might assume that they boost local GDP as part of the health system and services. We leave them out here is public spending is valued at cost. Crucially, there might be global supply chain disruptions, and high profile cases have reached mainstream media, such as Apple risking breakdown in its supply on airpods and phones, if the Chinese shutdown due to the Covid 19 crisis lasts longer than the 4 to 6 weeks inventory buffer (see https://www.latimes.com/business/technology/story/2020-02-07/apple-supply-chain-threatened-by-coronavirus-quarantines).

Other supply chain breakdowns are linked to the provision of non medical equipment such as masks. Ironically, the previous pandemic led to high stock of those equipments, which were never used, and went full depreciated, with many countries not repleting their stock, and now face an excess demand crunch. Supply side disruption is also visible in ingredients to produce virus test reactives, or in other essential drugs such as common antiobiotics and vitamins, as a result of factory closure in China and other countries.

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[8] At the peak of SARS, Hong Kong saw an 80 percent reduction in air traffic as well as a 50 percent reduction iin retail sales (see Siu A, Wong RYC. Economic impact of SARS: The case of Hong Kong. Cambridge, MA: MIT Press; 2004. (Asian Economic Papers).

Total GDP effects

Adding those effects on top of « labor supply », a total yearly demand shock of -0,2 % is plausible, plus an extra supply effect in the range of -0,3 % for the archetype of a pandemic flu. **In total, we estimate that the total depressive effect is between in the range of 0,8 and 1,1% for GDP, as one off, before a reversal. But this may not be the case : if recurrent, (when the flu goes back to seasonal), the total effect is minus 0,4 to 0,6% negative drift in GDP growth trajectory,**

Possible effect on the stock market

We need a few extra assumptions to get to an estimate on the stock market impact of the pandemic. Let us assume that the debt leverage is 50% of finance, and debt costs are in the range of 3%. If capital returns are 40% of total value added, the rest being labor cost payment, then a decline in 1% in added value translates into a decline of 3 percent in earnings per share.

This does not include **systemic uncertainty, that might also boost the finance premium risk**, at least for the countries at the epicenter, or for every company, ass result of deleveraging, or as a result of liquidity sustainability for SMBs. This has been estimated to be in the range of 100 to 150 basis points for large epidemics, or 3-5% increase, such as the Spanish flu (McKibbin, 2006,).

Recent computation by the BIS on country-specific effects of various pandemics, suggests that such premia are plausible, - possibly with overshoot in very short-term, before reversal. **Emerging Asian markets plus China have suffered some extra- country loss of roughly minus 5% stock returns after 10 days after the covid outbreak in their countries. The same loss was reached after about 25 days for Japan**. Whether this premium will last, and for how long, is difficult to conjecture, but China has already recovered fully since, - but not other Asian countries. Taking SARS as a different case, Japan and China cumulated loss to culminate at -10% stock return after about 50 days (see *Avalos andZakrajsek, 2020, Covid 19 March*).

Putting all those factors together, **the total stock return effect is more like 5,4 % to 8,3% in the equity markets, but bouncing back to recovery after the outbreak, a typical « V » recovery, as seen in the past. If,hoever the pandemic is however recurrent,** companies will not keep all labor; we assume then that it is put into unemployment for the extent of labor linked to the demand side effect. Further, recurring depressed earnings leads to a multiplier effect of 1.6 times on returns (see Hodson and

Stevenson- Clarke, 2000). We thus have a total effect of **4% to 6,7% a year will be taken off the stock returns pathv[9].**

If those figures are only directional, and back of enveloppe estimated, they nevertheless are in line with more sophistaced academic research in the last twenty years, using tools such as general equilibrium models, see Table 1. There, **a typical 1 to 2 million coronavirus like flu fatalities typically will have a depressive impact in the range of 0,5% to 1,5% GDP impact.**

Table 1 : other study estimates of pandemic costs worldwide, pandemic flu archetype

Source	year	Global scope	percent of GDP (recalibrated)
ADB	2005	1 to 2 million fatalities	2.5% (Asia only)
WHO	2018	Average flu type (1-2 million)	0,6%
Brookings	2020	Moderate flu (2 million)	1%

Calibrating to Covid 19 – back to last economic crisis ?

Covid-19 as we have highlighted, is possibly a stonger pandemic than the flu. Also, covid 19 has different medical features that will affect the size of the economic channels ? For example Covid 19 sufferers have longer time of hospitalisation and recovery, in the range of three times the one of the flu. Covid 19 might have larger fatalities than the flu, while the reproduction rate is higher also, leading to higher attack rate too, than the pandemic flu. What is also unique about a pandemic like covid 19 is that it is spreading worldwide,with a high risk of a depressive loop of lower supply, lower demand, etx. This effect might double the typical national effect.

Factoring this as back of the envelope, **the total range looks more like a decline of 4.5-6.5% impact on worldwide GDP, or a 3.5 to 4,5 trillion US yearly GDP shortfall.** If the pandemic lasts the 6 to 10 months average, and there is no cost for supply chain to rebound as well as for consumers to return to normal spent, we may talk more to 2 to 3 trillion USD in a year, or a 2,5 to 3,5% growth dip, but if this takes longer, and there are costs to relaunch the world economy, the long term effect may build up higher than 5-6%, in line with other external estimates (see Table 2).

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[9] If this is recurrent, possibly rela wages will increase, or capital will be invest to subsitute for shortfall in labor supply to rebuild productivity- but either way, increase in wages will be a cost to the bottom line, or new capital will need ot be financed, reducing operating free cash flows.

Table 2- estimates of pandemic costs, Spanish flu

Source	year	Global scope	percent of GDP (recalibrated)
World Bank	2013	Spanish flu (40 to 70 million fatalities)	5%
Brooking	2020	Spanish flu (40 million to 70 million)	6 to 10%

This impact figure also implies three critical points ;

a. The first is that **the pandemic effects on the world economy may lead at best to a flattish year versus 2020** : from roughly 3% benchmark to at best,between 0% to 1%, by 2020.

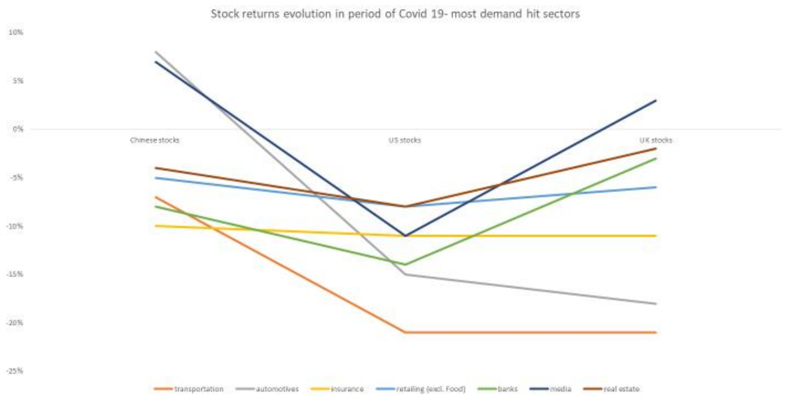
b. The second is that this is serious—**at full costs, the world will be suffering as much, of not more than the crisis of 2009**.

c. The third is that, the effect on equity value may also climb three times the one of the flu, up to decline range **between 13 to 24 % of the total equity markets in the short term** . If the economy fully recovers after the Covid 19 pandemic, the effect on stock market path will be a « V » recovery. If however, the recovery takes time at half rate, or leverage adjusts to the bear market, the blip might cost 3% to 9% of total equity value of stock market, or roughly **net 3 to 9 trillion USD**[10].

   Typically, we have witnessed such a material drop in recent weeks on the stock market. A fortiori, related stock price of sectors most exposed to pandemic outbreak, eg on the demand side, automobiles, retailing (non food), external or theatre entertainement are hit accordingly. Other sectors also affected are those where systemic risk light increase linked to the pandemic, eg (health and unemployment, and life) insurance, or banks/rela estate customer solvabiity risk (Figure 2).

[10] This is simply the cost of time, at 12% real equity return.

<u>Figure 2 : Most hit sectors during pandemic come from a demand side effect</u>



Source : Ramelli and Wagner, Griffiths et al, Institute of Fiscal Studies ; authors' own coputation

The Return of controlling the Covid-19 diffusion

Clearly, the insight from the simulation is that if Covid 19 is free to diffuse, not only the human costs will be high (tens of million of deaths) as will be the economic costs, implying in all logic, a possible recession. I had already mentioned a set of levers and actions, and the need for speed and agility to implement them at a global level. What is critical is both to identify and block superspreaders, to limit false negatives in the virus infection, and to stop any new node of the virus deployment, mostly by major social distancing, quarantines, and closure of social spaces for a few weeks/month(s-) at work, at school, etc. If this works, and reduces the reproduction rate by 0,5 people, and if fatality rate is reduced by 50%, the total GDP effect may come down from 4,5-6,5% effect to 1 to 2%, or a gain of 2 to 3 trillion US dollars a year.

Leveraging the cost estimate made available through the World Bank (Jonas, 2013) as well as through community studies led by Joel Kelso and colleagues (*Kelso et al. 2013,* Milne et al, 2013, the fully loaded disruptive costs of avoiding affection might be less than 1 to 2 trillion, enough to suggest a positive return of investment.

We thus learn that a short term programme of assets closure, combined with systematic quarantine of the contaminated   has a positive return if the virus outbreak has large damage ; it does not have

a good ROI if the outbreak is like a pandemic flu. The ROI is even larger if the economic recovery takes time, and/or alternatives to limit the outbreak, like a broad vaccine are a distant future. In this case, there is clearly a convergence of health and economic incentive to implement large and pervasive barries to flatten the curve of diffusion of the virus, as well as to deliver fast.

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4. We might be winning the battle of the Covid-19 epidemic in China: a dynamic R_t perspective

March 07. _Covid 19 went recognized at the end of December 2019, when a Wuhan hospital admitted four individuals from the Seafood Market. _The type of explosion of cases one witnessed from there made lots of insiders fear for the worst. In less than one month, from January 20 to February 17, **the recorded cases increased exponentially, from 270 to close to 50,000 in the Hubei province of China, or a factor of 200 ; with a continous doubling of cases every 7 days like in the early weeks of the outbreak, this could have led to hundred thousands infected cases by early April.**

But there are some good news. Even if China took a few weeks to launch strong actions, Chinese authorities then quickly imposed by mid January, large scale quarantines, as well multiple city shutdowns. Other, more recent actions have involved new series of ways to more accurately diagnose mild cases, as well as the establishment of a mobile based QR code coloring of Chinese citizens to secure more effective sorting of susceptibles, contaminated and safe cases[11] .

Those actions, in line with our prescriptions to maximize the chance to reduce the spread of disease, seem to effective. Experts are consequentially more and more optimistic that the pandemic may run out of course in China in the next two months, instead of exploding (*Lucey, Daniel, Sparrow 2020)*

Based on current numbers and the actions taken by China, and in other European countries with outbreaks such as Italy and France, **we may be leaning towards a scenario towards a severe flu worldwide**. **The key is thus to continue high vigilance, deliver fast and scalable actions of social distancing, shutdowns if necessary, across the globe when the epidemy is entering a new country. And make sure citizens adapt their social behavior as a significant contributor to curb the disease spread.**

What could drive a major pandemic for Covid 19?

A pandemic size, speed, and risk depend on level of, and spread of population clusters' reproduction rate, incubation and contagious period, and fatality rate. On the positive side for Covid 19, the virus seems to exhibit a strong, but not exceptional high level of the reproduction rate, called R0, (R0 is in the range of 2 for the whole of China, estimated from data january to February, and about 2.7 for same

[11] https://finance.yahoo.com/news/china-seeks-help-national-tech-110156832.html

period in the Hubei region). But on the negative, the virus has a material fatality rate (we estimate between 0,5 to 2%) versus a typical flu, as well as exhibits a possibly less concentrated distribution of social contagion than other viral diseases.

Changing Rt-the underlying maths and case study

As the exponential nature of the outbreak is driven by the mean and spread of reproduction rate, R0, it is critical to see how we can limit it. The reproduction rate R0 is easily interpretable as the product of contact frequency, c and the probability of being contaminated for each contact, p (*Larson, 2007*) :

$$R0 = p.c \qquad (1)$$

$$R_t=(p+\delta p_t).c + (c+\delta c_t).p \qquad (1bis)$$

Where $\delta(.)$ is the time differential change.

p is clearly a variable one can influence, and rather quickly. This implies that R_t may evolve through times, as a result of quarantines, or still because the population adapt behavior in terms of social distancing, with $\delta p_t<0$.

In general, the number of contacts, c, may be roughly constant behaviorally, at least for very low (perceived) risk disease, and for people not aware of the possible pandemic. However, the larger the perceived risk of the pandemic, the more likely citizens may adapt behavior and reduce contact, making dct<0, and Rt decline with time. For example, during the 2002 SARS, more than 25% of Asian citizens thought they could be contaminated, even if the ex post rate happened to be less than 0.1% ; as a result a large set of persons were reducing travel ; 10 to 50 percent declined in taxi revenues, and up to 80 percent decline in luxury hotels stay, (see *Brahmbhatt and Dutta, 2008*). Likewise during the 2019 H1N1 outbreak, 25% of Americans were avoided crowded area (*Steelfisher, et al, 2010*).

Recent research on pandemic suggests that, even with uncertainty, it would be rational for any self interested individual to decrease the number of contacts, $\delta c_t<0$. For a flu-type, frequency might change downward, with a resulting reduction of 20 to 40%. In general, the types of reduction depends on many behavioral factors as well ad the wisdom of crowd. Likewise, the result decline on p, depends on how people wishes to self-protect, and in general $\delta p_t <0$, and the effect may be more or less the same magnitude as δc_t (se, *Tyson, et al. 2020* or still *Eksin, et al. 2019).*

We have yet to know how behaviors have changed in China, as a result of the spread and perception of risk of the spread, of the Covid 19. But there is enough anecdotal evidence that behaviors have indeed changed for citizens, towards lower contact rates, while authorities in any case forced them towards that consequence. If one looks at other outbreaks, and looked at effective reproduction rates , we find a following tyyical cycle of exponential at the start, then a slowing growth to the peak, and then, a last phase, when epidemy phases pout (Table 1).

Table 1 : dynamics of reproduction rates

Outbreak	reproduction rate R0 -first three weeks	mid period of outbreak (3 months)	late period
SARS Asia	2.2 to 3.6	1.6 to 1.8	0.7
Sars Asia (delta)		-40%	-58%
SARS elsewhere	1.6	0.95	not computed
SARS elsewhere		-41%	
H1N1 2009	2.5 to 3	1.4	0.5 to 0.6
H1N1 2009		-51%	-63%
Mexican Flu	2.1	1.8	0.9
Mexican Flu		-15%	-50%

Source: Lit Search, author own computation

The dynamics around the phase, are not exactly the same. SARS and H1N1 were handled quickly with large quarantines.

The case of the Mexican flu is also a known case of active policy reduction, but it took time to be handled. The flu first took its spread in multiple villages in te country, but without very large awareness of the inhabitants—leading to a significant attack rate in the range of 40 to 50% of the population. The city of Mexico got the flu epidemy noticed, and in the first weeks of the flu moving into the country capital, social distancing was imposed together with closure enforced on schools, public spaces and hospitals reducing c significantly, and leading to a significant decline on the reproduction rate, Rt through times.

The dynamics of R for the Covid-19 case : we may be winning the curse in China

We still have to know the exact drivers of Rt for the Covid 19 in China, but we can estimate its effect, through the shape of how the outbreak has behaved. Using the numbers of recorded contagions, and estimating a « two weeks by two weeks » cut off estimate, we reach the following result that we might have reached a situation of control in China—(see Table 2)[12]. I

n response to the outbreak of COVID-19, a series of prompt public health measures have been undertaken (see Wang, *et al.* 2020). On 1 January, the Hunan Seafood Wholesale Market was closed in the hope of eliminating zoonotic source of the virus. On 11 January, reverse transcription-polymerase chain reaction (RT-PCR) reagents were developed to traceo infection' . Ten days later, the Emergency Response System was activated and intensive surveillance and isolation of suspect cases started aggressively. School and work were suspended. Close ties to infected received medical observation and quarantine for 14 days. Travel from and to Wuhan City as well as other medium-sized cities in Hubei Province went to be restricted.

Based on typical contact profiles (at home, with friends, at work, school), the frequency of contact may roughly be 40% based on public space connections (travel, school, at work), and 60% based on community and family interactions. Assume that complete distancing was effective in 80% in public space in the Hubei region, and that social distancing from community was half-effective, given asymptomatic cases at 50% of total cases. This means that δc_t =-60% for China. As R_t decreased roughly by 85% from Jan 23 to Feb 29, we would infer that δp_t =-25%. This number may be in line with change in protective behaviors seen in other outbreaks, (*see Eksin, et al. 2019*).

[12] China outsdie the Hubei region got to start the measure directly after the notice of rthe Wuhan epicenter, thus got more quickly into influencing social contacts to quickly reduce Rt.

Table 2 : dynamic R for Covid 19 in China

Date	Hubei region	delta change	rest of China	delta change
15 jan	5.5 to 6.0			
		-18%		
30 jan	4.0 to 5.5		2.8	
		-38%		-61%
15 feb	2.5 to 3.5		1.1	
		-70%		-55%
29feb	<1		<1	

Source : wikipedia, John Hopkins University, own computation

Note : ranges depend on hypotheses on reported cases, and on changes in contagion period

Dowgrading to a severe flu, instead of 20 million fatalities ?

It is important that those figures in Table 2 got confirmed by more torough analyses than just moving average, with no data filtering, as well as on only recorded contaminated figures. Further, wave 2 or wave 3 may also arise, as it was the case for the Spanish flu. But the key insights too, ares that, even if one assumes from now on, that Rt is getting indeed just below 1, **the total outbreak will be more like 3 to 5% of the total population in the Hubei region. For China outside of the Hunan region, the figures will be then less than 1% of total population**.

Otherwise stated, and scaling those figures to worldwide population, we will be between 0.4 million to 4 million fatalities (China outside of Hubei, and Hubei) regions, or a reduction of at least 80% of the fatalities, as it got noticed, after the actions to control H1N1 in 2019 (we estimate, roughly minus 85% reduction versus potential of the pandemic). We will have succeeded in controlling the outbreak.

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March 07, all errors are mine. comments welcome

5. Please, now it is time to use effective tricks to limit social contagion of the Covid-19

March 09. How Covid 19 will end up as a small or large pandemic, is highly dependent on how one can structurally decrease the level of reproduction rate in the population of the disease. In China, we are currently roughly at 60,000 recorded contaminations, or roughly 0.1% of total population, However, let us put ourselves 6 weeks down the road. If the reproduction rates remain constant, the difference of infections between R0=3 and R0=1.5 explodes to be a manyfold factor (see my high level simulation, in Table 1). We thus clearly see that actions must be rapid to curb the exponential threat in the first weeks of the outbreak.

Table 1 – After 10 weeks starts the critical take off : Hubei region, recorded only contamined cases[13]

	March 10 (12 weeks)	Early may (18 weeks)
R0=1.5	4,500 cases	120,000 cases
R0=2	13,000 cases	700,000 cases
R0=2.5	40,000 cases	2, 800,000 cases
R0=3	105,000 cases	3,600,000 cases
For info, maximum likelihood data fit		
R0= 2.7	60,000 cases	3,100,000 cases
Range of attacks	(>0 to 0,2% of pop)	(>0.2% to 5% of pop)

Note : My estimates, rounded figures, cycles of 2 weeks of contamination, growth g of cases computed as g=0.5*sqrt(8.R0*)-1, where RO is scaled down based on the flu power law of contamination ; growth scaled down by portion of immune contagion

Breaking good : some Chinese evidence

This is precisely what China has done, and what Italy has been launching this Sunday, by creating major quarantines, and larger set of controls of contacts within their affected regions.

[13] Those numbers are likely a fraction of total infection—this means that under larger figure, the dynamics are even more skewed agaisnt large R0.

The jury is still out for Italy, **but this is a very high priority to make it work there , as first set of data may seem to suggest that Italy is more like what the Hubei region was in China by early January**, with an average R0 that is more in the range of 4 to 6, and a fatality rate, closer to above 3% range, - a rate higher than my original view expressed one week ago at https://www.linkedin.com/pulse/three-key-covid-19-indicators-curb-likely-20-million-human-bughin/.

We have more perspective on China. Provided data reported are right, early data may seem to prove that it works, as the average R0=2,7 across the 10 weeks is in fact the result of a constant decline across the recent weeks, from R0=6 by the time the epidemy was recognized early January by the Chinese authorities, to possibly below 1, by late February (Sun, et al . 2020).

Imposing quarantines, traffic blocages, on school closure are actions of highly disruptive nature, even if rather effective. However, it is important to recognize that :

a) **All measures must be done alltogether to really put a major break**. For exemple, research tends to demonstrate that about 1/3 of all contacts happen at work/school ; 1/3 within communities and 1/3 in close family settings. And that typically, the average individual, at 45 years old, is impacted by the three sources of contacts.

b) **Behavioral responses to those policies are critical to have the imposed barriers effective enough** to curb outbreak and eliminate the risk of a pandemic disease (see Li, et al. 2020.) (note : The broad use of masks by more than 75% of the Wuhan population was also driven by police requirements,-- but this rather plays on the effectiveness of contacts ; see Qian, et al. 2020, Psychological responses, behavioral changes and public perceptions during the early phase of the COVID-19 outbreak in China: a population based cross-sectional survey. *medRxiv*).

We are thus in need to look as well as self- induced behavior changes.

Self induced changes : insights from incentive theory and other behavioral sciences

Further to policies enforcement, there should be indeed more subtle cases to push people to change their own behavior. Here are three examples that have proven effective in battling epidemics:

a) **Divert to virtual contacts**. In the case of the current China outbreaks, digital is playing an important rôle, both to spot spreaders, to reduce asymetric informations among cohorts, by color codinf citizens in terms of their degree of transmitting their illlness but also by releasing new and attractive digital entertainment and online social applications that let some Chinese people to **privilege the use of more digital life styles**, **instead of face to face social interactions**[14].

b) **Build the right SoCoMo awareness**. When a disease breaks out, one may hope that awareness may lead people, not only to protect themselves, but take measures to reduce their susceptibility.

Alas, in a well-mixed population, the epidemic threshold is not changed dramatically by national campaigns, because the outbreak is usually happening in a much more localised manner before it broadens to multiple groups. **SoCoMo (social,local, and mobile) tools seem to be much more effective to target and localise behavioral response in the proximity of an outbreak**, and may thus seem to be much better at curb the outbreak of a disease and if individuals networks face a high-level of clustering.

Mathematical simulations show that localized and peers media can significantly reduce the frequency of contacts, and that this peer media effect has likely been a driving cause of curbing the outbreak of SARS in China by 2009 (*Funk et al, 2009*). This has been confirmed in the case study of the SARS epidemic in Taiwan, where local social learning effects seems to lead to a reduction of up to 30% of contacts, -- in that case, study related to doctor visits. (see *Bennett, D., Chiang, C.F. and Malani, A., 2015.)*.

c) **Make risks tangible**. A large set of studies has confirmed that both reduction of contacts and use of other precautionary behaviors tend to larger among indiviuduals who worried about someone close, either as close friend, or in their household contracting the disease (*Kim et , 2009,*).

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March 09, all errors are mine. comments welcome

6. Each of us, we can do five easy actions to curb by the Covid-19 pandemics

March 12. The risk of a viral outbreak turning into a pandemic has become a reality for the Covid-19, affecting to date more than hundred countries, and with large concentration of known contaminated people in China, Italy, Iran and South Korea among others. People stress might remain large as pharmaceutical responses, (be it an antiviral method for infected individuals, or be it a new type of vaccines), are largerly absent, or will take months to be developed.

It is rather crucial **to act fast,** due to large attack rates linked to influenza type of viruses. In fact, we have estimated form our own model of viral diffusion that **one to two weeks delay in acting may easily create a multiple of increase in the rate of the virus fatalities, a few weeks later**.

Hopefully, we have shown that they are some proven, non pharmaceutical techniques, to curb a pandemic, even if some can create either large social disruption and/or are very costly from an economic perspective, such as school and work closing. Some can be relatively easy to do, eg hand washing, and may require not much, but more attention from ourselves, to perform systematically. We herewith review an extensive set of academic papers, through Google Scholar, as well as academic journals to provide a high level estimate of base line of non pharmaceutical actions, and how much fmore we should be doing to play our part in curbing the outbreak. Here are the findings :

A game plan in 5 actions

Wash your hands systematically please

Washing hands with soap is rather effective as a way to limit many types of infection if used systemically. For example, it decreases the risk of getting diarhhea by 25% to 40% (Freeman, et al. 2014).

Regarding influenza, the findings on reducing disease occurrence are slightly lower or in the same ball park than/as diarhhea. On average, hand washing reduces the risk by 20 to 30% of getting influenza. The 5% most lucky ones may be reducing the risk by as much as 50% but the less 5% lucky ones, might not get anything from washing (versus non washing). This does not stop here. If the personal contact is at high risk of having infected, or the surface is contaminated, washing hands can double the pay off, with an average 40 to 50% % reduction in the risk of catching the influenza.

As said, this is about washing your hands a) with soap, and b) systematically. Washing without soap strikes half the success rate, and the washing effect on risk reduction is roughly linear with the frequency of washing your hands.

What happens then if no soap? An alternative can be to use hand sanitizers. Even if there is large uncertainty in their potential, it looks like this is like a great, yet imperfect alternative, to hand washing with soaps, roughly on average, 80% effectiveness of soap.

Are we really doing the washing hands thing ? Research reports that, in a few years back, we were not good at it—in fact, **worldwide, less than 20% of people seem to wash their hands with soap after going to toilets**. In low- and middle-income regions, the rate was as low as between 5% and 25% of handwashing (remember that poor income countries have limited amount of toilets, and a fortiori, no water). Between 48% and 72% in high-income countries do wash their hands after going to toilets (see Freeman above). We also have a real gender issue : recent research with real tracking tools suggests that about 40% do wash their hands in UK, for about close to 70% for ladies (*Fleischman et al. 2011*).

The fear of pandemic makes people change behavior, but not at scale hoped. **Roughly 30% to 40% extra people are typically reporting to wash their hands versus periods without influenza**. This behavioral change is higher for children, women and families leavnig in large cities, and for people being sick (65% more) (Van Cauteren, D., 2012). Likewise, roughly half of those people washing their hands, do it rather frequently, up to 10 times a day.

Wear a mask

Asians have been using face masks extensively during outbreaks, and we saw some of them recently wearing goggles. Regarding masks, the use seems to be much more effective in the case of healthcare workers, -possibly an average as good as 50% protection. This protection is not necessarily as large in other parts of the populatios, with 20% reduction according to recent WHO estimates. This is presumably because the extent of protection is likely to increase with its frequency of use, and the use and frequency of masks use is not that large . In fact, it is reported that the systematic use of mask is twice more effective at reducing the risk of being caught with the virus, than for irregular users.

Mask usage is also not that frequent in our population- in the curse of recent, mild, influenza, roughly 5% (20 %) of Western European people had used masks at start (peak) transmission and roughly half of them did this in fear of catching the virus, while the other half did it to protect their relatives based on their illness. During the H1N1 outbreak in 2019 in Hong Kong, roughly 25% of the inhabitants use to wear masks, but the percentage raised to 80% when going into public spaces (*MacIntyre et al,, 2009*).

The average time a day wearing the mask is large, up to 4 hours, in the home, and is thus likely effective.

Ventilate : Always good to have a breathe of fresh air

Another possible action is to increase ventilation of close spaces. The WHO reports on studies claiming that tripling the ventilation rate could reduce the peak infection rate by 30%. This however is simulation based, and relies on the crucial twin hypothesis of equal contribution of airborne and close contact transmission, and air condition change from once a day to 9 times a day.

On average, 40% of infections may happen in close settings, yet typical research suggests that less than 20% of home owners leave windows open during sleep and less than 50% change air condition more than once a day (*Offerman, 2007*), The behavior increases by 40% during risk of virus infection.

1.4 Do stay confined, if not well

Remain at home, or quarantined, may seem a logical step when there is a virus outbreak. However, there are multiple reasons why people do not do it, etiher because, despite having the symptoms, they do not feel that bad, because of peer pressure at work, because they do not have health nsurance, etc.

Every year, it seems, a small, but material portion of workers or school kids keep their habits even if becoming sick from influenza ;in the US, for example, 1 person out of 3 would still go to work in the private sector (10% in public sector). About 90% of kids will go to school while being sick too. If the disease infection rate per contact is 15 % for influenza, and that the sick person makes 3 close contacts per day, and up to 6 in one week, the infected person may be responsible for one extra person sick in one week. This has led researchers in the US to say that non confinement is possibly half the causes of the flu pandemic attack rate.

During serious influenza, like H1N1, or a Covid 19 type, the rate of absence not only increases, but also the portion of sick workers coming to work decline, in the range of 30 to 50% versus normal infleunza, according to multiples studies *(De Blasio et al, 2012*)

Limit close contacts

We already mentioned in a previous article that one key driver of mitigating a pandemic, is through a reduction of contacts, -so called social distancing. Major policies enforcements exist for this, such as work or school closure, but they are might be more subtle and focused cases when the outbreak is still manageable (eg avoiding large, close, gathering festivities for example), and people might themselves change their own behavior. In the case of the current China outbreak, for example, Chinese people are privileging **the use of more digital life styles**, **instead of face to face social interactions, while a large part of people stop going out, to restaurants, or stop travelling**.

How large is the contact disease decreasing voluntarily ? In fact, contact rates happen at different moments, from work, communities and families, and some are difficult to reduce, eg at work, or at home, etc. Most studies suggest that contact rates for non infected individuals, have decreased by 30 to 40% during period of large influenza. A study made from data during the spanish flu waves by 1919 in Sydney, mentioned a reduction of 38% of contacts among the inhabitants, across a set of multiple waves of the flu reappearing (see Caley, et al 2008).

The baseline of those 5 actions during outbreak : flattening the curve

Deriving the high level math

The five actions above are all good sense, and have been used spontaneously by many, yet neither extensively and intensively, even in the context of a perceived severe infliuenza threat, such as H1N1. We derive hereafter the gain in contagion probability, for the typical extra use observed of each action, and come to the finding that the total extra reach of actions may already lead to a significant decrease in the reproduction rate, Rt.

Effect of washing hands with soaps

If we define a base line worldwide, there is roughly 20% extra population washing their hands with soaps, and/or use sanitizers during outbreak, of which 2/3 take the maximal protection measure. In such a case, we assume the lucky rate success of 50% reduction (the 5% lucky winners), so that the proportion of contagion is reduced by 8% worldwide . Likewise infected people protect themselves by washind end, reducing the probability of contaminating people, by an extra 15%, roughly. Matheatically, we have, that the increase in probability of being contaminated, Dp/p=dRt goes down, by

DRt = 8% + 85% (attack rate)

Hence, for an average influenza, with attack rate at 5 to 20%, the extra reach of hands washing, **leads to a reduction in contagion of between 13 to 20%**

Effects of wearing mask

Mask usage is not that frequent in our population. In the curse of recent, mild, influenza, roughly 10% (30 %) of Western European people used masks at start (peak) transmission and roughly half of them do this in fear of catching the virus, while the other half do it to protect their relatives based on their illness, in theri home or at work. During the H1N1 outbreak in 2019 in Hong Kong, roughly 25% of the inhabitants use to wear masks, but the percentage raised to 80% when going into public spaces (MacIntyre et al,, 2009). The average time a day wearing the mask in publi is large, up to 4 hours, in the home, and is thus likely effective.

Taking a rough average of extra protection use of masks out those studies, and the fact that roughly 30%/40% of infections occur in communities/ houses, we can compute the followng effects of mask usage

DRt = 2.5% + (50%). Attack rate

We can thus compute that, for an average influenza, with attack rate at 5 to 20%, **the extra reach of wearing mask, leads to a reduction in contagion of between 5 and 12.5%**

Effects from fresh air ventilations

Typically people spend between 75% to 85% of time inside, and only 50% can leverage fresh air ventilations at work (implying that home refreshing is the main natural domain of contagion reduction). We can compute

DRt = 5%

This is an average as we do not know how the behavior is pushed by extent of attack rate. **The average influenza leads to an effect of 5%.**

Effects from staying home when sick

We refer here as to contaminated person- where 30% extra will decide to stay home despite being at risk of contaminating people. Susceptibility of being contamined depend on close contact and infectiousness during one week. If we beleive that the peak infectiousness is 4 days, and close contact at work is 70% of total contacts, as per multiple studies, then we come the folloiwing reduction. For kids, the decsion to remain sick is 10%, thus on average we have

DRt = 10%* (attack rate)

For an average influenza, with attack rate at 5 to 20%, **the extra reach of staying at home instead of gonig to school or work, leads to a reduction in contagion of between 0.5 and 2%.**

Effects from close contacts

The effects on limiting contacts has been seen to be relatively large, in the range of 40% in the case of the 1918 high pandemic flu in Australia, for instance. This reduction rate concerns a three waves outbreak of the disease, touching 60% of population. Media suggests than 60% of those contacts correlate fully with outbreak, while roughly 70% of contacts are close enough contacts to be infectious . We can thus infer the following :

DRt = 10%+85%* (attack rate)

For an average influenza, with attack rate at 5 to 20%, **lowering contact rate, leads to a reduction in contagion of between 9.5% and 27%.**

The aggregate picture

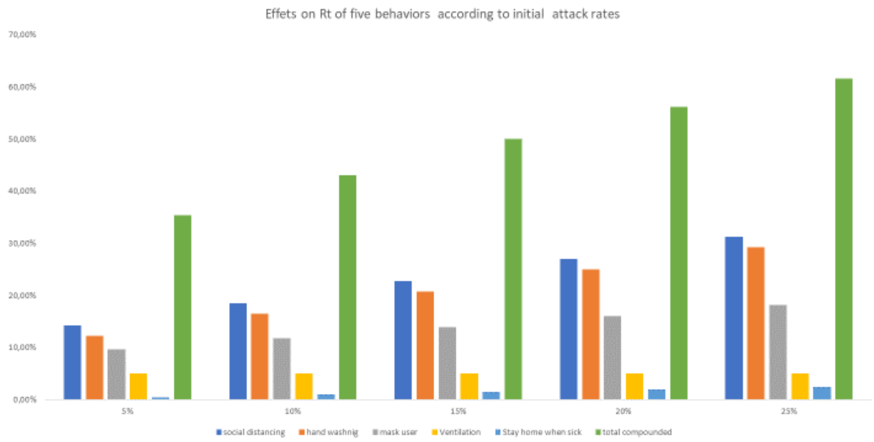
The aggregate picture is presented in Figure 1 with the following insights:

a) First, we rank the effects based on their marginal impact on contagion and the typical extra use during pandemics—**social distancing, hygiene and face protection measures are three most relevant measures**

b) Second, the reproduction rate of the Covid 19 as measured from Chinese data, quickly went down from 6 to 2.5-3 in one month, and now is likley below 1, or a decline of more than 85%. The below suggests that at potential attack rate of 10%, **between 35 to 50% of the decline is linked to spontaneous changes of the Chinese behavior- the balance may hence be due to policy shutdown**

c) Measures effectiveness relatively decreases with attack rate. If we move from 5 to 25% attack rate, of five times more, the probability of being infected decreases by a factor of two for the same level of measures. It is thus critical to play at the start and not wait. And it is thus clear that we need more than voluntary behavior to stop aggressive pandemics

<u>Figure 1—the likely effect of the 5 behavioral changes on Rt</u>



<u>Source</u> : estimates taken from extensive lit search, model- author's own. High level estimates, aggregate estimate suggests 50% overlap among individuals of the 5 actions

What else to do

As the above suggests that behavorial changes are powerful to curb infection, but not enough to stop viruses with reproductino rate above two, a set of structural policies must be implemented, such as school closure etc, --besides quick discovery of delivery of anviral doses, and of vaccines.

Another path is to push campaigns that really lead a broader use of people of the five behavioral measures above. We can still increase largerly the portion of people who will be washing hands, wearing masks, we can still refrain more close contacts, etc. In effect, the total reach potential may be twice larger what we have ; or for the average infleunza, this means we might increase by 50% the effectiveness of the portfolio of measures versus the average to date .

There is a real good news is we ALL to do the tricks. Do not wait and comply.

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March 12, all errors are mine. comments welcome

7. Do the right things that experts say: killing three (wrong) arguments heard in mainstreet

March 13. Europe is in the middle of the pandemic- and governments are now scaling measures to significantly limit social contacts. Here and there, measures of quarantines and restrictions are often not fully welcome. Not only, they lead to socio economic disruptions, but also because, they may hurt the democratic feeling of freedom and choice or simply because people believe that the crisis is limited. They are however wrong clearly, at this time of the outbreak, and given large uncertainty on how the virus behaves, the measures launched are necessary, an of the right scale.

Here are the three arguments deconstructed by those still not bought, or not willing to comply with experts:

Argument 1: This is like a flu. Wrong.

Typically, the seasonal flu has (a potential) to kill between 300,000 to up to 700,000 people every year, or ***roughly 0,01% of population worldwide***. In some cases, flu may become more lethal, even if this is a rare event. In the last 300 years, less than 10 cases prevail with excess mortality rates in the range of 0,03% to 0,1%, which would lead globally to 2 to 7 million fatalities a year (*Fan et al., 2018*). As example, the Asian Flu (H2N2) in 1957 killed a proportion between 0,04% and 0.27% of the population. The largest one, perceived to be less than 1% chance probability by insurance companies, has been the 1918-1919 pandemic, or more than 0,5 to 0,7% of population. If scaled to all countries, and to today's population, this may have led to a fatality close to 40 to 70 million people, across a cycle of 10 to 12 months.

We are at the average flu type for the covid 19, some argue. This is not right:

a) In the Hubei region where it all started, with about 60 million inhabitants, slightly more than 3,000 casualties have been reported at this time of writing. The concentration of cases lie in Wuhan, a city of 11 millions inhabitants, with about 2500 deaths, of 0,02 percent of the city inhabitants, already above the seasonal flu. Furthermore, the numbers have been heavily driven by rolling out the types of actions pushed by the European government today, such as major social distancing. If this has made the reproduction rate cut by half, as per our recent articles cross triangulate, the real casualties could have been more like 10-20 times the current figure of deaths. **Scaling this to the world, we are more in the 6 to 20 million deaths.**

b) As more and more countries come in, the crude fatality rate seems to increase, going from 2% in China a dew weeks back to uo to 3.6% today (and already above 5% in China) , while the covid 19 contamination speed seems to double every 3 days in Western Europe, twice the average rate of china (which was doubling every 6 to 7 days).

c) We do not have any vaccine for the Covid 19, so it might be difficult to control, and worse, we may not know if people can or can't be re-infected. Reinfection may cause new waves of outbreaks, as well as too vast release of social distancing.

d) Finally, multiple studies at WHO using recent Chinese data seem to suggest that up to 5% of close contacts of people contaminated by the Covid 19 were also tested positive If one believes the 6 degrees of separation argument, everyone has 44 contacts, leading in total to 1.2 secondary contagion, or **between 6 to 10 million fatalities** depending on 2% or 3.6% current fatality rates. About 5 to 10% of second member in households tend to be affected by one contaminated member of same household. If average household size is 3.5, we have as well **5 to 8 million fatalities**

Argument 2 : We have time to act. Wrong.

There are still a lot of uncertainties regarding how the virus way of working; we should wait and gain time instead of going with full shutdown. This is not right:

a) Virus outbreaks are typically exponential in their first phase, but may continue to expand, especially if no viral medecine exists to limit contagion, and if no vaccines can be found and administered. **Vaccines might be found in case of Covid 19, but it will take at least one semester to have it secured, and possibly same time to have its produced and distributed**, --- at the time the exponential diffusion has exhausted a large part of the population at risk

b) **People understate the power of exponential or power law**—by doubling every 3 days in Europe, this means that in one month (or 10 times intervals of three months), the scale of diffusion will be 1000 of today, if we add again one month, this will be a factor of 1 million. Clearly, acting every day and week faster is a major plus

c) **The capacity of beds or emergency rooms at hospital is typically planned based on non extreme events. As discussed here, figures ten times the flu means that hospital capacity may be binding faster than believed, and will create not only an operational flow problem, but also a critical choice problem against other patients**.

Argument 3 : A old timer disease. Wrong.

There have been argumentations that the Covid 19 is especially weighting on the old generation. This is possibly one of the largest mistake we do. Here is why

a) First, everyone is touched , but this is true that there is a power law happening **where the fatality rate is roughly doubled by decade of life**, that is the fatality rate is 0.2% at 30 to 39 years old bracket, double to 0.4% between 40- 49, and like this up to 15% for the 80 years old more bracket, that is the fatality rate indeed doubles for 5 decades from 30 years old (or there is 2 at the power of 5, or 32 times more fatalities at 80 than at 30).

b) **Nevertheless, everyone is touched** as said above. Recent figures compiled from various sources suggest that less than 15% of the contaminated are above 70 years old in China, but 1/3 is between the bracket 30 to 50 years (and about 42% between 50 to 70 years). **While representing 13% of the Chinese population, about 7.5% of the 20 to 29 years old tend to have been contaminated** (*Riou et al, 2020*)

c) An interesting comparison is also risk of Covid-19 versus the flu. We know that fatality rate is higher, **12 to 24 times more**, for Covid-19 than for the normal flu, but how does that look per age bracket? The rate is **only 4 to 7 times higher for the elderly** as many old timers still die from flu), but it goes up to 9 to 21 times for the 50's and older, 6 to 16 still for the 20 to 49, and 14 to 25 for the people less than 20 years old. This is thus affecting relatively all classes, and the younger, more than it seems.

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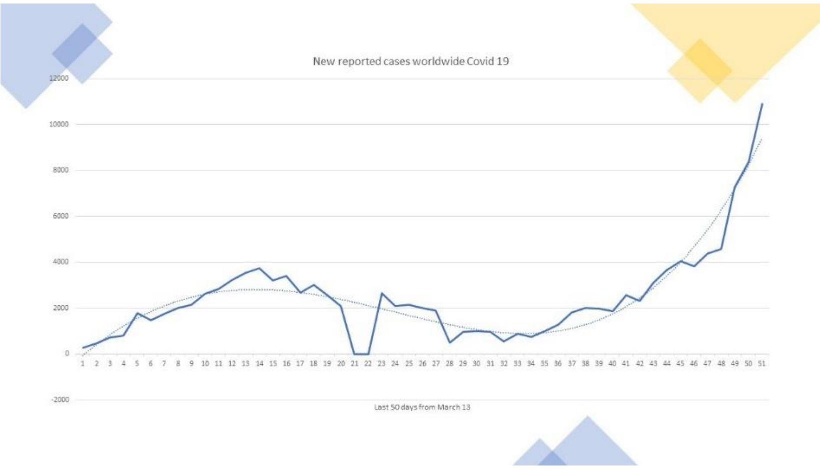
March 13, all errors are mine. comments welcome

8. Nowcasting citizens' behavioral changes in coping with Covid-19 through Google searches

March 14. Clearly, as figure 1 demonstrates from recorded data collected by the CDC, we are in an **inflexion point in terms of the Covid-19 pandemic**. Since 5 days ago , we have surpassed the positive linear trend of new daily cases, **and even we got up to 10, 000 new cases in one day yesterday**, as the virus extended its spread across the globe, and accelerated its diffusion in Europe, including Spain, Italy, but also Germany, France, Benelux and Scandinavia.

Figure 1 : How reported new cases have evolved during the Covid 19 outbreak



We mentioned that it is rather crucial that people adapt behavior significantly and quickly in the absence of a powerful epidemiologic response, and that **a set of simple measures must be applied by all of us to better flatten the curve of the pandemic.** The set of behaviors were discussed in previous articles, and include soap washing hands, wearing mask so as to protect themselves during social contacts, as well as limiting contacts through more remote work, lower travel etc. **But are people really doing it ?** On the optimistic side, case studies on the first wave of the virus hitting China seems to suggest that people are taking the necessarily steps, but on the pessimistic side, this possibly was often **because of enforced policies by the Chineese authorities**.

Here, **we review the evidence by looking at Google trends, under the tested assumption that online searches are powerful markers of awareness and call to actions, and thus « nowcast » behavorial changes** (see Choi and Varian, 2009)

Nowcasting coronavirus cases via Google searches : A strong positive correlation

Figure 2 provides a plot of new Covid cases from CDC statistics, and google intensity searches linked to the term coronavirus, for the period 23/01 to 13/3 /2020 (we took out 13/2 data point as there was a significant change in how cases were reported onthat day by Chinese authorities, the by then largest country under attack by the Covid 19[15]).

Figure 2 : Google coronavirus search intensity and new contaminated cases

The **correlation is large and positive with a contemporaneous value of 0.65**, demonstrating some nowcasting evidence, which we wish to leverage for answering our question as to how people behave in function of the pandemic. We also have tested how the correlation evolves with time lag, and the correlation is actually higher between search intensity, 2 days ahead of new cases, (at 0.7), but declines quickly with 5 days ahead. Correlation between new cases ahead of search intensity, is also lower , (one day ahead at 0.6, two days ahead at 0.45, **suggesting that Google searches might possibly be informative slightly ahead of time, even if there is clearly as well some online search reactions to news of new infected cases** (PS- technically, we should do some predictive modelling to confirm this matter, but this is out of scope here).

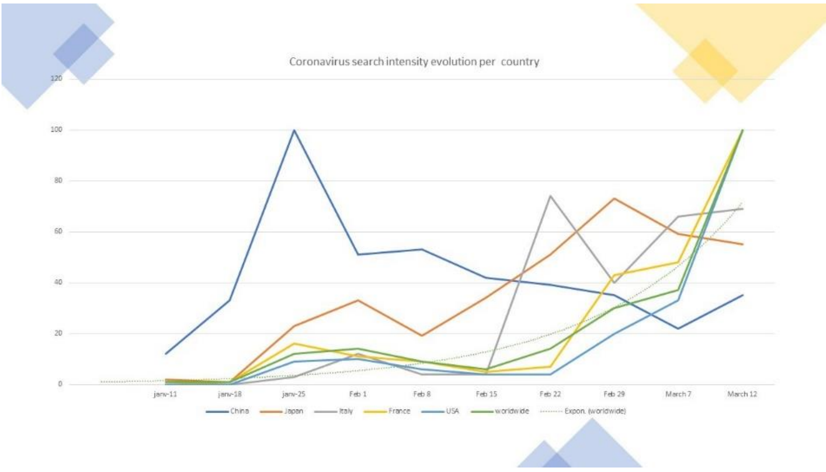
Given this positive correlation, what can we find in terms of Google trends ? Here are the findings :

[15] We took out 13/2 data point as there was a significant change in how cases were reported onthat day by Chinese authorities, the by then largest country under attack by the Covid 19

Covid 19 pandemic may spread over 2 quarters worldwide, and everyone can fix it like the Chinese

We first look at how searches intensity vary per country/region (See figure 3), bringing a few important insights.

Figure 3 : Search intensity re coronavirus -difference by country/region



- First, the **digital awareness started roughly between Jan 18 to Jan 25**, at the time people got noticed of the virus spreading in China, and the lockdown imposed by the Chinese authorities.
- Second, one sees **clearly the geographical waves of the virus**. First, China (with searches peaking by Jan 25), then Italy (and Japan by end of February), and now exploding in the US by latest data available, March 12 (The same is true for worldwide searches, in general).
- Third, slightly worrisome, **February went into searches standstill, and only search intensity rebounded by end of February, when the world realized that the virus was going global**.
- Last ,but not least, **Italy witnessed a rebound in search lately** (when the country extended its policies from the North to all the country), and searches remain high in countries like China or Japan, meaning that awareness/worries remain high.

If one uses the correlation from above as a way to anticipate the evolution, we might conjecture that :

- China seems to come to very limited new covid 19 cases by now, or **roughly 6 weeks after peak searches**.
- We do not know whether we have peaked in search intensity worldwide, but, assume conservatively that we have, this would mean that we are at least 6 weeks at minimum, away to stop (the concern) of epidemy. **This sends us at least to the beginning of May for a possibly control of the disease**.

- We of course may be optimistic here-- we do no know whether effective containment will work out and be applied elsewhere. In particular, we are really at the start (or in absent knowledge) of epidemic evolution in continents like Africa and Latam. In that respect, Latam search intensity in the last 7 days is roughly at 10% of the worldwide search intensity—this level seems to be the frequency of searches of the world seen by Feb 1 and then back at Feb 22, or at least one month to 6 weeks ago. Adding this to the time line, Latam may not be finishing its pandemic before June then.

We thus might **conjecture** that **the pandemic will last at least 6 months,-- thus roughly more than half a year round, if China becnhmark is used and succesfully executed** (but there is a good chance, it won't be as rapid)

People are (but slowly) getting ready to act

The hypothesis we have is that awareness will lead to appropriate actions by citizens. We find that there have been a significant increase in terms of searching for the risk linked to the Covid-19, and that the number of protective actions may look like growing if searches are a solid nowcasting of people behavior.

Towards awareness: active searches of risks and symptoms associated with Covid 19

Table 1 provides a snapshot of search intensity in terms of infection and fatality rates, as well as coronavirus symptom searches.

Table 1: Health search term linked to Covid 19

Google Searches	janv-15	Feb 1	Feb 15	March 1	March 12
fatality rate	0	24	7	38	100
infection rate	1	29	13	25	100
symptoms	1	22	16	31	100
coronavirus	1	12	6	26	100

Source : Goolge trends, worldwide, authors' compilation

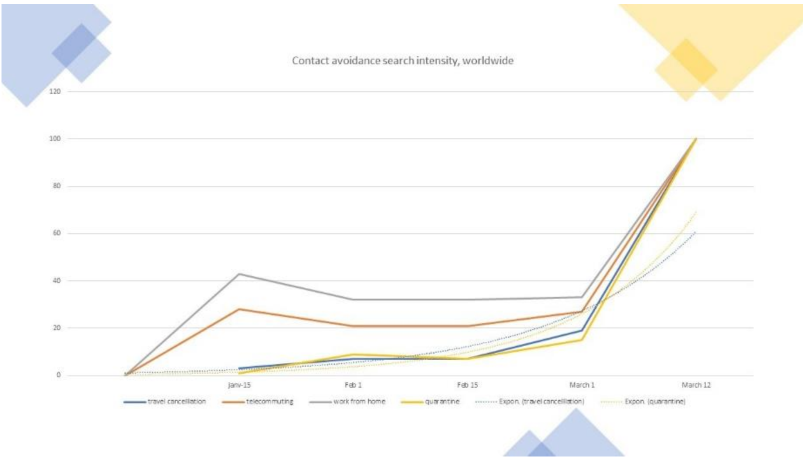
They clearly reflect the profile of intensity of coronavirus general searches, with significant positive correlation. vOther search terms (not included here) include Wuhan, MERS, CDC, Jon Hopkins University (reporting cases real time), or pandemic , but **the health terms below come more intense and more positively correlated with new cases of the coronavirus, suggesting that people are actively trying to inform themselves on the risk linked to the virus**.

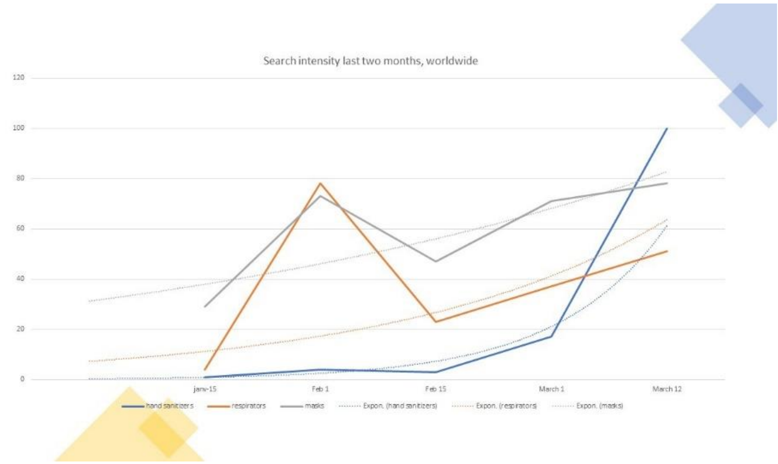
Towards possible actions-- protective tools and contact avoidance searches linked to Covid 19

Greater awareness should lead to actions. We are especially interested in protective actions people may perform, linked to buying masks, etc, and linked to limiting contacts. We find the good news that people are active searching, indeed (see figure 4 a and 4b)

There is an **exponential growth in contact avoidance**, with an exponential growth through times linked eg to quarantines. **Likewsie, hand sanitizers searches, masks, etc** are search terms with strong growth.

<u>**Figure 4a and b : Search intensity re coronavirus protection**</u>





All the above suggests that people are moving into the right direction in terms of behavior. Of course, we do not know whether searches lead to actions; further search intensity is a relative term, and we do not know if people buy and apply protective measures sufficiently and well. Time will tell, but this is why we might need incentives, coaching, and possibly enforcement policies to curb the pandemic.

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All errors are mine. comments welcome

9. Nowcasting the Bear with Google trends

March 16. The stock market has taken a major downbeat again on this day, as possibly the result of fear mounting that Covid 19 is more difficult that thought to contain in short time, further leading to inevitable sanitary risks, and breakdown of aggregate demand. Looking like I did in my yesterday article on Google trends, five points are becoming clear:

1. "**Stock market crash" and "recession terms" online searches are strongly and positively correlated**, **and have spiked five times in last 5 years**, eg end of Aug 2016, Early Novembere 2016, Early Feb 2018, last three weeks of Dec 2018, and now recently from Feb 23. **Those spikes are at same time the stock markets were in sharply down territory, and the change in intensity of searches (especially stock market crash) is closely linked to the size of the drop**, eg- minus 1400 points of the Dow Jones Industrial in Aug 2016 (for a spike of 2.6 times average crash term search intensity), minus 2300 in Feb 2018 (for a spike of 4.5 times average search intensity), mid february fall of 6000 points (and a spike of 6.7 times average search intensity for market crash)

2. We find a **strong correlation between stock market crash search intensity and Google search intensity for Coronavirus, lately**. In fact, there is a positive correlation in level of about 65%, and in the range of 60-70% in the window (t-3 days , t+3 days). Typically 10 points increase in searches for cororonavirus leads to 6 points increase in stock market crash searches

3. Combining both 1 and 2, and making possibly heroic and simplistic maths, increase of coronavirus searches to peak worldwide **has been more or less associated with a 10% points loss in the Dow Jones Industrial, or about 2500 points**

4. The stock market reduction is already twice higher than implied by online searches. The optimistic view will be that the market is over-reacting. The efficiency hypothesis side ('market knows it all') may rather suggest that search intensity for pandemic is uniquely high, and might have more disproportionate effects than what we found by simple linear extrapolation. Looking since 2004 (the earliest we got data onGoogle trends), m**arket crash terms intensity levels of this current level for Covid 19 were only found by 2007 and 2009 at the previous crisis**- as is the search for the term "recession".

5. This recession may be caused by supply factor (travel stop, disruption in value chains, deleverage affecting the company prospects and liquidity) , **but may be driven by a perception of damage on the consumption side**, requiring a budget expansion fix if this shock is permanent.

In fact, we had looked in previous research as to how different category searches may affect sales, -- in effect, we have looked at how non food shoppingcould nowcast retail sales, or aggregate private consumption. We also did so on how automobile searches could affect car sales, etc (see Bughin, 2011). The findings were that those **category search intensity changes were able to nowcast next quarter spending changes, and in such a way, that the dynamic of searches we are witnessing now linked to Covd 19, may mean a drop of consumer spending, of rather large significance, possibly in the range of between 5 to 10%**. If our analysis, by 2011, was anywhere, right -- where we managed to find a **cointegration between searches intensity and retail--, it may also mean that retail spending might be affected structurally,- read permanently**.

We might thus be in a clear demand shock in the making here. Monetary policy might be short of full fix; we need a New Deal plan perhaps, here. Should we then push the **"pseudo-excuse" to invest budget a) in a more comprehensive and agile infrastructure for global fit in healthcare worldwide (so as to get prepared to next pandemics), as well as b) in rebuilding habitats for animals away from our cities, (so as to avoid the inevitable rise of scary zoonoses)?**

Reference

Bughin, Jacques 'Nowcasting' the Belgian Economy (2011), SSRN: https://ssrn.com/abstract=1903791

March 15, all errors are mine. comments welcome

10. Why we must protect the healthcare workforce during Covid 19

March 18. The Covid 19 pandemic continues its world expansion, affecting now more than 200,000 citizens, and leading many countries in the midst of the turmoil to launch aggressive social distancing plans, constraining multiple business closures, and further adding economic stress, on top of health risks.

Those costs may seem to be large for some people, as indeed covid-19 does not match the fatality rate of scary diseases like Ebola, and many others, but it is critical to recognize that the level of contagion of the virus is large enough to induce a very large number of fatalities, possibly in an order of magnitude 10 times, higher than what we usually have observed with the normal flu. Last but not least, **a burst in the pandemic may quickly overwhelm health systems, leading to much larger fatality rates** for those 20% of serious Covid 19 infections, which either may be denied access to hospitalization, or may be hospitalized with sub_optimal care (emergency unit overflows, etc).

The importance of enough technical capacity of healthcare is thus critical for managing the Covid 19 epidemic as recognized by many. But **the healthcare workforce must also be fit as well. A burst of the disease would imply for the health professionals ascending workload, exposure to stress, possible violence by patients, or simply large and not fully safe exposure to the outbreak**.

As the Spaniards and Italians confined in their house and apartment buildings were applauding health workers for their commitment in recent days, **all of us should also do the same**. **We should also try to avoid scenes seen in Wuhan** as late January when hospital capacity quick came short, and timely treatment being denied to (suspected to be) contaminated**, leading to direct violence towards the healthcare workforce**. The solution there was to build capacity in less than 10 days, and reallocate health resources to the Hubei region. Not known enough, a large part of health professionals also volunteered to come to help, another sign of strong ethics of the healthcare professionals, seen in other exceptional settings such as the various bombings in recent years and the 9/11 attack[16].

[16] Not known enough, a large part of health professionals also volunteered to come to help, another sign of strong ethics of the healthcare professionals, seen in other exceptional settings such as the various bombings in recent years and the 9/11 attack.

Herewith, I look at, and try to porvide some quantification of the burden of health workers during outbreaks. Our finding suggests that the heavy lifting seems to be large, and healthcare workers must be prioritized and supported during and after the outbreak.

How healthcare professionals are affected : up to 5 times more disorder, and fatalities

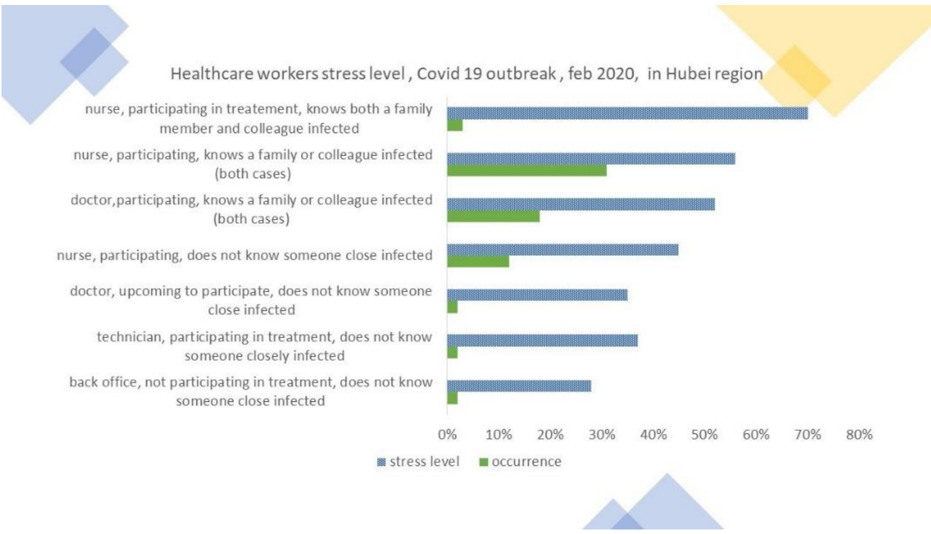
Besides possible violence, there are multiple negative channels that affect healthcare professionals. Let us take two main ones:

Psychological pressure : three times more frequent for healthcare professionals during outbreak than population

The first is large psychologic pressure. In a recent study on how healthcare felt during the exponential growth of cases in Wuhan, there is clear evidence that stress level is relatively high during such an outbreak (*Dai, 2020,* and *Fang, 2020*). Close to 4 out of 10 healthcare workers were in a situation of clinically diagnosed psychological distress during the exponential growth of the disease in early February in the region, and the percentage of stressed workers was close to 50% in the most affected citiy, Wuhan. This is **typically 3 times the rate of the population, and possibly more than two times the rate of healthcare workers** (See e g. *Wang et al, 2019, Study on the mental health status and infliuencing factors of chinese medical teams, Zonghua*).

Looking deeper at the data, there is clear evidence that **stress is highly correlated with the fact of being in the frontline, participating in treatment, especially as a doctor or nurse, and especillay if the worker is aware of any family members, or colleague being affected** (See figure 1).

Figure 1: overstess of healthcare workers dutring the Covid 19



Further, by recrossing the data set, **half of the most affine heatlh professionals where in situation of major stress when caring for Covid 19 patients.** This is similar to other results in Hong Kong, during the SARS with 57% of heathcare proffesionals were having large distress.

Morbidity afflictions : 5 times more exposure for healthcare professionals during major outbreaks

The story of Dr LiWenLiang, who had tried to warn, but was rebuffed by, the authorities of Wuhan on the danger of the outbreak, to become infected by the virus and who passed away in Febrary is a clear reminder that health professionals are at higher risk of contamination and worse.

There are many causes of accidents and mortalities linked to various occasions, eg a driving accident for truck drivers, bad sea weather for fishermen, or falling trees for lumber jackets. In the US, for example, the CDC reports that there are about 3.5 deaths a year for 100,000 workers, or roughly 5500 deaths , outside of infection related ; construction workers and fishermen will be much larger than that, as well as truck drivers. Rate is good for healthcare professionals, yet with a wide range, 4 times more for physicians than home nurses, and 8t o 10 more than home nurses, for those working in the emergency room.

Infections are nevertheless the largest cause of death at work, if one adequately traces causes of death from major diseases such as cancers , and cardiovascular disease[17]. Zooming on communicable disease for our purpose, the statistics, while very imprecise, seem to suggest that healthcare professional may be subject to fatalities, more than 2 times the average work occupation in the US (Table 1). The front line healthcare workers get about 2.5 times more fatalities than the average US workplace.

[17] See ILO work and recently :
https://www.who.int/occupational_health/activities/occupational_work_diseases

Table 1 Fatalities in the US, estimates

	Death from activity	Death from communicable disease (only)
Total workforce	5500	2300
Healthcare professionals	80 to 100	150 to 300
Ratio of death	1.4 to 1.6%	6.5 to 13%
Share of healthcare prof in workforce	3.7% to5.5%	
Odd ratio	30%	1.8 to 2.3

Sources : ILO, CDC, lit search, own computation

Those odds ratios against health professionals can be triangulated with disease specific cases, with a clear message that tens of infections have been transmitted to healthcare workers, including measles, varicella, and others. Outbreak-associated attack rates have been in the range of 15 to 40%, or roughly two to three times the rate of the population (see eg Sepkowitz , 1996, occupationally axcquired infections in health care workers, American College of Physicians). Odd ratios in this case have been computed for contamination, as death rates are very complex to gather :

A) Influenza typically boosts absenteism by 30% for the average workforce population,- it is 70% higher for hospital nurse, or a odd ratio of 70/30= 2.3.

b) For tuberculin skin test, 5% of US population was tested positive, for up to 40% for urban heathcare professionals, or a odd ratio of 8

c) Of all US healthcare professionals, 1 % to 2% could get chickenpox, while the rate is close to 10 times lower in the US in the nineties

d) Heathcare workers were the sources of close to 10% of all cases of measles, while representing 5% of workers, and 2.5% of total population

e) 15% of physicians used to get mumps, for 2% average of population

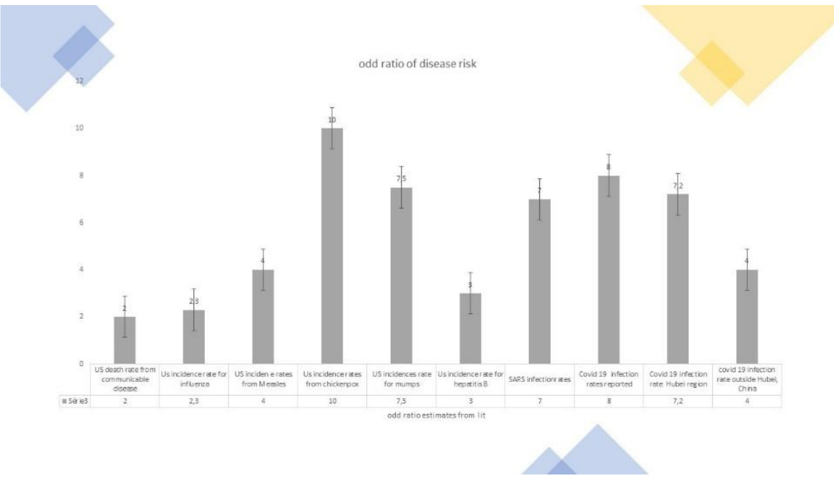
f) US incidence rate is 6 (per 100,000) among healthcare professionals, or about 3 times the incidence in the total population (see Kim, 2009, The epidemilogy of Hepatitis B inthe US, Hepatalogy)

Those statistics are for the average communicable diseases. What do we know for (more exceptional) outbreaks ?

·a) Regarding SARS and MERS , it was reported that 21% (19% ressectively) of the cases were linked to health care workers, representing 3% maximum of population, of an odd ratio of 7 (see *Park et al, 2018*) ?

·b) Regarding Covid 19, reports suggest that more than 3000 healthcare workers got infected by early february 2020 in China (*Walls, 2020*) . As there were about 60,000 professionals dispatched in Wuhan, and Wuhan was 70 % of the outbreak in China at that time, this might suggest that 0.7*3000/60,000, or about 3.5%. Other research implies that reported infection in the Wuhan region by healthcare professionals was 2.5 percent (See Dai, op cit). If one believes the Chinese statistics on reported cases, and Wuhan inhabitants is 11 million, the infection rate in the city is more like 0,3 to 0,4 percent, leading to an odd ratio of 6 to 10. The same research in Dai, op cit., shows that healthcare knew 5.7 more colleagues infected than family infected in the Wuham region , 7.2 times more in other regions in Hubei, and 4 times more in other provinces, -- reporting same odd ratio as other sources, but showing the the odd ratio is larger in most exposed regions. This is because the outbreak happened in the Hubei region and the Chinese authorities got ill prepared at the start, exposing the healthcare professionals more than they should have (Figure 2).

<u>Figure 2- Estimated odds ratio of disease exposure for healthcare professionals</u>



Why more exposure and distress?

What brings such high exposure risk and distress ? The first reason is that most of the hospitalization visits have higher chance of being contaminated, and if so, the contamination may be already for patients in risky health conditions. Otherwise stated, there is a large selection bias of sick people with a high contagious disease. This leads to a significant higher odd ratio of being affected, and a stress risk of the professional being likely infected (for 40% of workers).

One interesting thing is that the largest worries are typically altruistic, eg infection of colleagues (more than 7 out of 10) or of family (for 2/3 of them). (ps : The risk of colleague scores higher, not because, workers do not like their family, but because they were in an environment were the risk is decoupled, and in effect, workers in healthcare services at Wuhan knew 6 times more often a colleague being affected than a family member). Another crucial root cause of the stress was the logistic aspect and enough protective measures being implemented. Such shortages were prevalent in the first weeks of handling the outbreak in Wuhan, and were signifcantly adding to distress.

A mandatory roadmap

Hence, we have shown that risk and reality are high and match, making healthcare Professional quite aware of the danger of their jobs during outbreaks. Remarkably, 90% face those risks, with only 10% would hesitating to show up for work, and a large part would even like to volunteer. Given the risk they take, their altruistic behavior during those difficult period, and the fact they can save our lives, we must absolutely make sure that all is done to alleviate their effort, reduce their distress, and ensure best healthcare. This goes hand in hand with a non negotiable plan with at least those requirements:

1. Make sure to support the difficult journey through psychological squad teams. China has some good practice here- psychological intervention teams have been set up to cover the full workforce, with four action items. A psychosocial response team coordinates the management team's work ; then a psychological intervention technical support team build a psychological intervention material and design rules. Thirdly, a medical team, with psychiatrists, participates in clinical intervention for health-care workers. An assistance hotline team provide remote advice to deal with mental health problems. Hundreds of medical workers are receiving these interventions, with good response, and their provision is expanding to more people and hospitals.

2. Ensure a sufficient supply of protection for everywhere use in hospitals. This is a major concern, and this must be in enough supply to cover not only hospital beds and emergency rooms, but when patients come to the hospitals, etc. There is always the tension that supply is short, because of cumbersome commissioning procédures, etc. **It is important that the governements qucikly found and leverage other citizens initiatives and local sources, to build masks, protection etc.**

3. **Define beta protocols and refine along the way to treat patients**. With a new virus, and outbreaks may come chaos, and confusion. It is imperative that protocols are set up in great details and ingested by all heathcare workers- **this will save stress, live, and will help healthcare workers with clearcut instructions and a sense of being taken care of , in order to cope better with the outbreak. This has proven very valuable during previous outbreaks like SARS**

4. **Focus on health, - it is an investment**. Healthcare has large positive externalities, save days at work, and life. Thus this should be the mission, and the authorities should make sure the rest is not priority and is not of a concern for healthcare professional-- **if they put at risk their time, they should be paid accordingly.**

5. Thank them and show gratitude. I take this occasion to applaude their journey just right now- and will make sure my voice is heard that they deserve the best energy and recognition, without pain points, to make us pass through this outbreak. Thank you

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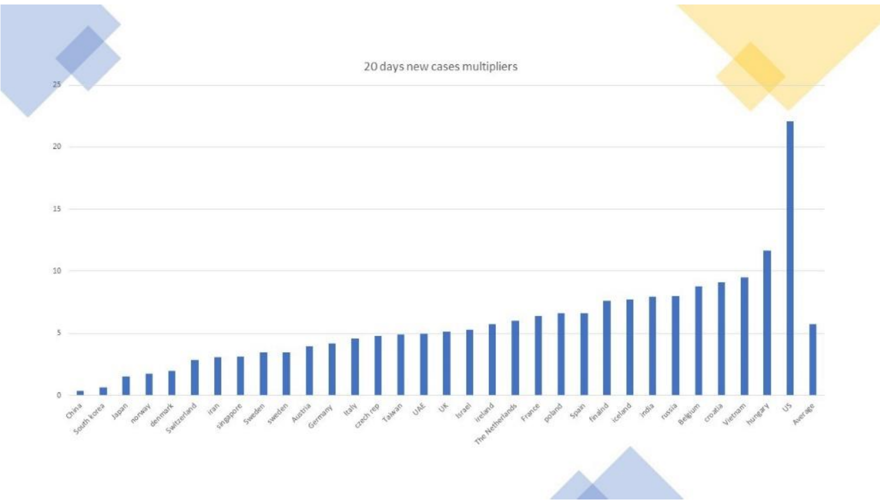
March 16, all errors are mine. comments welcome. References are listed as they appear in the text

11. The Western world should urgently play the "Asian smart" route to control the Covid-19 virus

March 22. The covid-19 spread continues, passing the recorded number of 330,000 contaminations worldwide, and about 15,000 deaths. We are twice the SARS outbreak by 2003, and just hitting the level of the 1976 Ebola outbreak. If the most hit countries suffering just below 1 to 1000 in the case of Italy (0.9 per 1000), Switzerland (0,8 per 1000) and the Hubei region (0,8 per 1000), the current figures are still in their phase of explosion. Traditional fluAsian countries, which have a longer experience of pandemics may teach Europe a few proven management lessons in order to curb the outbreak

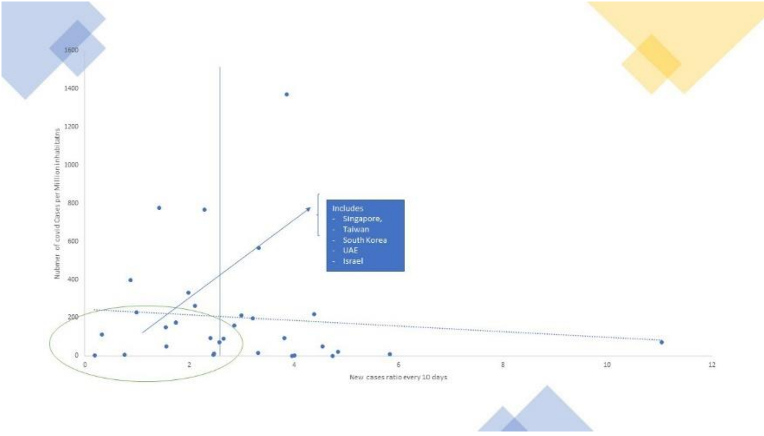
As in case in point, Asia, from where the Covid 19 originated (like 7 out of 10 pandemics since a few centuries, it seems) has close to three times more recovered cases than Europe at large. Its growth multiplier of new cases has declined largely along the way, and is close to three times lower than Europe, (with multiplier <1, in effect, a stabilization of the pandemic, in China, South Korea and Japan; see Figure 1)

Figure 1: Slower dynamics of new cases in Asia



That Asia has been able to curb its new case multiplier is only one feature of that continent—today, Asia has both lower than average build up of new cases as well as lower contamination of its population as one can witness from countries such as Japan, Taiwan, South Korea, Singapore, on top of China. Countries close to Asian performance include Israel, and perhaps, the UAE, see figure 2.

Figure 2- How Asian countries are better controlling the Covid spread



In fact, four elements make Asia a benchmark on how to manage and curb pandemics:

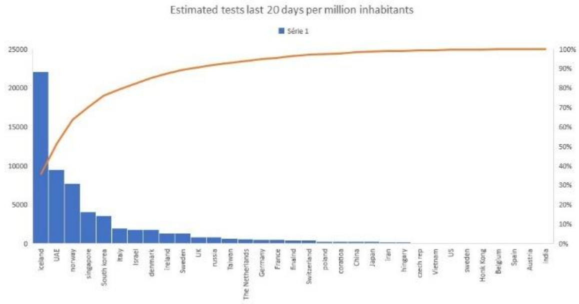
1. Asian countries share the characteristics that **they have faced most of, and thus learned from, early pandemics; the UAE got to face the MERS, too**. Those countries have **learned that they need to build a quick plan and got agile in its execution**. Regarding the plan, it includes getting the provisioning and supply chain right, eg they got enough supply of protections (masks etc) planned,; they managed their borders very carefully so as to limit imported cases (Taiwan, Singapore, Hong-Kong).

Regarding agility, when uncertainty hit, they did not got over-whelmed, but quickly reallocated and built extra resources when needed. China for example reallocated heath professionals to the Hubei region, **so as to double the local capacity of health resources from 14,000 to 30,000,** while they also quickly built up extra bed and respirator capacities in a record of a few days to face the peak.

2. Those countries got quickly into mobilizing their citizens to wear masks and into limiting their interactions drastically, and relatively early in the development of the epidemy. Again, **more than 80% of Asians were wearing masks during the outbreak, -an order of magnitude of what is seen in the Western world, -simply because Europe (and likely US) did not anticipate and currently lacks supply of those protective items**.

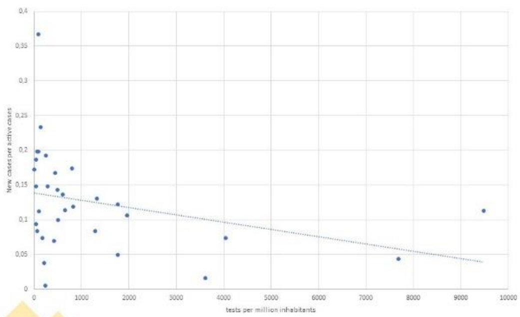
3. Asian countries added enough tests to spot contaminated people. I**n fact, the champion seems to be the UAE, as well as countries such as South Korea or Singapore** (See figure 3).

<u>Figure 3: Who is champion in testing</u>



Regression analysis we conducted suggests that 1000 extra tests might spot 30 new cases, or a 3% hit rate, a significant upside versus currently 0,2 recorded person out of 1000. In pandemics, any, even minimal way of spotting contamination is key to fallten the exponential curve. Hence, rven at low level testing of its population, Asia has been able to **spot twice more infections than Europe today,- de facto, controlling a major source of pandemics, with figure 4 clearly showing that more tests typically push down the growth of new cases.**

Figure 4: Effective testing limits the uncontrolled push of new covid 19 cases



The irony is that, without testing, the number of recorded cases might come optimistically conservative in Europe and outside Asia; using the same number of tests per million inhabitants than what South Korea and Singapore recently performed, w**ould imply that the world is closer to *800,000* contaminations to date, if all those new tests would spot new infected individuals**.

4. Last but not least, **Asia added a clearcut set of pervasive AI technology set to trace and isolate risky citizens**. The technology includes extra artificial intelligence tools to assess the likelihood of being sick, so as to limit people moves, including their close ties in their social networks. Among others, A**libaba trained an AI-based algorithm from a sample of 5000 cases of contaminated people to predict the contamination, at a precision rate of 96%, which then was used to color the QR code of multiple interaction applications** that restrict most probable contagious people to perform socially risky tasks such as travelling, etc. Baidu used video recognition tools and scanners in metro stations to spot people with rising temperature, etc. While in Western Europe, we might question the privacy and the ethics of those tools, they are possibly more effective, and surely much less costly, than imposing a full shut down of our economies. Adding this technology layer has proven to limit the time needed of the quarantine that is being imposed.

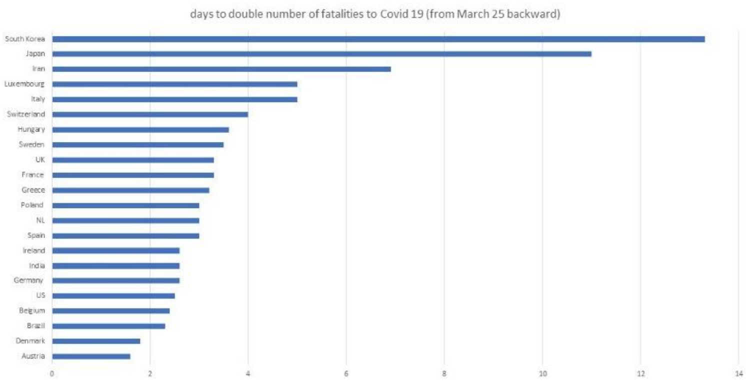
The Western world should definitely take notice, as much as Asia should take the lead to instill those practices quickly on a global world basis. In parallel, we hope that antiviral testing will bear fruit very quickly, and governments will organize a major boost plan to relaunch our world after we have managed to control the

March 22, all errors are mine. comments welcome

12. Better be Singapore than Brazil: Measuring country resilience to the Covid-19 pandemics

March 26**.** How different are countries able to handling the Covid 19 ? We see major differences in the way the Covid 19 spreads and takes life of citizens, worldwide. While the number of covid-19 fatalities has doubled in the last 5,7 days worldwide, countries such as Belgium have witnessed a doubling in fatalies in just 2,4 days only (or twice faster than the world), while Japan fatailies only doubles after 11 days (Figure 1).

Looking at how the number of infections is expanding, and comparing **within** each continent, so that we control better for the timing of the pandemic, Brazil is developing faster than Colombia in Latam ; US is growing faster than Canada, while in Europe, Norway is expanding slowier than Italy. Asian Singapore is much better than Iran, and within Africa, Morocco seems to be less affected than South Africa.



Of course, the pandemic is only a few weeks old, which means that those differences may soon evolve and change. Likewise, the recording of cases may make the current comparison at best noisy, at worse, rather inadequate. **But still, countries with large number of covid 19 tests, such as South Korea, Singapore or Norway, have recorded a more controlled growth of their fatalities to date**, and **we have shown elsewhere that countries matching South Korea performance in test intensity may be curbing by HALF the new Coronavirus cases** as infected people can be easily identified and put in quarantine, before contaging other fellow citizens.

How are countries exposed?

Further, independently of short term dynamics, some structural factors might affect how countries will come out faster, and better (or not) from the Covid 19, across three domains. The first is how well countries are able to control social contagion, the second is how countries can manage the fatality rate, and third is what socio-eoconomic model to support the management of the Covid 19 outbreak.

Regarding social contagion, three factors play a role, that is, how countries fare in terms of social contacts in their daily life, how close those contacts are, and how people tend to react and protect themseves from contacts in case of an emergency such as an outbreak.If we take those indicators, Asians do very well, with 82% of Chinese wearing masks during the Covid outbreaks, for about 76% of South Koreans. Europe is much less disciplined, and only in part because of lower availability of equipments.

On the other hand, the culture of protection is not only about wearing masks ; more Asian people tend to wash hands in their daily life than in Europe, for example. Gall up data and Eurostat surveys in Europe had shown that Italy have much more social contacts in daily life than say, in Finland, but also that **only 57% of Italians wash their hands after going to toilets, for 76% in Finland**.

Finally, governements with a culture of testing, while restricting social distancing, via coercitive measures and technology tracing are to be found again in Asia ; in contrast, the Anglo saxon and calvinistic culture, such as the UK, US, or the Netherlands, **have been much more loose in imposing social distancing restrictions, while their population testing is still in a ramp up phase, and three times lower in intensity than Italy to date**. Countries like Brazil also tend to have large intensity of contacts and promiscuity, with a president claiming that a targetted social distancing is a much more effective strategy- if we can Indeed spot the infected and protect the high risk groups.

Regarding fatality rate, factors are obviously linked to ageing and health situation of population, especially co-morbidity elements such as cardiovascular states or hypertension, diabetis or cancer prevalence. Europe has an ageing and old population, while the fatality rate linked to the Covid-19 doubles for every decade of life, from 30 years. **Likewise, co-morbidity makes fatality 5 times to 10 times higher for someone infected by the Covid 19 than for another without any history of other disease(s)**. Even if we remove the fact that comorbidity increases with age, and doubles in frequency, on average, between 55 years old and 85 year old, this explains only 25% of the difference in fatalities for older population, so age is really thez key driver of risk to die from covid 19 infection, surely linked to the ability of the immune system to battle the virus .

Regarding co-morbidities, a country like Russia, or Poland, or still Spain fare much worse than say, India, China or still Japan. India has also a very young population, while Japan is relatively old as are Spain and Italy. The health system and its capacity to manage an outbreak such as the Covid 19 is critical, as fatality rates correlate with enough capacity of ICU beds, ventilator equipments, and adequate healthcare professionals. **Asia is here again much better prepared with respect to capacity planning of healthcare resources, beds, and PPE, even if the quality of healthcare in some parts of Asia (and part of China) has yet to match the standards of Europe**. While with good health quality, Europe has been struggling, and the current outbreaks in countries such Italy, with an ageing and high comorbid population situation, has led to an excess demand of hospital treatments, at the expenses of the healthcare people themselves (with much higher infection rates than what was seen say in the Chinese Hubei region, it seems), or top of the infected, with a fatality rate close to 10%.

Regarding socio-economics, the economic outcome depends on risks (such globalisation exposure), cost of lost productivity and life (share of people affected and with fatal outcomes), and type and success of means applied to stop the disease (a clever model of spotting contagious nodes, and put people in quarantine is much less costly than a total cost of shutting down the economy, but to the extent that this model is available, and implemtable; in practice, for pandemic with high R Naught, this is rather difficult to make this work, and economic shutdown is the reality)

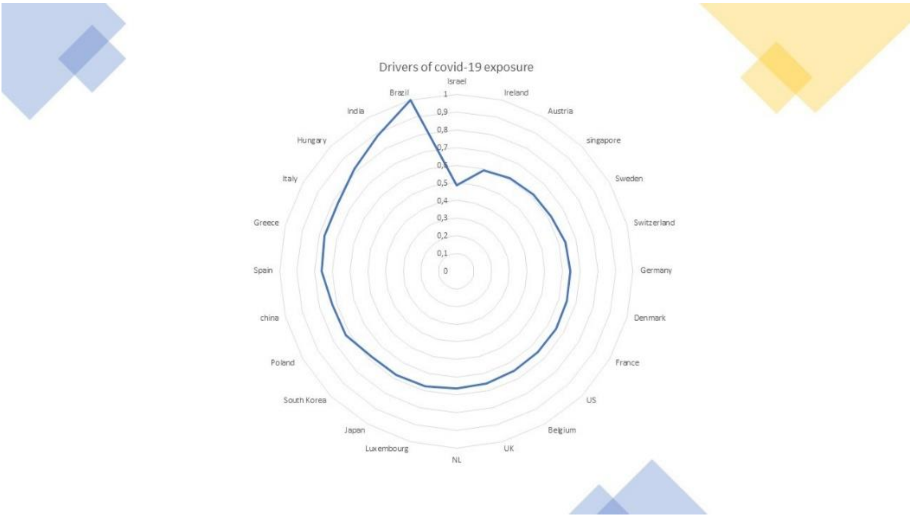
Regarding globalisation, small countries are penalized as their share of global exposure is larger. For instance, Germany is much less exposed than say Benelux countries. US has been exposed to China at the start of the Covid 19, following trade war with China, but since the outbreak is a global pandemic, US has become relatively as exposed than any other countries.

We have argued elsewhere that the r**eal costs of a pandemic like the Covid 19 are first of all driven by a depressive demand effect, then within supply, to a shutdown effect, more than a fatality effect** (as more fatalities happen at later age, outside of the productivity impact). The depressive demand effect is especially important for countries with large exposure to sectors such as entertainement, transport, automotives, retail, etc, and to the extent that countries finance the citizens for fall in revenue during the economic shutdown. Anglo Saxon systems are indeed more selective here in their revenue insurance. Hence, they may be in a more difficult situation to restart the economies than Western Europe. Hence, the major welcome of boost plan exceptionally passed at the Us Congress, for example.

Double the risk: Brazil versus Israel or Ireland

We have started to collect data especially on the two first drivers. Data are only high level, as they have multiple sources of collection, and time dimensions. They originate from top level sources neverthless, including multiple country studies in the Lancet, or academic surveys studies in terms of social contacts, etc. (Figure 2).

Figure 2: Drivers of covid 19 risks



Countries where we collected data on health system quality, population age structure, co-morbidities, and social contact and washing hand sanity, etc are a few Asian countries, and mostly Europe. Taking a simple average of the performance metrics, we find that:

a) Brazil is the most exposed, with Isreal the leastst. The difference is also a factor of two, i. e. **Brazil is twice more exposed to fatalities, in our simple maths, than Israel**.

b) Asia is ok-ish, with **Singapore taking the lead**. S**outh Korea faces however old and co-morbid population. Thus, Asia has compensated its exposure by much strong management practice to control the pandemic**

c) Europe has well see divergence-- with Ireland well placed, a**nd Southern Europe more exposed**, - eg consistent with the data, Spain and Italy, and Greece. Eastern Europe is more challenged too.

d) In general, **less exposed countries tend to combine good health systems, a good tracking and testing systems, and a younger population**, as this drives the outcome of fatalities, but at the end quickly curb the social contagion long enough is as important, -- and not fully measured here. Israel has yet to put major confinment for instance, on top or tresting and technology tracking.

We thus clearly see that countries are not born equal when it comes to their exposure to Covid 19. Nevertheless, Asia is not that insulated from the risk of pandemic. What makes Asia successful is an clearly effective management of the crisis, with some apparent success. This will be where the success lie.

March 26, all errors are mine. comments welcome

13. In need of more testing and a culture of social protection

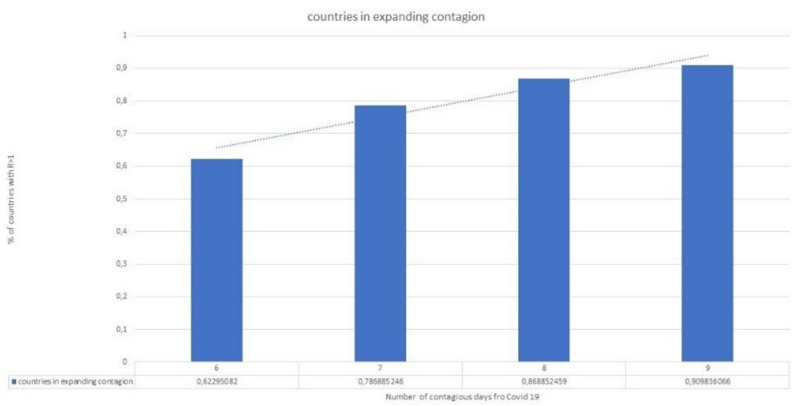
March 29. In early articles, i made clear that we need to be radical in curbing social encounters, and in protecting against infectious contacts, **both to control the covid 19 pandemics, and to secure a working healthcare system that may maximize the care to the contaminated**.

I also made clear that successful examples existed, especially when it comes to (some, not all), Asian countries. While proscratinating for a while during the Lunar New Year, China aggressively scaled measures after it was recognized by Jan 20 that Covid 19 was a major human to human transmission disease. Those measures included limiting mobility (remarkably, no public transport and no car in Wuhan were imposed in 5 days), an aggressive tracing of even mild cases via technology based predictions, a strict imposition of quarantines regarding any suspected case, and an enforced policy of protection via masks in public, etc.

The global status today : we are not winning

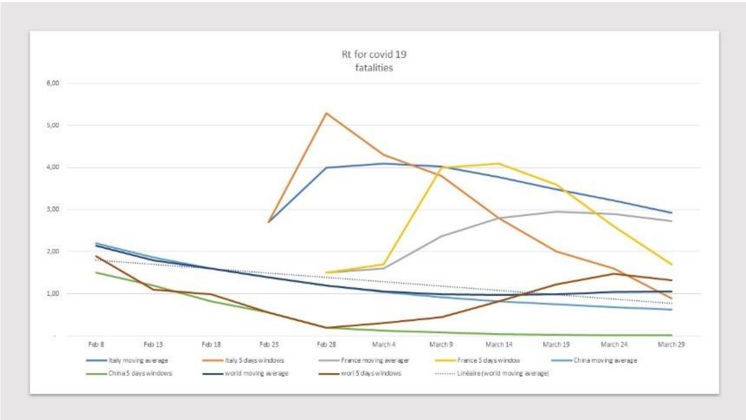
As a result of its measures, China has been controlling the pace of the pandemics, yet it is one of (the few) exception(s) that confirms the rule. **We are too slow to act, not agile enough to test, and not imposing enough to take control**. In fact, since the pandemic was recognized, about 200 countries have recorded covid 19 contamination cases. Using a normal range of contagion period (eg 8.5 days) , we compute that ,at this current day (march 28), **more than 90% of countries are likely still on the *accelerating* part of the pandemics development**.

<u>**Figure 1 : how countries are (not) taking control covid 19**</u>



Given the decline in the reproduction rate in China, the world Rt tended to be in control at early march, but then epidemy got to spread agressively in Europe, and **the estimated effective reproduction rate, Rt, in a five days period, has been climbing during all the month of March, reaching Rt =1,3** (from march 23 to 28). And worse if we rather take the top 25% quartile of contagion period (up to 12 days), we are mostly at 96% of countries in exponential mode, and with an estimated rate of reprodcution at R= 1,6 (reversely if contagion period is optimistically, only 6 days, like in the total of the flu, we would be at good news of Rt=0,9 but still with 2/3 of countries above Rt>1) :

Figure 2 : Evolution of Rt- contrasting China and others



Such a « Rt » figure is clearly not adequate. A transmission rate, Rt at 1 (where we control the disease) and one at 1.3 means that in the first case, the pandemic will peak 36 days later, and the peak is flattened enough to have about 45% fewer daily cases to handle. Thus, a lower Rt buys much more time to secure enough qualified capacity for sanitary measures, as well as by avoiding healthcare supply chain disruption.

Further, time is important to process at scale better testings and spot risky individuals. Hence, China managed to build the right momentum to decrease it faster : China average Rt (computed as moving average through interval of 5 days) declined by 9% every 5 days, from its peak to Rt<1 (achieved between Feb 13 to 18) , while the decline in Rt was only half that for Italy between its peak and its successful Rt<1 (just arrived in the recent few days). France has yet to reach Rt<1, and if we look from its peak, France decline is only 3% every 5 days, or 3 times slower pace than in China. The message is thus clear ; a low rate Rt achieved fast, both flattens the epidemic curve, and is a recipe for further containments, and lower pandemics

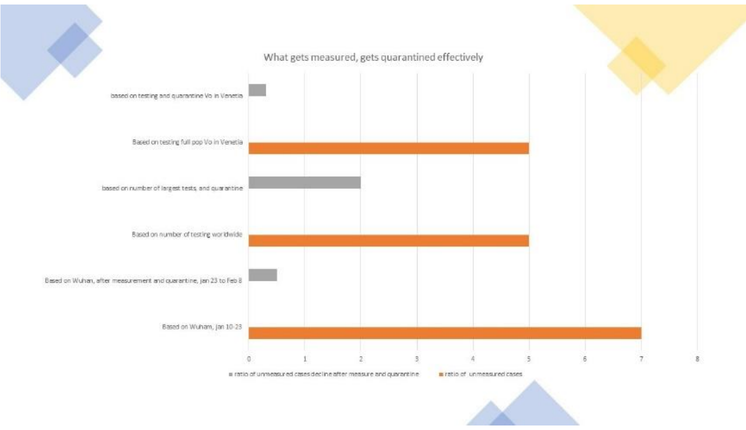
So lets reemphasize how countries can truly manage to control the epidemy, via the twinstrategy of measurement, and protection :

What gets measured gets fixed

One real danger of current pandemic is the **portion of unnoticed cases**. As said above, the average latency period for Covid 19 is actually not small (5 days, and could even go to 10 days for 3 to 5% of cases), and thus any un-noticed case may be a very large contributor to the pandemic. Recent academic work suggests that only one out of 6 contaminations got noticed in Wuhan -the city which is the center node of the pandemic- before the authorities implemented by Janaury 20 ; its radical twin approach of confinement and measurement. **While milder cases seemed less infectious, their sheer number meant that they could have contributed in reality to 2/3 of contaminations** in the early days of the outbreak in Wuhan (see Li et al., 2020, Substantial undocumented infection facilitates the rapid dissemination of novel coronavirus, *Science*).

Such un-noticed measurement may seem large,- but seems in the right bullpark, based on a few triangulations (see Figure 3)

<u>Figure 3- Measuring and putting in quarantine unnoticed cases of Covid 19</u>



In a recent research on the healthcare workers perception in China, during the Wuhan outbreak, the share of workers reporting knowledge of sick people was about 2-3 times what was the official share of recorded infections in Wuhan.

When we look at testing made by countries, testing seems to turn positive at the margin for 3.0 percent of the people, with decreasing rate by 10% every 10 points of population tested. We had mentioned elsewhere that based on number of tests done in the course of March by South Korea, (500,000 tests, or roughly 1% of its population-), South Korea managed to reduce its total death rate by 50% by now, as they could put more people in quarantine showing the importance of spotting those cases.

Finally, another fascinating example is the village of Vo, in the Veneto region in Italy, which went into quarantine lockdownby February 23. The strategy there was to combine quarantine and testing, wtih a staggering 97 percent of its population tested in one week. At that time, three percent of the population resulted in being positive, or roughly 5 times the actual number of recorded contaminations, for the population of the 11 towns put in lockdown in the Northern Lombardy. The operationalisation of the strategy was then to contact directly all those who tested positive. Asymptomatic cases or those with mild symptoms were quarantined at home, while those showing more serious symptoms (e.g. high fever) were immediately hospitalised.

In order to ensure compliance and prevent disease to worsen, contaminated people at home were called several times a day to make sure they were abiding the quarantine, as well as to test their evolution , eg through temperature (see https://www.theguardian.com/world/2020/feb/24/italians-struggle-with-surreal-lockdown-as-coronavirus-cases-rise).

The strategy worked out superbly, as the repeat of test by March 8th demonstrated that only third, or one percent of the population was still found positive, leading in reality to a major decline of Rt by Feb 23 evaluated at 2, to come to be Rt =0,3 by March 8th, or a reduction of close to 85 percent, we estimate. There is no new infection in the town currently, accroding to multiple media.

Protect, protect

Finally, it is critical that people got protected, and with the right priority.

Many countries have understood the need to play the social distancing game, even if the game has to be balanced with the effective testing of the population (see above).

Given level of effectiveness and costs linked to social distancing, the priorities are often easy to establsih, eg it is better to start with banning large gatherings of people, like theaters, cinemas, gyms as well as all market places. School closing and telecommuting always come second and third. The jury is still out regarding schools as COVID-19 has yet to affect children, and there is still large uncertainty as to how children may transmit the virus. However, one large benefit of school closures is to enforce adult parents to remain at home. The risk with telecommunting is lack of productivity, but the good news is that many workers have adapted rather quicky.

Another priority is to have an heatmap of indsutries at risk, and allocate protective resources accordingly, eg in healthcare. A large part of the necessary industries that need to work at full speed, involves likely large exposure to infected cases (eg healthcare at large, including pharmacies), and/or large number of contacts, that might increase the likelihood of contamination (eg retail, daily services, etc). This is rather critical as the odd ratio of contaminations may be rather large,- eg we estimate a odd ratio of close to 7, for heathcare workers in front line of the covid 19 outbreak elsewhere ?

Again, countries in Asia, were very quick in building effective healthcare supply chains to cope with the disease ; online merchandising was also very effective in countries such as Japan, China, South Korea and Singapore. In contrast, many other countries got very late into securing those supply chains, like the US among others, and many European countries, being relatively overwhelmed to secure appropriate protoective equipments for their heayh systems.

A final aspect is to make sure people keep delivering on the right protection measures, in terms of wearing masks, gloves, and washing their hands. There, as well, the respect of those rules look rather imperfect, according to multiple surveys.

Not surprisingly, Asia is much more obiding to those rules, and those are now part of the way Asian citizens nw leave. Eveyone in China and Hong Kong have stocks of masks at home—and **consumption of masks is as large as kleenex in Europe, it is said. Any commercial venue, or restaurant etc offers hydroalcoholic solutions to wash hands ; or there are workers systematically disinfecting any risky touchpoints in public space**, such as doors, lifts, etc.

This is still something to make it embedded in our Western culture, if we want to leave at peace with the covid 19.

References

Li et al., 2020, Substantial undocumented infection facilitates the rapid dissemination of novel coronavirus, **Science**

March 29, all errors are mine. comments welcome

14. Beyond the recorded figures: How the Covid 19 pandemic might actually be playing out

April 02. Since March 3, I started to study the Covid 19 outbreak, and related some of my key findings in more than 10 articles during the month of March. This article stands back on what was written in that first month anniversary article, and especially aims to comment on the measurement challenges linked to Covid-19 pandemic.

The main message is that **infections have been significantly unreported, and that the corrected figures provide a much more consistent picture as to the pandemic dynamics linked to the Covid- 19, than the current records**. By documenting more cases than not, we are making a better guide to the health system and economic reactions. **The metrics, adjusted from unreported cases, are « better » than what has been reported (that is, we find lower Ro and lower fatality rate than early estimates), but they also are pinpointing how milder and asymptomatic cases remain an understated, core dissemination vehicle of the pandemic. Careful zoom on those cases is a core battle to win and avoid a second wave of the outbreak by 2020**

A Reminder

Early March, I made the point that we needed to understand three core figures to have a better chance to fight covid 19.Those figures include the transmission rate potential (known as R0), the fatality rate, as well as the exact distribution of contagion intensity. At that time, the early consensus value of those KPIs were estimates of R0 sometimes above 3 (mean 2,5), and a fatality rate just above 3%, while the distribution of contagion might indeed be in line with other flu viruses. Those figures would have implied a significant pandemic risk, and were a clear confirmation signal that we were there for « something real », justifying the shutdown of China and Italy.

At that time, too, my « best guess » was also that we were risking a pandemic, but my figures were slightly more conservative than mainstream. My mid case scenario was a reproduction rate, R0=1,9, a fatality rate between 0,5 to 2% percent (average 1,2%), and likely, a semi-Pareto distribution of social contagion. The rationale for my corrections was as follows:

a) At the start of disease, fatality rates are typically not easy to compute given identification of causes of deaths, and lag between contamination and mortality. At that time, I then considered to look at the status of the Diamond Princess cruise boat (roughly 1% of fatality rate by early March). This was made clear that this is an upper case, given the age structure of the cruise ship clients , which is twice older than average population, as well as the density of people in a boat, creating a core net of close contacts for the virus to thrive (more than 3700 passengers in possible space of 10,000 sqms, or roughly 3sqm per person).

b) Regarding R0, my reasoning was that since R0 is estimated in early days of the pandemics from the dynamics of the virus infection build up, number of infected cases may typically be missed, or simply unspotted for asymptomatic cases, especially at the start of the pandemic [18]. This would imply that R0 estimates may then be biased upwards in early days of the recognition of a pandemic. Comparing how R0 was adjusted for other viruses, I came to conclusion that R0, might likely be more like 2.

My estimates by March implied a mortality rate in the range of **0,2% of population** (2/1000) if the pandemic runs its curse without barriers being set up to curb the pandemic. Obviously, this is a upper case, but it shows that without barriers, this leads to **a significant figure that warrants large social costs if the pandemic runs its curse. It also might push hospital systems under major stress towards insufficient capacity, as some countries indeed proved us righ**t.

Any update?

Today, what do we know more about those key figures? We **know much more, but we are far from having a perfect view**. Consider that

a) Testing for Covid is building up among countries, but we are very far from having tested the full population. By March 20, for instance, in Europe, **Iceland was the testing champion with nevertheless, only about 2,7% of its population tested**. Norway was at 0,8%, but Italy was at less than 0,4% percent, Germany at 0,2%, or Belgium at just 0,1% of its population.

b) The link of fatalities with co-morbidity and age was quickly recognized, but this is only recently, that those are better understood, (**eg a population 10% older than the average would increase its fatality rate by 30%, due to age (15%), and co-morbidity increase with age, 15%).**

c) **The portion of asymptomatic case was felt to be large, (as it is for flu -like disease), but its importance is only being recognized since a few weeks**, where studies emerging that the portion is

[18] A fortiori, if asymptomatic cases are less contagious than the other cases

material, and is then a key driver of the contagion , reinforcing the first point that we must absolutely test people to know where the contagion originates from.

As a case in point is the village at Vo Eugeno, from which the patient zero was originated from in Italy, and which tested its full population after lock down—discovered that by late february, **more than 50% of the positive cases were asymptomatic, a very large number, indeed, up to two times the flu for example.** This figure is independently **confirmed in the case of the Diamond Princess. About 52% of cases were seen as asymptomatic**, based on the 94% of people on the cruise which had been tested up to February 20th (see, *Mizumoto, et al, 2020, Estimating the Asymptomatic Proportion of 2019 Novel Coronavirus onboard the Princess Cruises Ship, MedRvix*)

d) R0 is converging towards a consensus of between 1,5 to 2,5—still a wide range. Yet, this range will be difficult to stabilize if we do not have clear visibility of the exact number of contagion.

Building the new baseline

Based on those new observations, I relaunched the various models to re-triangulate new key estimates of R0, as well as a fatality rate. While the numbers are based on triangulation,- and ay remain uncertain, here is what i found :

Number of infections : Can't be so few as recorded, and is likely 10 times more

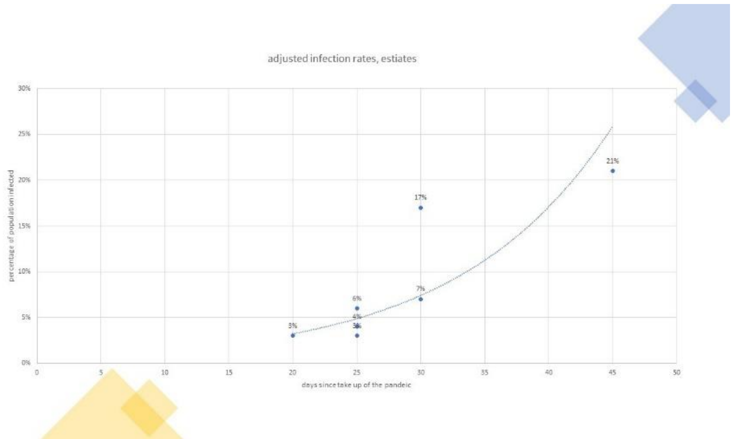
Current data may suggest to date that only 0,1 to 0,2% of the population gets contaminated. Spikes include smaller countries (Luxembourg, Andorra etc), or countries with heavy nodes of infections, such as Spain, or Italy for instance.

Clearly those figures are under-estimates as they do not reconcile with personal experience (« how many people do you know personally who may be infected ? »). Likewise, those figures « do not match » with early estimates of R0 either, as Ro would imply much more infections than recorded. Either R0 is much lower, or our barriers set up to curb the pandeics are luckily good enough, -even without testing to spot the right people infected. This also looks irrealistic, as many countries are far from putting an extensive amount of barriers. Eg Sweden and the Nerherlands are still not actively intervening in directing policies towards its population, or countries doing it are yet to see people complying fully to social distancing- see for instance https://neurohm.com/wp-content/uploads/2020/04/FALA_2_COVID-19_Fever.pdf

We thus triangulated thus multiple sources, eg, we have full experiments like the cruise, or like the town of Vo in Italy ; we have country comparison by level of testing, as well as we have ways to rebuild data from time of incumbation and symptoms etc.

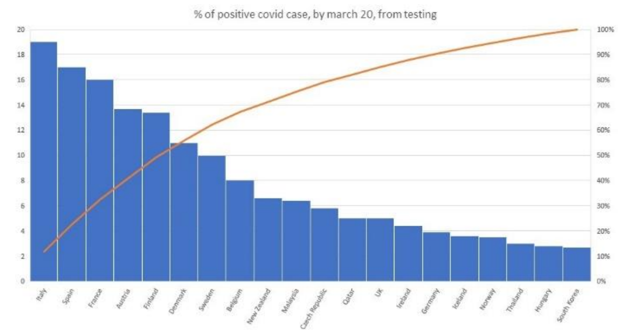
What do we find ? All those experiments are explained here-after but suggest that a significant percentage of the people is being infected in line with what to expect from a contagious disease, moving from a few percentage, say 4-5% after less than 1 month, and accelerating to 4 times that infection rate, more than one month later, in line with a pandemics,).

Figure 1 – the build up of corrected Covid 19contagion



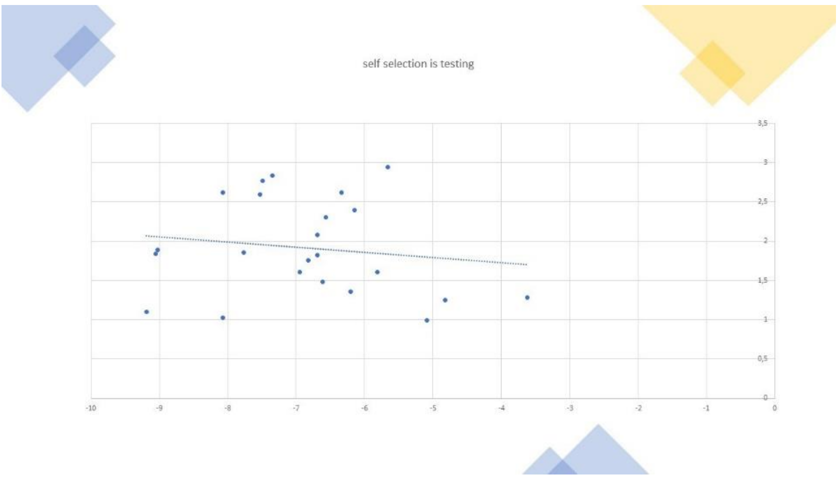
A). If one looks at the outcomes of tests made : 4 to 5% of Europe infected by mid March after 4 weeks of hits. The average is about 8%, and the median at 6,8% by March 20. We also observe that countries linked to a tradition of hosting winter sports (Italy, France,Austria, or Scandinavia) have twice the rate of the others, roughly, see Figure 2.

Figure 2- how tests have spotted infections, total by March 20



Those figures are likely biased upwards as a large part of tests has been made of people feeling unwell, etc. Indeed, we find a strong link between intensity of tests and positive tests, in the way we expect ; that is, more tests lead to lower positive rates. Using those (statistically significant) cross-sectional links, we estimate that the selectively leads to up to three times the true average. Otherwise stated, the true infection rate was more in the range of 3% of contamination than 8%, by March 20. This average comes just above 25 days after first deadly cases observed.

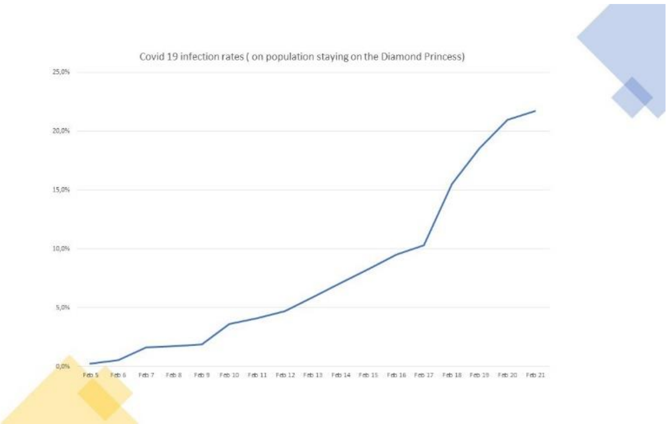
Figure 3 : Computing the selection bias in population sample tested



B) If one deep dives into population cases : 12-15% after 45-50 days. If we know look deeper at full population, the total number of contagion in the Vo village amounted to just above 3% by Early march, or roughly three weeks after the first casualty in Italy, after all the population got tested, and strict confinements were put in order. At this level, this eans that about the true reportec number is roughly 8 times, what would have come out if the same process of reporting would have been in place like in the rest of Italy. Furthermore, if R0 is in the range of 2, and considering the time for contamination, this may mean that, without actions others than own people taking some caring measures as a result of their risk perception of the virus, we should reach close to 12% by March 20, or roughly 45 days after first casualty in the region.

Looking at the Diamond Princess cruise ship, figures were about 17% by February end, or roughly 4 weeks after the first case was spotted and in final, roughly 21% by march 15th, or roughly 50 days after the start of the contamination . This figure is possibly into the high-end, because the cruise has attracted lot od old people (75% of infections came from people older than 60 years old, while typically the share of infected has been more 30-35% in China, South Korea and recent figures released by the CDC in Europe). Correcting for the high propensity of contamination, the figure is about equivalent to a 16-17% contamination effect.

<u>Figure 4 : The development of covid 19 infections on the Diamond Princess cruise ship</u>

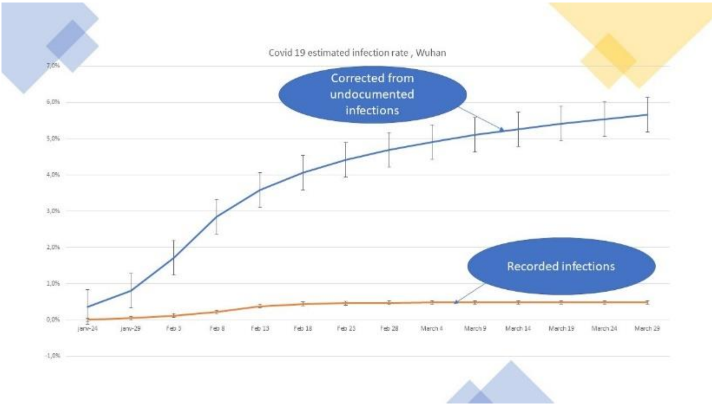


C) If one performs a deep dive case study on Wuhan : Minimum 3% after 20 days. We finally have leveraged data from Wuhan, to correct for the actual number of cases. In particular, we simulate a model, by which we revert back the infected cases both based on timing of contagion, as well as on a study recenty performed by Li and colleagues hat simulates the spatio-temporalc dynamics among 375 chinese cities. (*Li, et al., 2020)*.

As the later study still takes the recorded figures as the "official" background figures, we also corrected the figures by considering the estimate of cases by Jan 23, based on our cross-sectional tests by country, and/or by taking more credible figures, arising from a survey of people in Wuhan in terms of how many people they actually knew of being infected, leading for instance to about 3% of the Wuhan population, by early february 2020 (see *Guo, et al., 2020.).*

By doing those adjustments, we were able to estimate that by today, close to 6 % of the extended population of Wuhan is already infected, despite very severe measures to stop the virus outbreak. The ratio of likely to recorded infections is now close to 10.

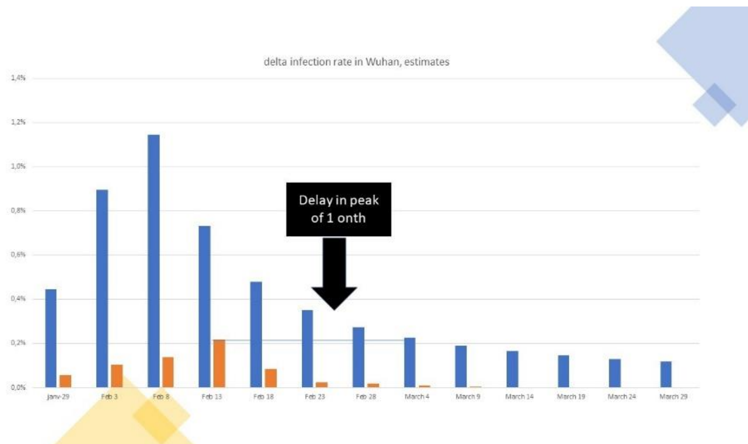
Figure 5 : Corrected contamination developments in Wuhan



Implication for pandemic momentum (->longer) and fatalities rates (-> in the range of 0,4% for Western Europe countries)

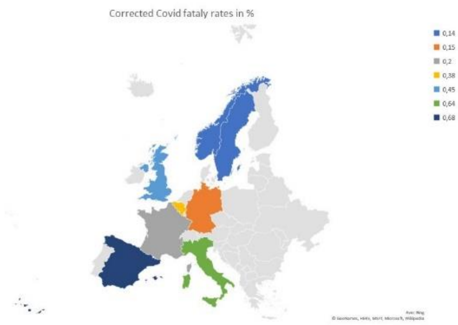
a) One first implication of the above is that contamination will build up longer because of those unreported. We take Wuhan as a case example. Based on adapted figures, the same level of contagions, which was recorded, as the official peak at Wuhan, in fact happened one month later, during the declining phase of the corrected dynamics of the epidemy. For each period, the number of new cases is higher than the recorded one, leading to an increase in the relative stock of corrected versus recorded contamination.

Figure 6 : The dynamics of new cases recorded versus corrected case, Wuhan



b) The second major implication is that the fatality rate is lower than expected. Using an average 20 days from being infected to death, we estimate it to be in the range of 0,45% in Wuhan (if one believes the recorded figures of death casualties). It currently oscillates between 0,14% in Scandinavia to up to 0,65% for the average of Spain and Italy, for an average in Europe of roughly 0,35%. We find fatality rates are higher in countries with older population, larger co- morbidity and with either lower quality of health services and / or not enough critical health capacity. Thus, we expect those figures of fatalities to be higher in countries with older population and poor sanity, and qaulity of healthcare. This may mean that rest of the world is likley above the European fatality rate.

<u>Figure 7 —adapted fatality rates in Europe</u>



New Ro computations : figure just above 2.

What do we infer finally for Ro ? First we estimate from the death rate as a proxy for dynamics of contagion under some strict hypotheses, then we recompute Ro using new adjusted data. Our hypothesis is that the new Ro should be slighlty lower than some early estimates as early recorded data may under-estimate the pandemics. This is excatly what we find.

Ro estimated from the death rate

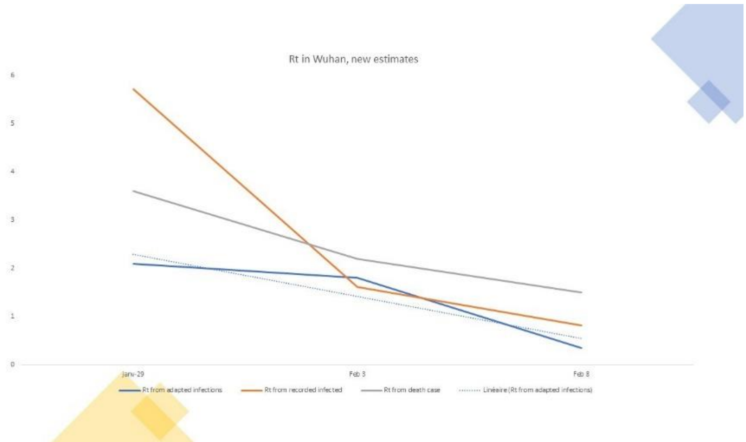
Technically, Ro is computed from contagion, but if we assume that the fatality rate is more or less constant and that deaths are more or less fully diagnosed with covid testing, then the dynamics of the death evolution may provide some indications as to how R0 might converge. Using a 20 days windows between contamination and deaths, the average R0 looks to be in the range of a weighted average of R0=2,2 (1,7 to 2,8) when doing the computation for about 20 countries.

Ro estimate from the the amended infected cases

The above RO estiates relies on some key constant ratio assumptions. We however can also compute a new Ro, from the amended contagion data, as we know have all cases, and not only the registered cases. We provide this for Wuhan as an example. We compare Ro from recorded data, then from death rate and then from amended data.

The last one should be ideally the most accurate, and demonstrate a R0 in the range of 2. The R0 at the very ealry days of the outbreak is relatively high from recorded data at more than 5, while the one on death rate is in between the tow other figures, but obviously the death rate has a time lag effect which makes it diffcult to compare at same period as the two other estimates.

Figure 8- new estimates of R0.



So what

The update tells us a few critical insights:

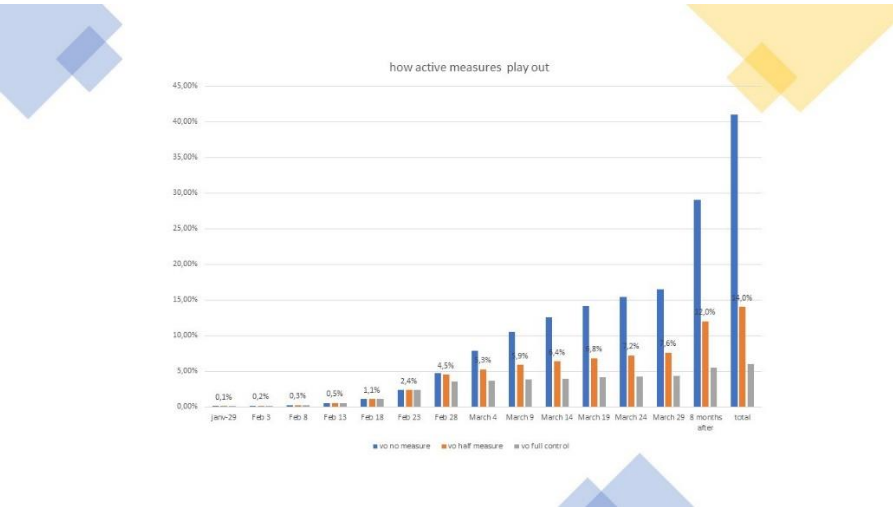
1. A serious pandemic- more than the flu. As to be expected, -and if the adjustments appear to be confirmed- , the dynamics of the covid 19 is more in the range of R0=2, and a fatality in the range of 0,45% . Applying an natural protective adjustment of the population along the pandemic development, we estimate a risk of contamination at 29% by end of year 2020, and an implied mortality of 1,3 out of 1000 individuals.

Scaled to the world population, this is a potential of 8.5 million by end of year, and up to 12 million at infinite. **The figures tell us that the dynamics of covid 19 is serious**, as this means the pandemic **will be at par with the first and/or the second most lethal diseases, such as heart disease or strokes worldwide, but its scope of impact will be much, larger affecting 1 out of 3,5 people.**

2. We may not release our effort both to keep the pandemic at the bay, as well as to avoid a second wave. Of course, most of the countries have been taking measures to limit the pandemic. Some have been extreme, like China, or because of its small practical scale, a town like Vo, in Italy, which could test and identify infected people, quarantine them while protecting the population. In general, most countries are taking confining measures, as well as protective measures, some with stricter enforcement rules than others, and/or with much better testing process.

We have rebuilt the model, and are able to show that adding those measures and be very successful fast in executing against them lead to a control of the pandeic, reducing the total contamination to 5.5% of the population by end of year, with an outcome, of 1.6 million fatalities worldwide, or still twice the flu mortality risk. This is because the R0 of the covid 19 remains higher than the flu (R0=2 versus R0=1,3 for the flu), as is the mortality rate (0,45 % versus lower than 0,1% for the flu).

Figure 9 : How (un) successful containment measures make a difference



If on top, measures are only followed at 50%, the risk is that the pandemic will reach more than 1 person out of 10 by end of year, and will still put a large burden of fatalities and continued hospitalisation—peak will have passed, b**ut still we might still be running at thirty percent of current capacity to care about covid risk until end of year.**

3. There is no way back to normal this year. Last but not least, controlling the disease as done today, clearly shows that there is no back to normal, as from the case of successful stabilisation, say below ten percent of the population infected, **the epidemic data might suggest that up to twice the same risk potential as current may reappear within the year.** We must structurally prepare against a second wave, and speed up for effective testing and vaccine protection. We only get started in the journey

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All errors are mine. Comments welcome

15. Fighting the virus requires to know its habits better and for us to rethink our social interactions

April 4. The covid 19 has passed the 1 million recorded cases and driving a crisis feared to be like "no other," - with many countries in economic standstill. The tension is clearly building between saving life and saving the economy. Yet both can be reconcile if we adapt our model of social connections, and we kill a large set of remaining unknowns about the covid-19 virus, that drives a lot of excessive protection to date.

Imposed social changes: multiple flavors

There have been quite some discussions as to the best policy model to actively manage the Covid 19. Three models have been tried. Countries such as China, followed by many Central and Southern countries have been going for enforced social distancing, while some other countreis such Scandinavia (notably Sweden) have go for self-responsible containment. Other countries, like South Korea, have been playing the cards of extensive testing and individual tracing.

It is relatively known that testing and social tracing is especially effective, but to the extent it is started early in the pandemic, and to the extent that the asymptomatic cases remain low (so that testing is sufficiently effective). Despite the poor specificity of current testing, the current evidence is that countries with extensive testing have been more able to control the pandemic.

Yet, many countries in Europe have been resisting such extensive tracing, usually in the name of privacy, and in memory of watchdog governments (Germany ,and Eastern Europe).

When it comes to directed containment, the economic costs may become excessive especially (in the range of 10% and more of GDP) if this lasts long, -- and this may be the case in the Covid 19 situation, especially if the policy was set up late and takes time to control the pandemic. Italy implemented the shutdown of the country when more than 800 people passed away, while France, a country of the same relative population size, locked down the country just after about reaching four times lower fatalities than in Italy. By winning one week in the race, France today has still 2/3 of recorded infected cases, and 15% higher illness recovery than, Italy.

When it comes to a "more laxist" containment, -or one which is left to the entire responsibility of citizens-, the bet is that the spread of the virus may be left to develop, and build natural immunity, without in parallel adding the economic cost of shutdown. The risk is that virus spread may escaladate rather quickly and could overwhelm the heath care system before natural immunity might be built in. UK actually shifted gear to more directed containment, after it realized that a milder model may not work.

Independently of the model used, three important messages must remain ;

A) The first is scale and speed. Social contact reduction must be large enough and operate *fast,* in combination with self protection, for the virus to peak, -and the more so, the larger the number of non recorded cases that may be contagious.

B) This social contact reduction may not need to be uniformly distributed-- it may be indeed wiser if it is applied strictly to social ties of the infected so to avoid too large economic costs

C) The third message is to reduce the unknowns. Covid 19 must be understood much better than today, eg wherther asymptomatic cases are contagious, how can they turn themselves into casualties, are relieved patients immune and non contagious, and for how long -- as all those questions fundamentally condition the ability both to curb the pandemic, as well as to design the minimu viable solution for our social intereaction change.

A Belgium case study

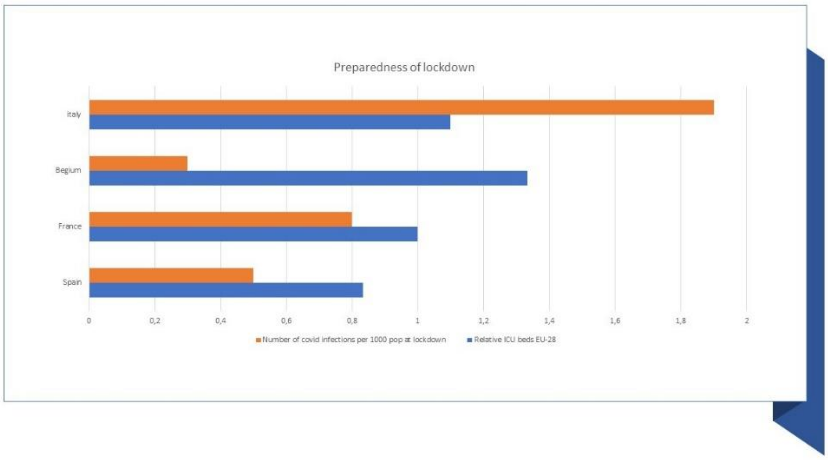
To back up those two messages, I rely on calibrating a model of covid 19 fatalities applied to Belgium, at the date of April first. At that time, Covid 19 has killed slighty more than 850 people, and now the total casualties are close to 1600.

Belgium to date

On the positive side, Belgium went quickly into active containment in Europe, and possibly one of the fastest countries to act on imposing strong measures, onyl after a few covid 19 deaths. In effect, Belgium has possibly taken first measures faster than say Italy and Spain, and is in the top 5 in EU-28, in terms of ICU bed capacity.

Also, a good, but work in progress, is that tracing is being implemented, with telecoms cooperating in giving mobile data to understand the evolution and geographical nodes of the disease. But data are only provided at some aggregate picture as to how the outbreak is developing. Using data, it seems, to act upon individuals, and their social ties, is not used at scale to date.

Figure 1- preparedness to fight the covid 19 disease.

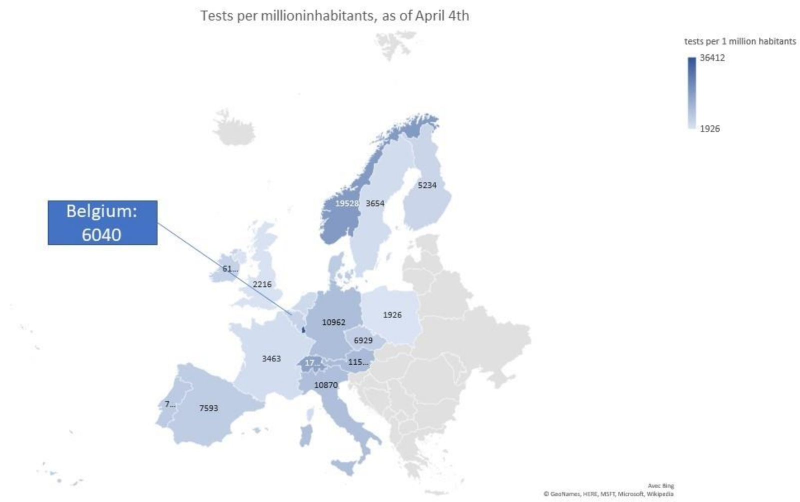


Other improvements should include:

a) Belgium is in short supply of protection equipment (masks, gloves, etc), as well as respirators.

b) Belgium also have had limited ability to testing, and about 4/1000 citizens were tested by end of March, far below other countries in Europe, such as Switzerland ,Germany and Austria , or yndeed the Asian countries such as Singapore or Spouth Korea . Belgium is however building up capacity to handle up to 10,000 tests a day, and is intending to move up to 50,000 a day.

Figure 2: How testing fares in Europe, April 4, 2020



c) Finally, Belgian citizens have been applying, yet not perfectly, the rules of confinement. It is said that for instance, about 70% of people are working from home, travel outside home has been reduced by see https://www.vrt.be/vrtnws/fr/2020/03/26/enquete-de-l_universite-danvers-les-seniors-suivent-mieux-que,and https://plus.lesoir.be/29074/article/2020-03-28/selon-une-analyse-des-donnees-telecoms-les-belges-adaptent-leur-comportement

Taking all this together, Belgium looks a typical case of an European country, caught in the storm of the Covid 19 virus outbreak, but with both supply chain issues (medical and protective equipment, test avaibility), as well as with issues of citizen compliance to containment. **Versus our key messages, Belgium has reacted early, and is working on both supply and citizens issues, even if with delay, and uncompleteness. But still, it has limited knowledge of actual infection intensity, and a fortiori has yet to implement a model of spotting the infected, and of tracing social ties. Finally, and like other countries, it is still left in the dark regarding major behaviors of the virus**.

Hence, if as a result of containment and fast actions, **we migh anticipate Belgium to start to "see some light at the end of the tunnel ". this hope is likely very sensitive to a few fundamental unknowns and social interactions drivers,** as we show here-after.

Simulation results of Belgian outbreak developments

First, a word of caution- a lot of data are unknown. We thus want to make sure the reader take the simulation result as first-order approximation only. Nevertheless, we believe the results are sufficiently illustrative to back up a few important messages going forward.

For our simulation we especially wish to understand the dynamics of development of covid-19 fatalities in Belgium, from late March to beginning of May. The underlying development is linked to a reproduction rate, Rt, with the following time dynamics:

Rt =rt. R0 *(1-srt)*(1-It/Nt) exp(er)+ (1-rt). b. R0 *(1-st)*(1-It/Nt) exp(e)

where: t is a time period, R0 is the reproduction rate of the Covid 19; 0< r <1 is the portion of recorded infected cases; 0<sr<1 is the share of reduction in contagious social contacts, It/Nt is the ratio of infected cases, I in total population, N, and er>0 is a factor of risk aversion that leads to a reduction in Rt the larger er as a symptom that population self protects better. 0<b<1 is the ratio of contamination of non recorded cases. We may have that e is different from er as well as s is different from sr; as we do not have data on this, hence we assume simply that e=er and s=sr, going forward. *d*(1-rt)/*d*t<0 if b<1, and especially if Belgium increases its level of testing beyond people showing up at hospitals. We assume that tests will increase by 10,000 a day for the next ten days, and up to 25,000 afterwards.

For the simulation, we freeze Ro at about 2,3, in line with consensus and with my previous Linked In posts. Regarding b<1, b is linked to milder cases or asymptomatic cases, as they tend to be not recorded. Those cases have been seen to be less contagious than others, and various studies suggest that b might be in the range of 0.4- 0.5; see Li, et al. 2020, Substantial undocumented infection facilitates the rapod dissemination of novel coronavirus, Science.

The variable (1-s) depends on extent of social distancing measures, and how people respect them. For Belgium, it is likely to be in the range of 0,5 by now. Typically, 40% of contacts are driven by schools and work and 35% by social community contacts, and the balance, by households. Schools in Belgium have been stopped at 90%, work is being stopped by 70% of individuals, and social contacts seem to be reduced by 35%. This leads to s being close to about 0,6, before ajustment for the social power of contacts. As remaining work contacts tend to be in more front line jobs (2 times more contact)s, or social contacts are less respected by younger individuals (50% more contacts than average), we might expect (1-s)=0,5 for Belgium by now, or half the full potential. Note as well that at this level of s, **more than 50 % is coming from both school closure and work, and thus this containment is very costly to society**.

Finally, r is not constant and was likely very large at the start of the pandemic (as infection was incumbated for a while, no tests were set up, etc). We calibrate the base case at 100,000 cases by April 1, versus a record of about 13,500 cases (of which roughly 4500 cases from direct tests). This means that a ratio of non recorded to recorded cases was 7.4 by April 1. This is consistent with other figures we have estimated and reported elsewhere in Linked In posts, and in line with Li, et al. (see above). We nevertheless present the results for total infected cases at 50,000 (3.7 times recorded cases), as well for recorded cases plus tests as a last alternative (1,7 recorded cases outside tests), by April 1.

Our simulation is based on the following sensitivites. C is contamination power of unrecorded case, versus recorded case, or b, and we assume b=0,2 (L for low case); b=0,4 (M for medium case) and b=0,6 (H for high case). S is social contact, or (1- s); and we assume s=0,8, achieving low social contacts (LS), s=0,4 (High social contact remaining). Finally, we look at risk aversion, es=e. Low aversion is estimated at e=20, High risk aversion is given by e=100. Those figures are also aligned with calibration to Chinese data regarding how people adapted their behavior following the development of the Covid 19.

Given the above, our results should lead to a less severe impact of covid 19 at High risk aversion (HR), at low social contacts (LS), and at low contagious power of unrecorded cases (LC), - thus in the generic case of LC,LS, HR. This is what we find in Figure 3, among the 12 possible combinations.

The importance of redefining social interactions and know the enemy

The figure 3 presents the results, in terms of fatalities, assuming current fatalities of recorded cases, and a fatalities cut at 1/5 for those unrecorded. This assumption does indeed change the final figures, but not our message. Finally, we draw the implied capacity of ICU beds in "fatality equivalent". The following insights emerge, for May 1:

1. As far as we are able t***o remain at LS**,* (that is 80% reduction via social distancing), the number of fatalities remain ***below ICU bed capacity. Such a high level of social interaction decline versus today is not possible for everyone in long term of course. It must be tailored to the infected cases and their social tie to be sustainable***
2. I**f** ***unrecorded cases build*** **up*, and a fortiori are more contagious, the higher the number of deaths,*** *-- that is, at LS, the number of deaths go to close to double the number of recorded cases, and even 2.5 times at HC*
3. When social contacts are **not reduced by at least 50%**, (HS means contact reduction at 40%), Belgium will face ICU constraints, -even if risk aversion leads to high protective measures (eg even for scenarios with HR). This gives a clear insight that individual protections are important , ***but this reemphasize point 1, that we must learn to live with a new form of social contact interaction.*** .
4. ***If all changes are weak*** (social distancing is minimal, risk aversion is low, and contamination of unnoticed cases is large), ***then we have a real pandemic boost, up to 10 times the best case. This again implies we must work on ALL levers to hope to control the covid 19 pandemic.***
5. ***At intermediate cases, the number of non recorded cases may be large enough to boost a natural immune effect (number of death lower than in the cases of recorded cases, as large number of cases build up a natural immune barrier). However, at those intermediate cases, ICU bed capacity is too low to care about severe infections at hospitals, building a health crisis. Further, for countries with low self- control, the risk of death build ups more quickly. In other words, Japan may do it, but likley not the Us and Europe.***

Figure 3- how the pandemic will play out-- a view by may 1 in Belgium

	LC, LS, HR	LC,LS, LR	MC, LS, HR	MC,LS, LR	HC,LS, LR	HC,LS,LR	LC, HS, HR	LC,HS, LR	MC, HS, HR	HC,HS, LR	MC,HS, LR	HC,HS,LR
death-7,4	1,83	1,90	1,99	2,15	2,20	2,50	3,06	3,96	4,60	6,33	6,81	10,93
death-3,7	1,19	1,22	1,27	1,32	1,37	1,45	3,08	3,59	4,26	5,51	5,20	7,20
death-1.7	1,00	1,02	1,02	1,05	1,05	1,07	4,82	5,23	5,20	5,64	6,45	6,30

Epilogue: Where might Belgium be on the outbreak by may 1?

Everything being equal, we might be today on the Orange or more likely on the Blue curve. We might be at just the cut- off of s> 50%, and self protection is likely in the low range, given limited masks in the public, etc. With those figures, Belgium may see a peak in number of "recorded" cases by mid April, and possibly a toll of about 1600 to 2500 fatalities, depending on different hypotheses.

The real danger is when s<40%. There, the peak will not happen before May 1- if any,, and deaths will keep mounting, especially if number of non recorded cases are large, and (a bit) contagious.

Otherwise stated, **the simulation is very clear that where Belgium will be by May 1, will depend on ways to sustain a model of social contacts that is likely halved for the average individual**. This is likely not viable for many economically valuable segments (eg worker with kids), and thus we might need to find a model of selectivity, rather than reach, to amedn social contacts. As said, a more promising one is one that allows to spot the infected to be quarantined. This means we must test, and protect more, and we must really understand all elements of unknowns linked to the pandemic of Covid 19.

A last and crucial word; **we must manage our social contacts because we may make the heathcare system overwhelmed**. **This challenge is even more acute for countries with less than 10 ICU beds per 100,000 inhabitants** (and they are a lot). With the healthcare system, ***the number of contagious contacts is not to be reduced extensively given health workers must save life; we thus have to protect them heavily.*** There , it is a priority for the governeent to put all levers so that all clinical equipments and tests are made available as soon as yesterday, so as to make those workers work safe-- and for our life.

Written April 4 and 5. All errors are mine. Comments welcome

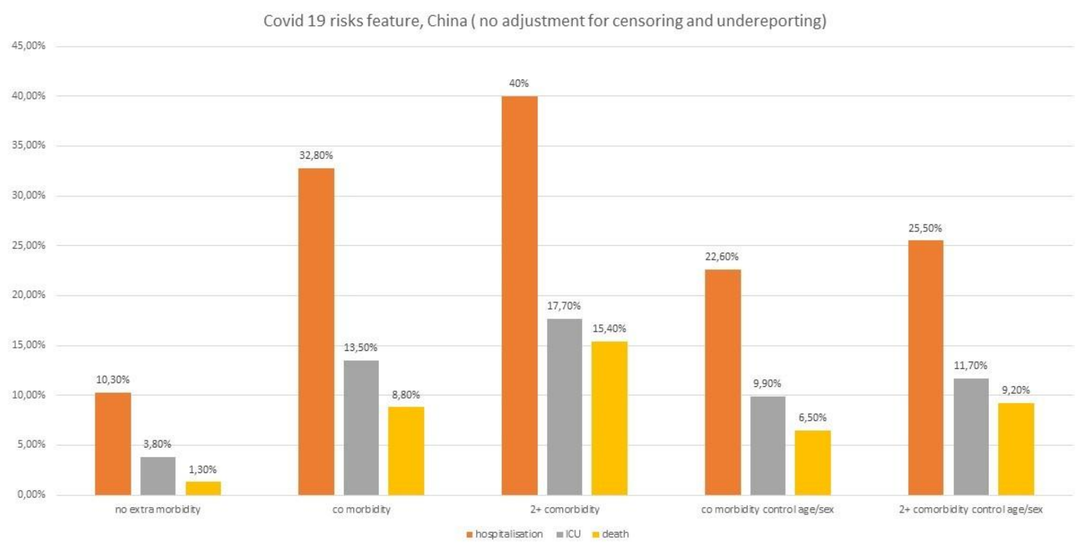
16. A welfare state should care about its home care

April 15. While Covid 19 follows its worldwide diffusion, affecting people differently according to health system quality, governements and citizen protective actions, the exact toll of the virus will also be dependent on citizens state of health, and socio-demographics.

At current, it is claimed that its death toll is apparently larger for men than for women, but this may be in line with odd ratio on total population. Age disproportionately affects death rates versus a sane population, but this aligns more or less with death rates of sick people, looking at other viruses such as MERS or still influenza (Guan, 2020 ; Gzaja et al, 2019, and Yang et al. 2017).

Co-morbidity seems to be one critical feature of covid-19, where odd ratios to death are relatively large, on average 50% higher than MERS for example. We compute that in China, death rates, even after controlling for difference in gender and age, are still 5 times higher for co-morbid hospital patients, and more than 7 times higher for patients with at least 2 co-morbid illnesses than none (Figure 1). Co-morbidity is especially linked to hypertension (up to 40% in case for fatalities), pulmonary and/or heart diseases (45% of cases), or diabetis (22% of death cases)

Figure 1- how co-morbidities limit recovery from covid-19, China, gross and adjusted for age and gender



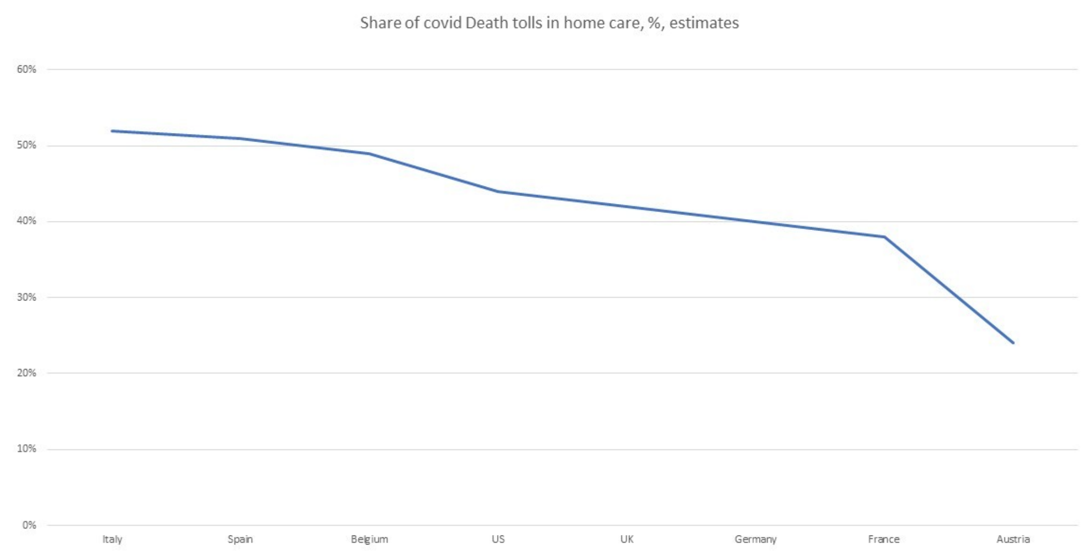
The missing link- home care

It is time then to add home care. Because home care concentrates old people residents, with consequently more co-morbidities, adding to the high risk of deaths in those structures. In fact, the mortality rate of a typical home care patient in China (75 years old, and 65% of comorbidity prevalence, versus a median age individual of 37 years old, with only 1/3 of comorbidity prevalence), **implies a mortality rate which is 9 to 10 times than the median Chinese citizen**.

Statistics are usually not easy to get, so we went 'on the search' for. While data are patchy, we tried to harmonize data as of April 11, 2020, for a set of countries, or roughly 6-8 weeks into the pandemics.

It is clear that, if the focus has generally been on hospitals, -because they concentrate the means of equipment and specialized healthcare workforce-, home care has become a major driver of the fatalities in most countries. Home care units have been contributs 25% of deaths, eg in Austria (or New York for that matter in the US) , but can easily climb to up to 50% like it seems to be in Italy and Spain and Belgium (or Philadelphia in the US to date). (Figure 2).

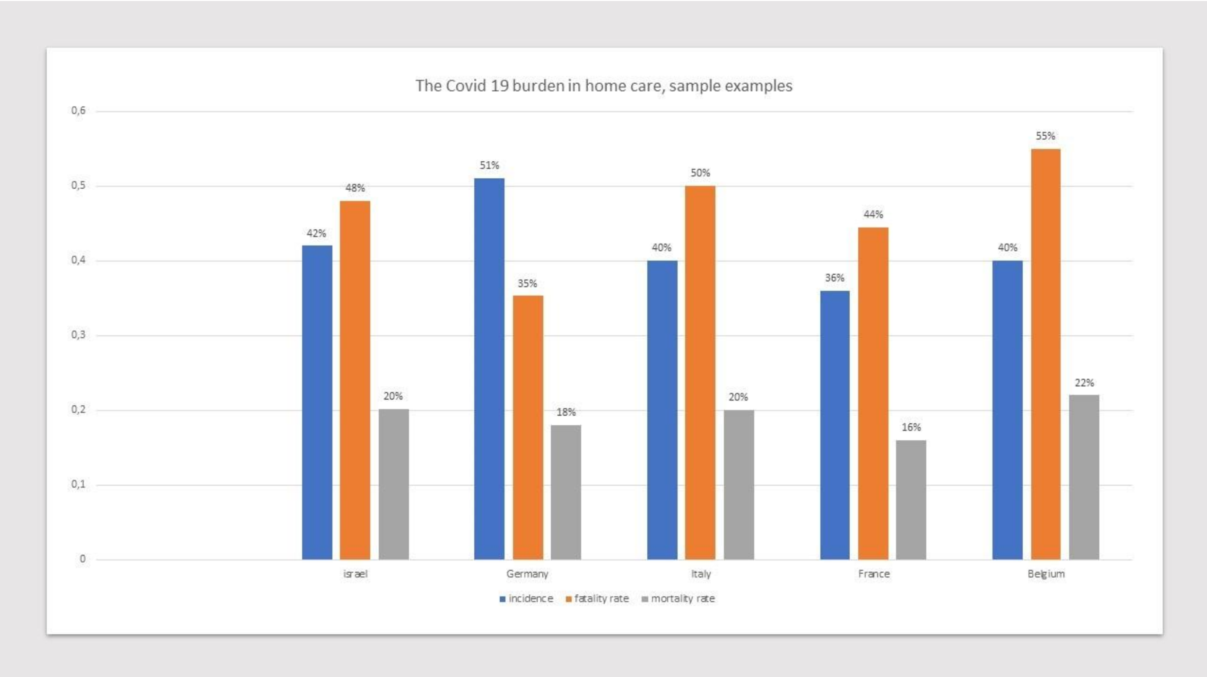
Figure 2- Home care contribution to covid 19 mortality



Digging deeper (Figure 3) , we aslo see that covid incidence and mortalities are higher than expected, even if we control for age and other morbidities :

1. The first finding is that **close to one out of two homes is affected by the virus**. This is very high considering that, even if the virus runs free, with a R0 of 2,3, we might have about 5-10% of the population affected. Further, assuming an uniform distribution at the household level, (but with 50% higher infection within the household given proximity), this would lead to 8-20% households infected in 2 months. The difference with the 50% hit rate in home care is difficult to explain by difference in susceptibility per se, as the odd ratio for old individuals is about 1,5 to 2 for hospitalisation rate for Covid 19.

Figure 3- Home care excessive tribute to Covid 19



2. The second finding is the **high rate of infection within those affected homes, that is between 35% to 50% of home care hosts**. Diamond Princess cruise boat , with same type of shared places, and limited self space, reached about 22% of contamination, after 6 weeks. Look only at the older ones, the rate is close to 40%, but not reaching 50% . If we further take as benchmark that the covid 19 daily transmission rate is about 0,25, and that an average home hosts 60-80 people, we come quickly to the conclusion that 40% of the hosts will be affected in a period of 30 days. If the world has 6 degrees of separation, each of us would then have a cluster of 44 people we know, and about 17 contacts, that are geographically close. At this level of connections, we have only a 8 percent chance to be infected. If infection rate is 1,5 to 2 times higher than average for older people, we easily got 16-25% infection rates in home care in a few weeks time if covid-19 is allowed to go free.

3. The third finding is that t**he death rates converge to 20%**, while the age-morbidity adjusted death rates should be rather between 15-20% in our estimates. 20% is olny plausible should all home care patients have 2+ comorbodities on top of covid 19.

We know that nursing home residences are highly vulnerable, given the nature of their hosts. They also concentrate a major risk for exposure, given confined, and shares living space and care givers (see eg Czaja, 2019).

But the findngs above show that all indicators are in the red, and may to be justified at their current high level, except invoking too extreme assumptions.

The message is very clear that we have been neglecting this channel as port of entry for the current coronavirus. We have enough anecdote that equipments were not available to care about the home residents. Likewise, tests are not done, and many hosts did not get a chance to get to ICU units in hospital, as people did not fully realize their (bad) state. Finally, many heathcare workers could not be protected, and got infected by the coronavirus, which led to a depletion of workers, - in some cases, more than 40% of them did not come to work, given stress of exposure and illness.

We conclude that is thus time to care about home care- **acting to protect "our elderly" is a reflect of our democracy, and a proof of strong welfare system** .

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17. Covid 19 requires a massive recovery plan to stay on our welfare growth trajectory

April 20. The current coronavirus breakout has already claimed more than 160,000 lives worldwide, according to recorded statistics. As a result of the pandemic, a significant lockdown has been plut in place worldwide, especially in order to flatten the curve of the pandemic in compliance with hospital capacity. The consequence of the containment actions has been already been made clear by many economists that this would lead to **an economic reduction in the range of more than 10% of worldwide output in first semester of the year, or close to 3% for the full 2020**, under a optimistic? "V"-like rebound.

Economic activity measures are an important metric to gauge about the pain of a major outbreak, -b**ut they also are likely to understate the true citizens consequence, given other non-GDP impact, of which the most obvious is an healthy life**.

If, instead of looking at GDP change only, we take a simple version of economic welfare change, t**his will be essentially driven by the product of healthy life expectations change times the flow of certainty- equivalent income**. Regarding life expectations, this would be a reduction in welfare, as covid19 is firmly putting itself in the list of the top 15th largest pandemics back to the 14th century. It is already converging to the rate of deaths of the 2009 H1N1 outbreak. This number of deaths continues to escaladate as Covid 19 death claims have doubled in just 10 days worldwide according to Worldometers statistics. Regarding income change, this is more or less the same of GDP change, a shrinkage of labor supply, as well as a reduction in aggregate demand Further, forced lockdown reduces economic output -and as seen in the reaction of the major, (even unprecedented) stock market reaction worldwide. Uncertainty is however another important factor, affecting the utility of citizens, as uncertainty as to the severity and time of covid 19 may lead to major worries on personal situation.

By looking through this lense, **high level figures suggest that welfare may be significantly affected, in the range of more than 10%, - or a significant decline for 2020, of no recovery is assumed**. Compared to an annual welfare growth in the range of 2 to 3 % a year, this means that t**he covid-19 crisis may eat more than 3 years of welfare built up in the past for our citizens**. Looking this way, this is a bigger reduction and a longer time to recover from covid 19 than usually said. **We are thus to do everything to limit such welfare loss to our society, including allowing anything to suggests a fast and large recoverty plan**, at the level of impact never heard of, of the welfare loss inducesd.

Measuring welfare at high level

There have been some measures of how pandemics may depress GDP growth. Mild effects results in a decline of 0,8 to 1,5% in a year, but can quickly build up to 3% to 5% decline, for major pandemics (See recent post, at https://www.linkedin.com/pulse/recovering-20-million-lives-avoiding-us-3-trillion-dip-jacques-bughin/).

GDP however may fall short of many impacts to welfare. Forced unemployment, inequality in containment measures, or still mortality risks, are some of the major factors affecting living standards that are incorporated imperfectly, if at all, in GDP. We leverage work by Jones & Klenow, (2016) to define welfare change as an evolution of consumption equivalent. In particular, under its simplified version, the relative change in Welfare due to covid 19pandemic, noted by D(W), is the sum of relative change, D, in healthy life expectations EL, and of change in certainty equivalent income D(CI), or :

$$D(W)= D(EL)+D(CI) \quad (1)$$

We further assume a constant risk aversion,

$$(CI) = I-s(I) \quad (2)$$

where I is disposable income , and s(I) is its standard deviation.

Combining (1) and (2), we have (3):

$$D(W)= D(EL)+D(I)-(s/I)) \quad (3)$$

Equation (3) simply states that the covid 19 will play negatively though a reduction in D(EL) (increasing weeks of illness, and mortality rate), a reduction in I, through lower economic activity and income, and a possible volatility of income.

What do we know about how covid plays on welfare ?

Effects on healthy life

Covid has a clear negative impact on healthy life. Regarding morbidity, and considering a reproduction rate, R0, of 2,3, and a asymmetry of contamination events like the flu, there is **a potential of about 65% of individuals eventually affected**. At this level, there should be 50% asymptomatic cases, and for the rest, 43% mild cases, and 7% requiring hospital treatments, with longer recovery time (20 days) than the mild cases (15 days) (see Riou, et al, 2020). Regarding fatality effects, the current crude rate of death is close top 7% worldwide to date, but this rate is a large overstatement of the true fatality rate, as it is computed on recorded infections, which themselves are mostly done at hospitals for lack of enough testing capacity. Using the statistics above (Riou, et al, 2020), the consensus that is emerging is a fatality rate **in the range of 1%, assuming that severe cases are treated.**

This rate, however, suggests that there is enough hospital capacity to handle the crisis. This is likely not to be the case as currently, there are about 1,5 beds for 10,000 households. We estimate from basic epidemilogic modelling that the peak is happening at 23-25% of population, after about 70 days, if covid 19 runs its course freely. As 7% requires hospitalization and 1/3 would need ICU equipments, we talk about a simultaneous bed capacity at peak of 5/1000 person, or virtually, 97% patients at risk of no hospital capacity . **Taking the full curve, 90% requiring ICU may be at risk, which means that the fatality rate may be as large as 2.8% of infected, in the case of no control measures implemented to flatten the pandemic curse**.

Income effects

As a side effect of a depreciation in healthy life, the covid 19 pandemic creates an opportunity cost for time not worked, affecting GDP down. As made clear in a previous blog, other depressive effects will also be co-existing. The first is a reduction in demand, eg in retail non food, travel/transportation, etc. The stock exchange shock has been relatively large, with stock valuation volatilities larger than for Oct 1987 or during the Great Depression. This entails a lower wealth effect, which in turn, would lead to additional reduction in spending (McKibbin and Fernando, 2020). There might be significant supply chain disruptions, too, in particular as seen in the healthcare equipment provision.

Assuming the pandemic can run freely, the total effect wehave estimated elsewhere in a previous blog, is in the range of -0,8 and -1,1% for GDP, for a typical flu. This can be boosted to 4 to 5 times in the cases of the covid-19, or a decrease in the range of 3,2 to 5,5%, assuming no rebound.

In the case of major containments, the economy takes a **much larger hit**. Typically, 65% of the economy has been shut down out through physical distancing, and for those working at home, productivity is 80% the level as a result of absence of complementary capital, and other negative externalities (less team gain, loss due to take care of family in the containement, etc). This results in a drop of 20% for a month. In China, for instance, industrial output fell in the first two months of 2020, by more than 13.5%, while investment fell 25% year-on-year (and 30% when it concerned infrastructure only) ; consumer retail sales collapsed by 20%. As shutdown seems to operate for two months, and some partial containment may be needed, in the next 6 months, at 20% of total, to contain the outbreak, a total drop is possible in the range of 6-7%, outside any rebound.

Uncertainty effects

Last but not least uncertainty induced by the Covid 19 will further reduce income. The reason is that :

a) Even absent all policies of containment, the covid 19 may build uncertainty quite a long time. For example, most of pandemics lasted for a period of 8-16 months, with the 1918 Spanish Flu lasted 16 months, across three waves. Mathematically, the peak, at current epidemiologic features of the Covid 19, would typically happen in the range of 2,5 to 3 months, with a fraction of contaminations at about 35% at that time. As two times more people still would be eventually affected, but at a rate of transmission three times lower on average until the end of pandemics, this means an extra time of 6 times the peak, or still 15 months to go. The total time might thus be >1 year, if it spreads to all susceptible population. At this level of continuous risk, pressure on wages may prevail, if it is compounded by higher risk on unemployment[3]. Likewise, consumption will be pressed downwards (Barro et al. 2020).

b) If shutdown is used as a way to flatten the pandemic curve, economy will be challenged, as it creates disruptions that are difficult to re-absorb afterwards, in a smooth V shape scenario. We beleive it will be more like a U shape,. As example, following shutdown, unemployment has significantly increased. ILO for example is recently predicting 195 million full-time jobs destroyed worldwide because of the pandemics. 5 million people in China lost their jobs during the pandemic ,while more than 10 million Americans just applied for government aid. Upon return to normal, unemployment may not come down automatically, as some jobs may remain risky as front line, or some unemployed will have significantly human capital eroded. Likewise, most SMBs have barely 2 months of cash to assets, leading to major risk of bankrputcy in the medium term. Those would close a channel for people to rebuild their work opportunities

A significant reduction in welfare

Taking those high level impacts, we can now compute the change in welfare. We compute it for both cases of containement and non containement, under our base line assumptions. The findings are :

1) A significant drop **in welfare in any of both cases, that can be above 10% if there is no recovery, but mostly possibly if recovery is done at 50%, a peak decline at -8%**

2) A **better case for containement, with -5% reduction of welfare versus -7% by end of one full year**

3) The **difference arises because of mix effect**, as in non containment case, a large loss is due to excessive (by définition) non recoverable deaths, and a major dip in economics, which implies a higher rebound for same portion of recovery.

How do we get to those findings ? Consider the non containment case and no rebound, we end up towards a total of minus 10-13%, as computed as follows.

a) D(EL)= -3,8%. (There is a reduction of 2,0% of healthy time (35% of people with symptomatic infections, of which 80% sick for 15 days, and 20% sick for 20 days as more severe cases), as well as a reduction of 1,8% due to death, and under the hopsital constraint significantly binding)

b) D(I) = -3,2% to -5,5 %

c) -s(I)= -3,5% (we use here a set of triangulations for this figure. First, we use the findings by Baker et, al. (2020) which calibrate a model of economic growth based on implied volatilities in consumer sentiments and from the stock market VIX, that concludes to a volatily depressing economic activity by about 5% in one year in the US, including shurtdown. Second, we use change in perception of personal economic situation based on perception on the severity of the covid 19 outbreak, as computed by Fetzer et al. (2020). There is 0,16 standard deviation of percent income depression for the group feeling that covid is severe versus the other group that feels it is mild, thus -s/I =- 0,16/5=-3,5%).

Consider now the containment case (and still no rebound), we end up towards a total of minus 10-13%, as computed as follows.

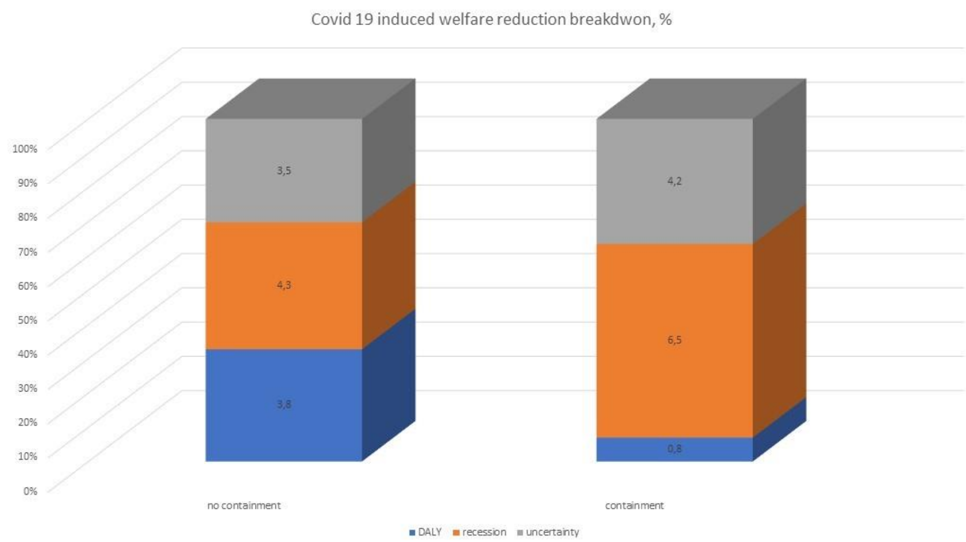
a) D(EL)- -0,8%. (There is a reduction of 0,6% of healthy time as we assume that recurrent measures of containment leads to meet ICU capacity, leading to a decline of attack rate by 2/3 in total, while fatality rate is only 1%)

b) D(I) = -6% to -7 % (from above)

c) -s(I)= -3,5 to -5% (as per above)

From those computations , it is notable that containment goes for higher economic costs and lower health costs, than in the case of let the virus freely evolve in the economy (see Figure 1).

Figure 1 : Gross welfare decline due to the covid 19- with or without containment measures

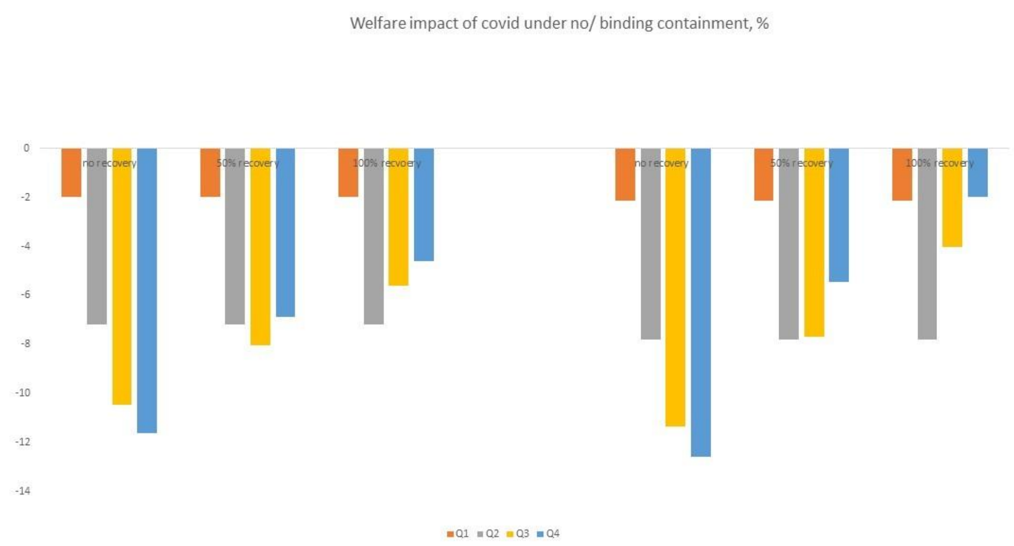


Using the same figures, we can build up the evolution by quarter in fonction of the dynamics of the attack rate, and assuming that recovery starts after peak period, with a lag of one quarter (Figure 2). Even at 100% recovery, we do not fully recover, given death tolls, and (in this modelling case) because recovery is delayed by one quarter.

In general, welfare has been increasing by about 2,5% a year (1% healthy life, and 1 to 1,5% of certainty equivalent income), thus the scenario of covid 19 will be a yearly dip in welfare, even ingesting the positive welfare trend of the past.

In general, welfare has been increasing by about 2,5% a year (1% healthy life, and 1 to 1,5% of certainty equivalent income), thus **the scenario of covid 19 will be a yearly dip in welfare, even ingesting the positive welfare trend of the past. We thus need to work on a plan to successfully still crush that virus, but also a major plan for fast recovery as well as extra *spending* to rebuild towards a positive welfare enhancing trend for our society.**

Figure 2 : Covid 19 Welfare evolution in function of recovery



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18. A roadmap to execute after the 1rst wave of the covid-19

April 24. In a recent article regarding the impact on covid-19 on our economies, we have used a more broader "economic welfare" approach than GPD alone to come to a more holistic view of the size of the challenge we are facing. **The insight in the article has been that fighting the covid-19 will be generating a significant welfare loss of about 10 percent decline. This is hence a major hit, any way we look, at, and react to covid-19.**

Welfare model update- confirmation of the loss, but also that we are at the start of the journey

This sizeable effect on welfare has been parametrized by some key assumptions. We have updated, -that is, refined some, for this research. This includes a refined "Susceptible Infected, Recovered (SIR)" model of contagion, based on an original epidemiology contagion of Ro =2.5, that ultimately predicts the portion of infected. But contrary to the referred article, we further "endogenize" the demand side, in that we anticipate that segments at risk of being at higher risk of being infected (eg the old group segment) will adapt and reduce their contact rates as a self-protection, reducing in part, the final size of the pandemic. We also have adjusted the fatality rate to 1 percent, (under no healthcare constraints), in line with new data that make fatalities likely lower than the original crude rates of 3-4%, from the start of the pandemic in China (Riou et al, 2020).

With the new changes, we end up **with a reference scenario of covid 19**

a) infecting 55 percent of the population,

b) for a peak of infection happening at about 30 percent of population being contaminated. (After this peak, -also called herd immunity point-, new infections will continue to arise, but with a decay, up to to none infection emerges).

c) The total welfare for this curse is slightly below 10%, thus, a confirmation of a major hit to our economies

d) With only 5-10% of people infected versus at total potential of 55%, we may infer quickly that we are far from being finished with the covid-19 , and we might expect to live long with it, and/or to see new waves of outbreaks if we do not manage to contain the contagion, as we just did in Wave 1. <u>We are thus **in an absolute imperative to learn fast from the mistakes many countries have done during**</u>

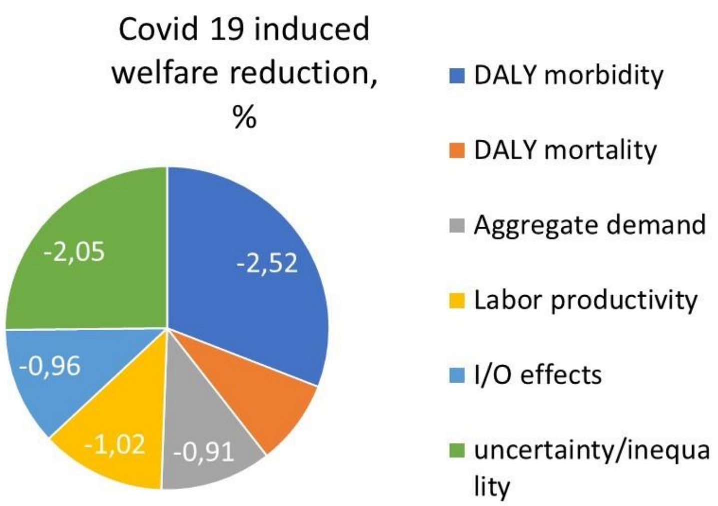
<u>the first wave, in particular, we are also in the need to do the containment differently, as it brings, and upload in time, the same level of welfare loss as the pandemic itself.</u>

Uncovering what works, what does' nt

Lets look at the different drivers of the covid- 19 welfare loss to have a better fact based on what works, what does not.

The welfare loss orginates from three components (Figure 1): The first is the DALY (disease adjusted live years) reduction in terms of sick days and mortalities. The second is the income loss from labor productivity loss , magnified by an I/0 multiplier and a demand reduction for precautionary reasons (eg in retail non food entertainemnt transport etc). The third component is the large disparity linked to the outcomes of the covid-19, eg, the contaminated may die, while the non-infected may suffer from income loss, etc.

<u>Figure 1: the various elements of welfare loss- (case of free curse of the coronavirus)</u>



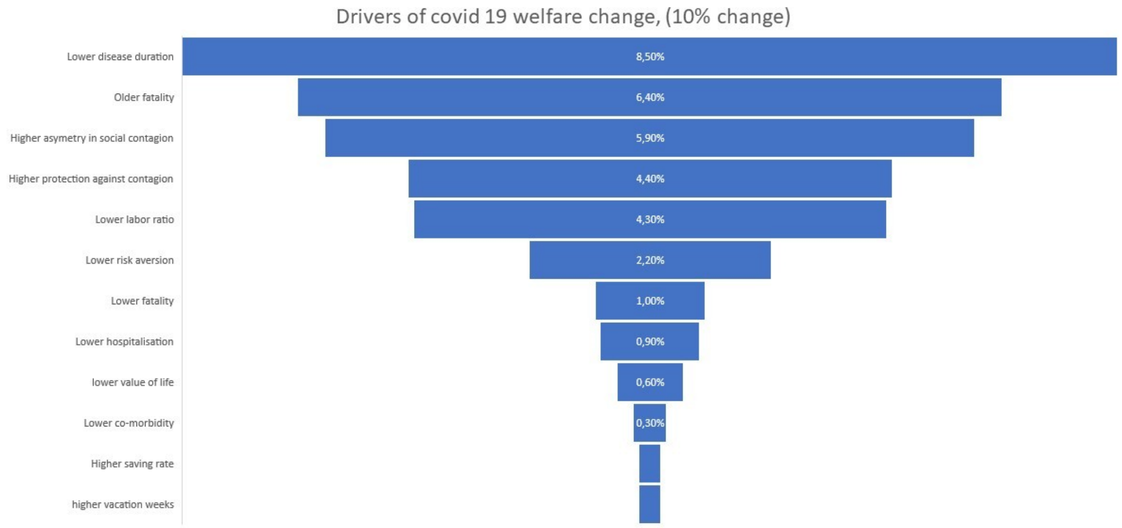
Base case:

R0	2,5
contagion asymetry	0,7
life value	1,25 times GNP
fatality asymetry	0,7
tracing	5%
success of tracing	50%
labor use rate	0,75
labor ratio	0,6
hospitalisation	30%
recovery hospital	60%

How to prepare the next round?

In order to break those loops , lets first look at the list of key drivers that affect the extent of the welfare loss. We specifically look at 12 drivers, as shown as a 10 percent change of driver to welfare gains (figure 2)

figure 2: rank of drivers to covid 19 welfare loss



We note a few critical points:

1. Most of the drivers are "inelastic"- that is, a 10 percent increase in any of the driver never increases welfare by more than 10%, or proportionately. The reason is that no lever plays on all three components of welfare.

2. **If all of those drivers are being played at once in the right direction to increase welfare the total gain is material, yet still less than 30% improvement . We thus have to play "at scale", up to 30% improvements on levers if we want a radical regain of welfare. This in practice, is likely impossible, as many drivers are pretty sticky (eg co-morbidity, labor ratio, saving rate, etc)**

3. It is evident that this is a pandemic that will affect a large amount of population, and among others, **the working population. It may be more insulated from death, but will have its hit on sickness impacting labor productivity significantly, and further, depressing demand.** Given this sickness impact, we should also carefully check how we can make it less costly to our welfare.

4. Today, we have look rightfully at the worst cases (hospitalisation), but we need to integration the full journey. Today, the "**figures do not foot"**. On average, we have a fatality rate of 0,2% outside hospitalisation, but moving to 6% (times 12) under hospitalisation, and up to 30% (times 5) if going to ICU. **This is extremely skewed.** Age (without morbidity) fatality rate moves up to 6% fatality for

people above 80 years old, and twice that, if we account for their morbidity. Those numbers are on average smaller than when the average patient goes to hospital, - t**hus questioning the time effectiveness of hoispitalisation -are we too late in handling risks?**

5. We should make sure **we have a way to continue to improve curing** Trying multiple treatments is fundamental, especially, anti-virals, etc. We also have to have diagnosis right, eg **understand better to cure better, eg the interference of covid 19 with eg cardiovascular disease. Progress remains minimal here, in terms of co-morbodities.**

6. **The more you play at the source, that is, on the extent of the contagion, the better you are**. In particular, this means protecting those with higher risks, and creating ways to mitigate or internalize the risk of contagion. Mitigation may happen by invoking morality, or still by **punishing lurking or cheating.** PS: A norm may be a fine per third party contact of more than 800 USD, as the value of lost life is roughly 50,000 USD (given age profile for covid 19), and R0=2,5, and 15 contacts per day, we come to (50K/15)*2,5/10 days contagion)=**833 USD.**

7. Regarding contagion, it is evident t**hat a way to trace and systematic quarantine of the infected,- and its close circle, is the only structural enabler that scales (see** Christoph and Gunther (2020))**, - and in particular via technology**. If we make only 50% of tracing and 50% right, we increase welfare ***by 40%, more than playing on all levers together by 10%***. This is easier to do as we play only on one lever to pull- not 12 in the list above.

8. Last but ont least: something **not to think and do.** From figure above, welfare might seem to improve if we had the tautology that "only people in last stage of life die" . THis result follows simplt from the fact that their DALY impact will be smaller, and their contribution to economic activity is lower than others, as they have retired. This of course is an artefact of the restrictive wy we measure (*only)* economic welfare from *remaining* time to live . Another alternative would be to look at willingness to-pay by age,- that clearly shows that actual perception of value of life does not decrease generally-- and if any, only a bit by maximum 20-30% after 70 years (see Alberini, et al. 2004). Likewise, under the permanent income hypothesis, older people may have a higher value of life than others, as their death includes larger consumption loss (see Kniesner et al. 2006). I**f we include those two effects, (permanent income and willingness to pay), the total elasticity we estimate collapses to zero**.

Roadmapping the future

Based on the above, let us make a simple sketch of how to manage the future of the covid 19. This is a 10 points proposal to be futher shaped:

1. **Migrate to an extensive tracing technology, and build an mandatory containment, in exchange of a guaranteed compensation**, why not the compensating value of not putting people in danger--the value as said above is 850 USD per day.

2. **Protect the key segments under risk**- this includes the people above 65 years, and those with key morbidity risk, especially cadio cascular, diabetis, for instance. Regarding the old, a special focus on home care must be done, that should preempt the entry of the virus into the home care, and from the shared services side

3. **Extend the capacity of hospitalization**, both for events of new wave, **for pre-loading growingly risk profiles,** etc

4. **Provide all means of protection, that is, easy and freely available masks, gloves, and others. This includes major desinfecting means of shared assets and services** (food services, trnasports, etc). This includes tools to allow entries into shared services, like the Alibaba red/green signal technology.

5. **Boost human resources for health care across the full value chain**- including detailed check points of temperatures, symptoms, via call feedbacks, or automated call platforms.

6. **Fine tune the contact intensity- experiment rollout by regions (work in one, stay home for the others, etc); - try 4 days a week work, under rollout over a 7 days week,** etc, etc

7. **Build a very large communication tool to make sure we still have the population to cooperate and to internalize the negative contagion opportunities**. Communicate on the impact of poor social distancing on global recession, communicate on the impact of social distancing, on own probability to get sick

8. **Integrate a full supply chain of health. Not only the hospital, but all constituents, including pharmacies, doctors, kine,** etc

9. **Mobilize local industrial resources to avoid dependencies of international value chains**.

10. I**ntegrate a major plan to compensate for the economic disruption** (this must include finance bridge to SMB) but also for judo economics towards re-growth-- **in particular, it is time to integrate a plan for a) sustainable technologies, b) for cooperation R&D for antivirals and vaccines, among others**.

Be this roadmap shaped and executed as soon as possible in order to rebuild our welfare- *they are worth 10% of our welfare*.

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Written on 24 April 2020. References listed as they come in the text. Comments welcome

19. Why our social future is changing and how Covid-19 will accelerate the pace of change

May 7. Our lives have always been closely linked to a social structure, enforced by law, or informally by norms and habits that evolve through times. **Social norms of the past which led to a long period of enlightenment and happiness growth, have become challenged**, due to the combination of three forces: digitization, globalisation, and sustainability. While we are at the point of crisis leading to large social divide, we believe that the Covid-19 crisis may well be the case in point for an acceleration of changes, and for a new solution space.Here is why.

Covid 19 interaction with forces at work

Not only the emergence, but the consequence of the Covid-19 pandemic is linked to our social model, and the forces at work that are reshaping it.

Regarding the emergence of Covid-19, more than 75% of the new communicable diseases have been zoonoses in the recent past. If we recognize that zoonoses are complex and dynamic diseases, part of their outbreak are clearly linked to human-related factors, such as ecotourism, or culinary habits (see how the Covid-19 patient zero originated most likely from the Wuhan food and animal market). **But it may well be that the virus is the long term result of human intrusion into life ecosystems as well our new social way of leaving, that is, increased urbanization.**[1]

Urbanization on the other hand, is not only a cause of epidemic occurrence. **Covid-19 becomes more of a problem in cities, as close contacts increase with inhabitants density and because urban areas employ more workers in customer facing occupations**, that will be affected by more or less social distancing measures put forward by many governments to flatten the curve of the coronavirus pandemics.[2] Covid-19 also brings some advantage to cities. Because of the business model, the sharing economy is more developed in high density of population, helping to find a solution to the logistics of retail trade and food services, two sectors most affected by the containment measures of social distancing. Finally, cities concentrate more on the new skill set in demand, which are now using digital platforms as new models of social interactions.

We all know that **globalisation directly affected the spread of the Covid-19 to become a pandemic, affecting more than 200 hundred countries by now. We also know how pollution and sustainability also interact with Covid-19**. It has been recently claimed that pollution increases the morbidity risk of Covid-19. In Italy, for example, it has been reported that cities that exceed twice more often the limit set for PM10 than others have also registered twice more cases of Covid-19 infections.[3]

We have seen h**ow digital technologies are a blessing to trace contaminants timely and put those infected in appropriate quarantines, like done in most Asian countries.**[4] We have witnessed how digital technologies can be used to resolve supply chain issues (eg 3D print of swabs for covid 19 testing), and how AI has quickly helped identify the genome of the Covid-19 (with the hope) to accelerate the effective race for antivirals and vaccines.[5]

Finally, the social norms leading to more individualism have been tested heavily as being moral enough in the case of deciding whether to comply with quarantine rules. One case study illustrates the point. When Italy decided for a full containment measure in the hope of curbing the Covid-19 disease, a few individuals decided to move from a high-risk zone such as Milan to southern regions of Italy. 40 of those individuals were enough to cause the sudden spread of the virus observed afterwards in the South.[6]

Of course "cheating" has been part of life, and can be tolerated. But exceptions may have to prevail, especially in situations such as Covid-19, creating major externality risks. This is especially so, as the fatality rate associated to contagion of the Covid-19 disproportionately affects the old population (about 12% more than average, after controlling for other factors such as comorbidities), while the largest contributor to close contacts is the young generation, also the one less inclined to obey to the rules of social distancing.[7]

Covid-19: a catalyst for a new social future

This being said, the episode of the Covid-19 crisis is likely to be more than just another force at work. It may be the catalyst to a new social model of interactions for multiple reasons:

- Covid-19 is only at the start of its pandemic status, with a first outbreak wave slowly ending in a few countries, but with more and more evidence that likely less than 10% of the population got infected currently by the virus. **This level is proof of the effectiveness of the lockdowns, but in the meantime, is also a level, far away from the implied immunity threshold of between 35–55% that will ensure a control on the disease spread, and the insurance of no new outbreak like we have just witnessed**. In passing, this level of immunity is based on initial reproduction rates of R0=2,2, and accounting for behavioral changes, as well as asymmetric distribution of contagion[8]; infections however do not stop at this stage, but the flow is slowly declining to stop at possibly 65% to 85% of the population.
- G**iven the above, the risk of multiple waves for Covid-19 is non nil, so that, if we phase down lockdown, we are not going back to the same social interaction model as before, at least in**

the foreseeable future. The new normal would likely entail a model with lower physical interactions at work, for education, and for economic exchange. **The new normal may also make lurking and cheating less acceptable to many, supporting the idea of more coercitive measures** (eg Taiwan put fines on those who were noncompliant of containment, at level in the thousands of USD). **Likewise, while there has been a large movement towards keeping our strict privacy, tracing to prevent the large outbreak of Covid-19 might be accepted under certain conditions , eg more US citizens accept it than refusing it, for example.[9]**

- Another consequence of Covid-19 is **the boost towards further enterprise digitization,** which has been largely lagging the one on the consumer side. Many more companies are likely to adopt remote working, and digital interfacing for work, replacing physical contacts but r**ecognizing that progress in enterprise platforms has made the digital remote experience as good—if not better—than physical encounters.**
- Large pandemics in general affect social capital for a long time. For example, the Spanish flu of 1918 led to a significant burden of deaths that **affected a decrease in social trust and in turn led to lower growth and prosperity**. Of importance, the descendants of people who face the pandemic did reveal this social behavioral change.[10] There is thus a risk that after Covid-19, our social capital will be in part depleted, leading to lower economic welfare. As social trust has been damaged recently with multiple crises (bombing, migration, financial crisis of 2018), **Covid-19 will only add to the fire, and must require active actions to rebuild the role of our institutions as trusted partners**. In particular, a major recovery plan will have to address all the leftovers, with a notion of prioritization towards the most fragile segments of the population. The home care crisis, as well as the lack of equipment support to hospital workers will have to be turned around soon, and vocational careers built up, as well as stock equipment buffers made up, to face the ongoing waves to come of Covid-19.
- Last but not least, **Covid-19 is likely a catalyst for how our model of interactions will evolve towards a more global model, one which will embrace—rather than be afraid of—machines**. Covid-19 has proven that automation may easily complement our work (eg, video conferencing), and health (eg, AI-based genomics).
- The **new model of interactions will also be more respectful of our earth resources, as Covid-19 has shown how pollution can be dramatically reduced under economic shutdown and how pollution may be an important driver of Covid-19 infection.** The fact that the EU commission is likely to rebuild the economy after the Covid-19 shutdown, through a major green infrastructure plan, is proof that people can learn to turn a crisis into a necessary green opportunity to come by 2030.

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20.We badly need a dynamic dashboard of behavioral changes to best navigate our way out of covid 19

May 8th. A large part of the discussion related to how the covid 19 outbreak will evolve is based on a set of crucial epidemiologic models . Among those, the most classical one is the S-I-R model (« S » for susceptible, « I » for infected and « R » for recovered), which tells that the dynamics of the disease is closely related to the basic reproduction rate, R0= b/y where b is the rate of effective contacts between the infected and the susceptible, and y is the rate at which infected individuals recover.

In particular, for the covid 19, the rate of infection seems at least twice faster than recovery (R0>2). Furthermore, complex cases requiring hospitalisation in intensive care are large enough (between 15% to 20% of infected cases), to both create a pandemic explosion and a major risk of excess demand for healthcare. In consequence, the SIR model has implied that a more or less stringent lockdown is required to slow the curse of the disease. If we note by « a » the parameter of lockdown, this is equivalent to build a bridge between the basic reproduction rate R0, and the effective rate, so that R= R0*(1-a), with 0<a<1 is a measure of intensity of social distancing success.

Different analyses suggest that for countries which had opted for lockdown, this has been very effective, with a=0,64 for Belgium ; a= 0,8 in France (see Angot, 2020), and a>0,9 in the case of Wuhan in China (Lin et al, 2020). But, at the time when we go to a relaxation of the rules of the lockdown, the dynamics of « a » added to the S-I-R model may be crucial to re-assess . What if some susceptible people feel that the outbreak of covid 19 is controlled, and they start now to over-compensate with more social contacts ? What if people feel that economic risks are too high versus the cost of being infected, and decide to go back to work without many protections (not necessarily that they wil not try to self-protect , but the availability of masks may remain limited, etc) ?

Thus, individuals will be the ones « in fine » to make 0< « a »<1, high enough for a sufficiently long time to crush the pandemic, with little room for covid 19 to come back as a revenge, in a new wave. In general, we may think that « a » will naturally decrease for the susceptible with time, as the higher the number of infected, the higher expected cost of the disease if infected. This behavior is possible, but the pace of increase in « a » is likely not enough to avoid the heath care crunch (see also Bethune, and Korinek, 2020). For a significant and structurally long term decrease in « a », **we need *more, and possibly some incentives.***

Regarding incentives, t**he economic theory of moral hazard is a good avenue to look at designing optimal incentives**. One example of (negative) incentives is to tax inadequate risky behavior. In the case of Taiwan, it looks like the penalty for infringement has been put at the *expected* value of a lost life from Covid 19, as result of misplaced social behavior,- and whether you are contagious or not. In the spirit of optimal theory, this multi)thousands money fine aims to have people fully internalizing the risk by making people pay for the ex post materialisation of risk .

Today, many actions launched by governments, during or after lockdown can be tested through the theory of optimal (dis)incentives. But usually, this is not done**. Rather, the idea has been to hope for the best, that is, governements keep recalling people of their « moral obligations » to comply with distancing rules**. While necessary, it is by far not sufficient, and is clearly important that we know more about how individuals perceive the disease and its evolution, and how they react to consequences of pandemics and policiy actions, be it for health and for socio-economic reasons, to design such incentives.

While we defer a post to this later on, we are here more concerned as to what citizens do and think, so that we have a clear basis as to how to thing about the right focus of incentices. Surprisingly, the data remain sparse.

We have collected a few data, courtesy of Neurohm (see **www. neurhom.com**), from a survey being rolled out across a large set of countries worldwide on the covid 19 situation. The interesting element of the data is that AI is used in order to ensure a base line of probing survey answer, so that we only use survey answers that look like sufficiently solid for the findings below (See https://neurohm.com/wp-content/uploads/2020/03/FALA_1_COVID-19_Fever-FINAL.pdf) We here use France as an example, via a sample of 1300 individuals. The data below may have some bias, so we caution that we should not be taken the findings as fully representative. For example, we find that 0,8% of the sample population claims to have been positively tested. This figure is higher than currently reported in France (roughly 0,3% of population). **But the idea is also to show how crucial it is to understand behaviors and behavioral changes, -and rather quickly, to secure the crush of the disease**.

Behavior at time of covid-19

Here are five facts of importance we collected :

Finding 1 : Own and collective infection perception match

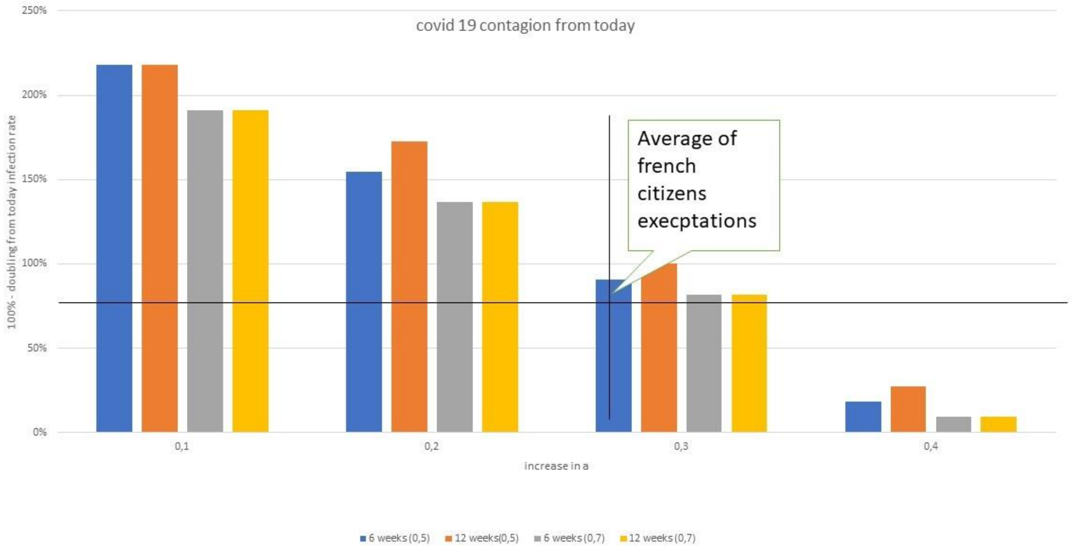
We know that the disease is difficult to be diagnosted, with formal test. We find that the perception of being infected by the disease, is large (about 9% outside testing), but this also is quite close to how people report on their knowledge of third parties being (said to be) infected in one citizen's community. Otherwise, stated, expectations are likely built as a convergence between personal and social perceptions, in line thus with the SIR model that the dynamic of contagion is linked to the stock of infected.

Finding 2 : Voluntary reduction in social contagion expected to be >35%

Based on epidemilogical data, and supposing that there « a >0 » is only linked to imposed lockdown, simulations suggest that lockdown effective at 50%, will stabilize the outbreak if imposed for a period in the range of 50 to 80 days. The total span of the disease may be then be close to 6 months, at which time the disease dies out (See Alvarez et al. , 2020). As discussed above, however, the good news is that individuals may be increasing protection with the disease, so that benefits of lockdown is not fully lost and the pandemic may be finishing faster and with lower infections.

At the time of survey in France, the individuals were already about 2 months in the pandemic. But looking at their expectations on the likely extra duration for the outbreak to disappear, the average is above 1,5 months extra, for a doubling of people being infected, versus the current perception of 11%. Calibrating the risk of getting the covid 19 to the expected cost of life, so that susceptible people reduce their exposure intentionally without lockdown measures, and using the S-I-R model, we find that the above is compatible with « a=0,26+0,7* portion of Infected » going forward, leading to an effective reproduction rate decline to Rt=0,7 at the time the disease fully dies out, and a=36% (Figure 1)

Figure 1: what "a" to anticipate from survey expectations?



Finding 3 : Typical behaviors barriers well , but not perfectly understood/accepted

Reducing the rate of effective contacts can be done through a large set of behaviors, among which washing hands, etc. In general, we find that a population adhering to a few protective behavior may indeed make a growing to 40-50%, pending obviously on the availability of supplies (eg availability of masks, etc). The data survey clearly show that the bulk of, but not all individuals have understood the importance of those behaviors. In fact, while 90% clearly see the danger linked to the disease, 80% actually clearly state that washing their hands is key, and fewer than 60% understand the home insulation, the importance of mask wearing, or restrictions in public transport.

Assuming that people acknowledgement leads to behavior, a would just indeed just go up to 30%. However, this may be far stretched- if behavior is done in 2/3 of cases (as often noticed in behavioral studies), the self protective mechansims will not be enough to match the expectations of the population, and would be also relatively «tied » to ensure that the disease does not have a second wave.

Finding 4 : Average is not necessarily representative

The above has looked at the average, but the distribution may be skewed in terms of perception. Regarding the expected duration of the disease, 40% said that the pandemic has been crushed already, for a median that is less than 3 weeks, or more than two times faster than the average. To get to this figure, and number of expected extra infection at the median, « a » will need to double from 0,25 to

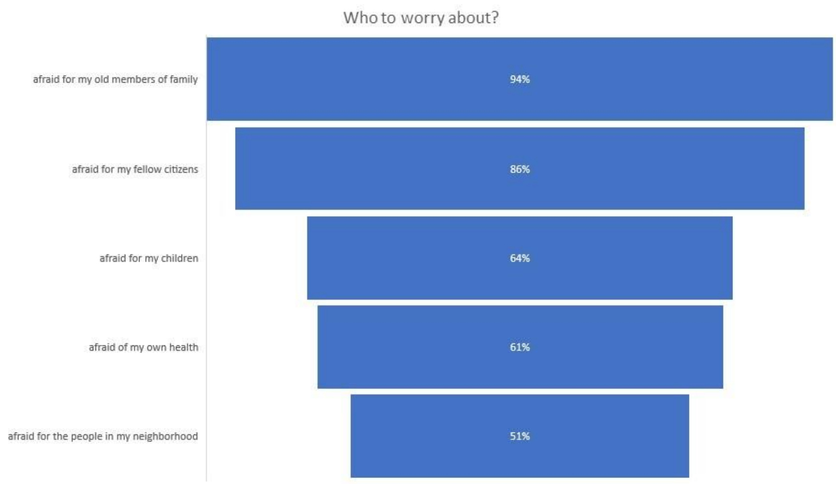
0,50, which is not likely to happen based on finding 3, as the protective behavior importance is also reduced at the median by about 25% versus the average.

The risk here is that some part of population do have too optimistic behavior—which may lead to failure of expectations and a disease that will last longer.

Finding 5 : the importance of social circles

If our curse is related to our social behavior, we may also see how social consideration may play to counter-act the wrong behavior. Here is a good news : close circles health is as important, if not more, than own health on average. In particular, people are especially worried about the health of old members of their families and about their children health . Also important, people worry about their own citizens for 60% of cases figure 2).

Figure 2 - self or third party caring?



Action plan

The above data are usually not available- but they bring a key message. When we get out of the lockdown, **we will need to make sure we track (and guide if any) people behaviors to ensure to crush the disease**. Self- interest, of possibly, third party interest may be already a good incentive to reduce social contacst, but it is likely to be not enough to navigate through the disease. **We need to create a dynamic dashboard on how people may think and act *along the way***- without this, drivers to ex post measures of recovery, infections and the like, may not be understood, or understood too late versus the fight of the pandemic we still need to have.

The french data also make clear that **a few assumptions made in the literature are too simplistic**. Do not think average, as the distribution of beliefs and behaviors do not obey a typical distribution ; do look at how people loop back social circles to influence their behaviors and beliefs ; do not hope for the a sustained reduction as close to the lockdown. If we make the point that beliefs are not necessarily biased, one can really infer how people may adapt behavior in the medium term. Their behaviors often do not match the core assumptions of policy makers. **In the case of the French data, the fit between compliance to self protection and beliefs of the pandemics suggests that the effort to be driven by the Franch citizens is *less than half* of what has been triggered by the imposed lockdown**.

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All errors mine.

21. The case for more digitization at covid time

May 8th. The covid 19 pandemic has officially taken the life of hundred thousands people worldwide. It has put the economies in standstill, with about a 5% decline in GDP for this year, as a result of the lockdown imposed to crush the diffusion of the disease.

While we are at progressive exit now, the challenge remains large to prevent a "L-scenario" of economic recovery. We make the case here for including a digital toolbox to government stimulus plans, so as to maximize a more promising recovery emerging out of the covid-19 outbreak.

A more pessimistic scenario

Covid 19 impact on economies is estimated to be gloomy. Yet, most estimates are however based on the assumption that the society will go soon "back to normal", with a gradual and smooth reopening of economies, even if possibly some localized and less prolonged shutdowns are to be implemented to avoid a second wave of outbreak. Those estimates all are leading to a recovery in about one year, and a pandemic that is mastered without any large second or third wave

Those two assumption may be optimistic. On the health side, there is still a possibility of a second and worst outbreak than the first, like the world had witnessed in major infleuneza pandemics, e.g. during the 1918-19 Spanish flu. **On the economic side, there is also a risk of what is called a « L » economic recovery, where the disruptions may lead to a permanent output gap**. This is not an "extra doom scenari"o – after all, ten years after the sub-prime 2008 crisis and the Lehman Brothers bankruptcy, **about 60% of countries in the world, still have an output trajectory below precrisis** according to robust research by the IMF[1].

A major cause of this gap is a large cut in intangible capital by firms or reduced education due to school close that may impact long-term productivity[2]. Other factors are citizens behavior, among which, fear that may not easily go away. For example, more than 40% of US workers do not feel at ease to go back to work[3], while 65% of Chinese citizens might resist to consume as much as before the disease[4].

A cost of another outbreak, versus the gradual case assumed, is likely to weight another 2-3 percent drop in GDP, should the risk materialize. T**he long-term impact, may be of the same magnitude, cumulatively after 10 years. That is, if we use the comparison with the 2008 crisis** from the IMF that led to a mode of sustained drop of yearly output of minus 15 basis points a year, for countries affected by the sub-prime crisis.

Digitization as a way to limit covid-19 risk and boost our future

Given those major risks, covid-19 is also making transparent how digital may be a formidable enabler to fight the disease in the short-term , while building a more productive, and safer society than currently in the long-term. Consider a few examples.

1.*Tracing and testing for the disease*. A challenge is that the covid-19 is very contagious, and one needs to spot infected very quickly and timely, while also act upon the social chains of contacts. Digital technology tools, leveraging location services, big data and analytics, are critical for making this happen, and there is evidence that countries with such tools at hand, mostly in Asia, have been able to better curb the disease[5]. **This is not exclusive to covid-19, as nowcasting was successfully used during the 2015 Zika virus, or even for the flu**[6].

2.*Supply chain boost*. A major issue during, and of, the pandemics has been supply chain disruption. **Dun & Bradstreet had once reported that million of companies around the world have a first and second tier supplier in the Hubei region**, the center of outbreak of the covid 19.[7] Digital technologies here may help better anticipate those effects and react accordingly for much better resilience[8]. Examples include digital twins as more pervasive simulation tools or effects, and better synchronize responses[9]. A large set of companies are also using 3D print of health supplies (eg swabs) to circumvent shortage.

3. *Effective R&D*. As early as in February of this year, digital machine learning tools have identified multiple rheumatoid arthritis treatments as being powerfully repurposed for treating the virus. **Such type of drugs have been recently confirmed as effective in random health trials by end of April, or two months later**[10].

4. *Working with, rather, than against the machine*. Many companies are now adopting tele-working, and digital automation interfacing tools for work, replacing physically-exposed contacts. **Without appropriate technology, the alternative would be *not* to work for 40% of non essential jobs time**. For essential jobs,-those that allow the economy still to work, eg retail logistics, etc-- the risk is to expose individuals to the risk of infection. Digitization of the full chain of retail, including e-commerce, has proven to be a very effective solution to the covid 19 challenge.

In need of faster digital diffusion

The digital technologies above are part of **frontier of digitization**- as it includes big data, AI, 3D, IOT, digital twins, or still AR/VR. Those technologies, and related applications are however still far from being used extensively both by consumers and enterprises.

For examples, testing and tracking tools based on digital technology have demonstrated very good specificity, eg they may spot 70-80% of infected cases, despite a large set of non-symptomatic cases. The key challenge for the case of digital tracking is that it must have sufficient reach- eg more than 50% of citizens must it to spot infected and warn their social ties. While this means a penetration *à la* Facebook in the US, this rate is in practice not easy to achieve. **Even in countries promoting digitla tracking, the adoption rate is not at this level- it is reported to be at 40% in Iceland, and about 20% in Singapore and Israel** [11]

Another example is the use of teleworking technology to put to work the workforce, with non essential interaction tasks, while automation may be the solution for virus-prone interactions. **About 50% of people never worked from home before covid** [12]. Yet, again, here, **teleworking is usually used by less than 30% of employees in countries such as US or Japan, to date, and half of them only do it for one day a work week**[13] . Similarly **advanced automation is also relatively low, eg about 10-15% in entreprises are implementing**, as it is badly perceived as a way of machines against employment[14] .

Regarding digital supply-chain tools, the effects may be in the range of boosting productivity by 10-30%[15]. There as well, the challenge is adoption—**only about 40% of companies worlwide have been digitizing their supply chain.**

We conclude that digitization holds the promises of both fighting covid 19 in the short-term as well as offering a solution for faster and stronger recovery of our economies, against the worst case of « L-scenario ». T**he current economic stimulus plans advocated by many governements must include a digitization tool box- a message to relay in the face of limited awareness of the digital lever in the current discussion of those plans.**

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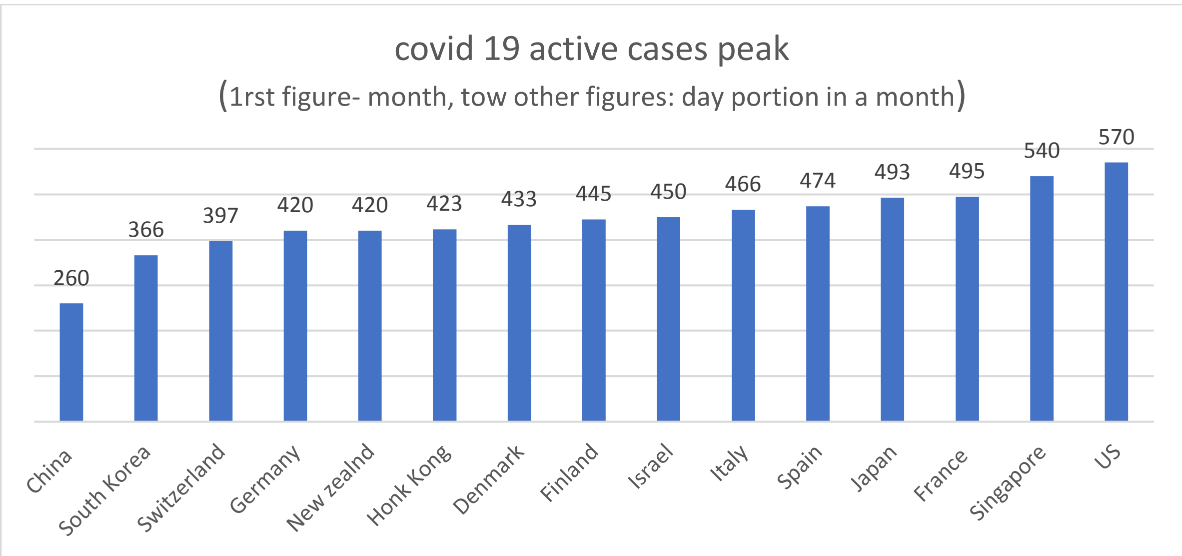
22. After the great lockdown : five uncomfortable truths to be worked out

May 24**.** Since its recognition as a human disease by mid January 2020, the covid-19 has infected five million people, and killed more than 300,000 worldwide according to the official statistics.

Along the way, major lockdown has been put in place in more than 40% of countries, accounting for nearly 80% of the world population (Lipton and Prado, 2020). While this has brought a major drop in economic activity, which may lead to a global GDP shrinking by 3% this year, according to last estimates by the IMF[19], the pandemic is now getting in some form of control five months later, with health systems able to breathe. The narrative around ther covid-19 has evolved drastically across time. It was first " a bug that has no evidence to spread to humans" and "it is like another flu", to, "the covid 19 pandemic is real" ; "social shutdown is the only way to flatten the curve of diffusion of the disease", and now: " we have managed it, it is time to exit and to look forward".

Figure 1 : Country examples of covid 19 peak time



While most of us have possibly followed the same cycle of narrative, from « this is nothing, to this is very scary, and we are now relieved » , the evidence is indeed that wave 1 outbreak is getting under control, witth many but not all, countries having active cases peak (as early as Feb 17 for China, but

[19] see https://blogs.imf.org/2020/04/14/the-great-lockdown-worst-economic-downturn-since-the-great-depression/),

just before May for Japan in Asia ; in the second end of April for Europe, with Switzerland and Germany just ahead by early April, and May 21 for the US , see figure 1).

But going back to the "new" normal is laudable, but must also keep a close management eye on both the disease evolution, as well as on the socio-economic burden that has come along the covid 19 crisis. Here are five uncomfotable truths to cope

1.We must get ready for a second wave

The odds of having a second wave are high. This is what we may learn from the past influenza-like pandemics, and what we might infer from the "official statistics" regarding the covid 19 infection rate to date, -- as the total infected are far away from the threshold of herd immunity that allows to control the disease.

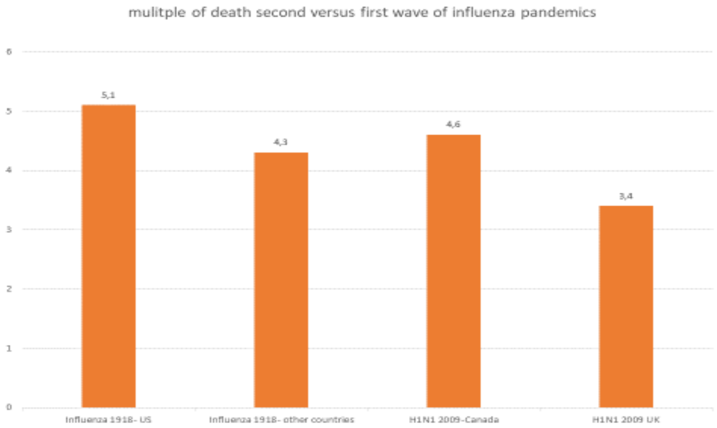
But what else can we derive from the past experience of pandemics, and from own simulation post pandemic?

The past has shown that :

a) The pandemic often come back rather soon as wave 2, in the four to 8 months of the first. This means we may be hit still this year by the second wave.

b) the second wave can even be more lethal-- for example, in the second wave of the 2009 H1N1, some countries like Canada, got hit... **5 times more**-- and the second wave in 1918 of the Spanish influenza seems to have killed **at a multiplier the same size** as the one found in Canada during the 2009 health crisis, see Figure 2.

Figure 2- Wave 2 can be dangerous



Simulation is also useful to see what might happen if social distancing is no longer imposed but made directly by citizens at 50% of the success of the lockdown and if the covid-19 behaves under some extremes, such as the common cold (HCov-0C43, mild disease but seasonal and fast decay of immunity, disappearing in 4 to 6 months), or the SarS-Cov-1(more lethal, but with longer immunity, in the range of 1,5 to 3 years), and if we believe or not that cross-immunity within the family of coronaviruses might work.

Using parameters in the literature, such as seasonality that implies a peak -through of 20% gap for the reproduction rate , or cross-immunity between viruses of about 30% (see Kissler et al, 2020), the messages are clear that :

a) Wave 2 is always capable of happening, whatever assumptions taken
b) Short immunity (like the common cold) and limited cross-immunity leads to faster as well as larger occurrence than vice-versa—and possibly, or a size higher than wave
c) Social distancing, if too stringent, may however lead to a strong wave 2, as no built immunity is deployed, but we better need at least 50% reduction of contacts of effective lockdown to control the disease

The past as well as scenarios fine tuned to the socio-epidemiology of the covid-19 and its coronavirus family leads to the uncomfortable truth that « one battle was won, not the war ». And the next battle may come soon and be big(ger than what we just won).

2. We may not be taken off-guard by being fooled by the wrong figures

It has been said multiple times that we are « flying blind, regarding key figures on the pandemic ». The current official figures suggest a rather low infection rate for a virus with such a difficult profile of latency and symptoms, and a high fatality burden.

We do not suggest that reported cases are intentionally under-reported. Those figures may be adequate if they only cover the people with severe symptoms, requiring hospitalization, and where systematic testing was made. The danger of not having a comprehensive view on figures is however many. The first is that we may forget other channels- the typical example has been not to look at home care, which happened to be a major source of deaths, -see my other article at https://www.linkedin.com/pulse/welfare-state-should-care-its-home-jacques-bughin/.

The second risk is that the fatality rate at time of hospitalization is moving from virtually zero to 20%, at time of hospitalization, and possibly at 50% when someone is at ICU. **Those stats are not good, as it may look like the odds of dying become as large as flipping a dice**. **This means we must look before hospitalization, when people critiically upgrade from death free to death liable** . But without statistics, it is very difficult to prevent.

The third risk is that we may be **put off-guard as to the timing of the wave 2.** We have collected many statistics and run maximum likelihood models to find most probable estimates of infection.Many new studies also reveal that the recorded cases may be off by a factor of up to 5-10. For example, one recent study done in France suggests that hospitalization is only 3,6% of total infected, or a ratio of 28, while the 85/15 rule (85% mild cases, 15% severe cases for covid 19), rather implies a ratio of 5, leading to an understatement of actual infection by 5-fold (Salje et al, 2020). The implication of such a gap is that fatality rates are clearly overstated, but also that people can be more often faced with getting the disease than said. At current transmission rate, and given that, despite a 5 to 10 fold adjustment, most countries are far off the herd immunity portion of infection, **a higher contaminated stock means that the infection flow is larger per day, as the infection figure builds up like a power law. We might thus take high risk for wave 2**, as bed capacity are fixed, or at best can be increased, but usually only linearly.

3. Health risk may only start for the recovered from the Covid 19

At current, a large focus has been on serious cases and fatalities in the covid-19 crisis. **The typical assumption is that recovered people are all « fit and proper ».** But remember, that, for 1 death at hospital, 5 others survive—and possibly, for one person requiring hopsitalisation, possibly 5 times more officially, and possibly 25- 50 times more did recover outside the hospital channels.

What if this massive number of people, -between 5 to 40 million people worldwide, recovery is not complete ?

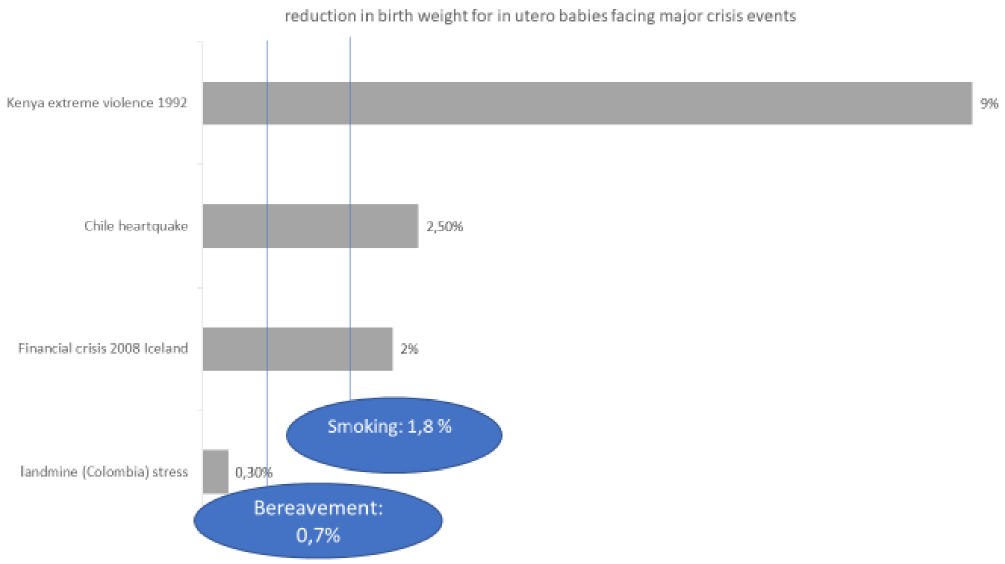
Those risks are not nil, as acknolwedged by Kelly Servick, a writer for Science, in an April piece entitled «**For survivors of severe COVID-19, beating the virus is just the beginning** »[20]. In fact, the history provides some clear evidence of short and long-term damages.

Regarding short-term damages, more than one third of people who got hospitalized for the 2003 SARS outbreak felt anxiety and depression disorders, still one year after the infection (Lee et al, 2007). Likewise, if pneumony is a marker for covid-19, there is four times more probability to suffer a cardiovascular disease, for those getting hospitalized for acute pneumonia than not.

But those are only short-term effect ; long term effects may be present too. In fact, **multiple studies looking at in utero reaction of to be born kids from parents caught into the 1918 pandemics suggests large morbidity effects** still 25 to 40 years after, affecting lung, kidney, and many other organs, with impact on productive and social life (Almond, 2005 and 2006). Compiling a series of in utero studies, the effects may be important, impacting the next generation, in a ratio of **1 to 9% of weight of new borns,** see Figure 3.

Figure 3- how adverse shocks may affect the long-term- in utero effects

[20] see https://www.sciencemag.org/news/2020/04/survivors-severe-covid-19-beating-virus-just-beginning



4. We must be bold enough to relaunch inclusive economies

The burden is not only about health, it is socio-economic. Short-term costs linked to lockdown are not small, with eg in the US, average income and wealth lost estimated to be more than 5000 US Dollars and 33,000 dollars respectively (Coibion et al, 2020).

If total burden may come to 5-10% of welfare lost, it is already clear that a « V » recovery may be rather optimistic. A « U » shape may be a better representation, as seen from the early data of China, where economic recovery has been slow pace.

A « L » shape is possibly not to be neglected, both because of the risk of Wave 2 still this year, and because crises of that size may lead to major distorsions, affecting investments and ultimately growth path in the future. Plans have been announced by a large set of countries to stimulate growth, and prevent the worst case of a « L- like » recovery. The key question remaining is : **do they spend (fast) enough and inclusively ?**

To date, most countries have put a fiscal stimulus in the range of 2% of GDP, on top of facilities of re-payment. The later is de facto crucial as the OECD, leveraging Orbis data, finds that **1/3 of firms may run out of liquidity after after three months of lockdown. This liquidity crunch is thus massive and must be sorted out clearly** (OECD, 2020). Regarding the former, the size of the stimulus might appear not bold enough.

Consider that the spent figure is higher than during the crisis 2008 (eg., G-20 spent roughly 1,4% of GDP in stimulus package), and at that time too US spent significantly more (like China) to reboost the economy. Today, we see the same pattern, with US, but this time Germany, spending close to 10% of their GDP (data courtesy of Bruegel, see Figure 4) for their stimulus package. Yet, there remain some clear surprises :

a) Why is it **that countries with more covid damages seem to commit less amount of stimulus than others** ?

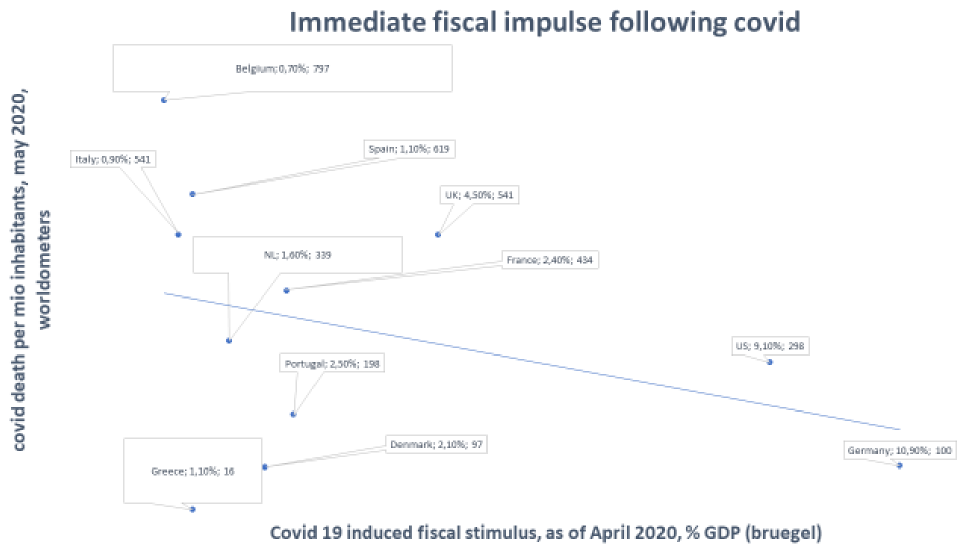
b) **Why is the level of fiscal spent not bigger than the 2008 crisis**, while the GDP shortfall of the pandemic may oscillate between -2 to -8% percent for 2020 alone in developed countries, that is, an effect that is larger than witnessed during the 2008 crisis ? In fact, if consumption and private investment is 70% of GDP, the (undiscounted) multiplier effect from year 1 to 5 after the spent of 2%, would be 3,6%, with recovery of spent by 2022, and for a total of 5,6%, of just the mid range of risk of output contraction for covid 19.

The EU Recovery plan proposed by the Franco-German team of a €500 billion of spending that has been recently backed by the EU budget a few days ago is **a path to boldness and would represent an European-wide fiscal policy**, that could be jointly spent on key forward looking infrastructure in sustainability theme, new investment in frontier technologies, among others.

Finally, the question is not that we spend enough to restore- the question is whether we remain **inclusive**. There is clear evidence that the **ethnic and socio-economic distribution of health impact of the covid 19 is not favorable to lower socio-economic group and minorities**. Eg lower socio econiomic groups suffer more often from comorbidities and are thus more at risk of fatality from the disease ; likewise those groups are more at risk of unemployment.

Or, if employed, they are more at risk of exposure with lower probabilities of remote working among others. Increase in inequality from the covid 19 must be part of next agenda, as it ultimately wolud weight on prospect of recovery and growth.

Figure 4- Immediate fiscal impulse commitment for covid 19 risk



5. We must secure democracy

Last but not least, it will be critical to fix the impact of the covid-19, **on the role of the the State, the dynamics of election, and public economy at large.**

Many states have voted for exceptional power, in the frist place to take measures linked to confinement. But it may remain crucial to consider those powers are temporary, as part of this exception—**not as a new rule**. Some governements are already tempted to take advantage of extra power given by the covid 19.

More subtle is the issue of election. France is going for a second round of vote for municipalities, at covid 19 time, that may undermine the representation of election, for example. A recent study conducted in the US identified that **counties that voted after Super Tuesday and which were then exposed to covid outbreak, were less likely to support Sanders , leading to 4 percentage points less support** compared to Sanders 2016 vote (Bisbee and Honing, 2020). This effect is material and may mean election may be greatly influenced by the hazard of a pandemic wave like covid-19. **We may extrapolate this argument for the US presidency election, a fortiori if a new wave (is likely to) break around that voting time.**

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