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Marcello Basili
Antonio Nicita

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Marcello Basili* DEPS University of Siena
Antonio Nicita Department of Law Lumsa University

Abstract

The new coronavirus CoVid-19 (SARS Cov-2) pandemic outbreak all around the World puts in evidence how institutional failures may end up in a catastrophic event. The precautionary principle (PP) has been proposed as the proper guide for the decision-making criteria to be adopted in the face of the new catastrophic risks that have arisen in the decades of this century. Unfortunately the political institutions at the national and supranational level, such as the European Union Commission, seem having neglected it opening the scenario of a lethal global pandemic that could cause millions of deaths, principally elderlies with chronic diseases, based on early evidence in China and Italy. According to scientists and health authorities human beings are facing the high probable nightmare of a very aggressive and mortal pandemy, worst than the Spanish flu (1918-1919) the most famous reconbined avian flu killed millions, without targeted therapeutics for treatment and vaccines.

*Corresponding author: Marcello Basili DEPS University of Siena Piazza San Francesco 7, 53100 Siena (Italy), marcello.basili@unisi.it

1 Introduction

In the 90's of the last century the Precautionary Principle became known worldwide after the 1992 Conference in Rio de Janeiro and has been advocated as the right response to new catastrophic risks such as: global warming, genetically modified food, acquired immunodeficiency syndrome (AIDS), pandemic avian or swine flu. In 2006, Nicholas Stern, chair of the Grantham Research Institute on Climate Change and the Environment at the London School of Economics, released a report for the Government of the United Kingdom known as the Stern Review of climate change. In the 700 pages report, Stern and his colleagues considered in detail the physical impacts of climate change on economic activity, on human life and on the environment, putting in evidence that existence of deep uncertainty, distinguished from risk, makes any evaluation very ambiguous and imprecise. In this perspective the Stern review states that "modern theories embodying a distinction between uncertainty and risk suggest an explicit precautionary principle beyond that following from standard expected utility theory" (2006, 33). To illustrate the relevance of a precautionary principle when a decision-maker faces uncertainty, the Stern review refers to two cases: "the link between bovine spongiform encephalopathy (BSE) in cows and Creutzfeld-Jacob Disease (vCJD) in humans and the link between asbestos and lung disease. For the first, UK scientists asserted for some time that there could be no link because of 'a barrier between species'. However in 1991 scientists in Bristol succeeded in inoculating a cat with BSE and the hypothesis of 'a barrier' was destroyed. Around the same time, a scientist, Stanley Prusiner (Nobel Prizes in 1989), identified protein mutations that could form the basis of a link. These results did not establish probabilities but they destroyed 'certainty'. By introducing uncertainty, the finding opened up the possibility of applying a precautionary principle. For the second, a possible link between asbestos and lung disease was suggested as early as 1898 by health inspectors in the UK, and in 1911 on a more scientific basis after experiments on rats. Again the work was not of a kind to establish probabilities but provided grounds for precaution. Unfortunately, industry lobbying prevented a ban on asbestos and the delay of fifty years led to considerable loss of life. Application of the precautionary principle could have saved lives" (2006, 34). Referring to modern decision theory under uncertainty (Gilboa and Schmeidler 1989, Marinacci et al 2005, Chateauneuf et al 2007) Stern concludes his report by saying that "'uncertainty should not be inflated and invoked as an alibi for inaction since we now have a theory that can describe how to act" (2006, 34).

In theoretical and applied papers, Gollier et al (2000), Immordino (2003), Basili (2006), Basili and Franzini (2006), Basili et al (2008), Asano (2010), Grant and Quiggin (2013) and Jeleva and Rossignol (2019) describe application of the precautionary principle as a leading guide to public decision-making under irreversibility and uncertainty. Nonetheless real life applications of the precautionary principle have been rare generating, often, catastrophic events. The most famous case was the BSE-vCJD epidemic outbreak in 1995-2000 originated in the UK. Then epidemiologists showed that BSE originates from scrapie and vCJD from BSE crossed the species barrier and the consequence were extremely expensive. UK agriculture felt in a serious recession for about five years when the total agricultural income fell from £5.3 billion to £1.9 billion (- 64%) and the agricultural labor force lost more than 51,000 people.

In 2019, the coronavirus outbreak appears as a new failure in the application of the precautionary principle. However, this time consequences could be catastrophic because of its high contagious rate (R_0) and case fatality rate.

Institutional failures are here defined as the unjustified inertia of national and supranational institutions in front of ambiguous and extreme risks, as an epidemic event.

2 The Precautionary Principle

The precautionary principle is generally regarded as the most useful guide for behavior to be adopted in the face of scientific uncertainty and when the risk of catastrophic events is non negligible. It became notorious after the 1992 UN Conference on the Environment in Rio de Janeiro, when it was put forward as the tenth of the great principles agreed upon at the Conference. The precautionary principle was introduced in the Maastricht Treaty under article 130 and was renumbered as article 174 in the Amsterdam Treaty (1999). It was often quoted in EU law and was used in 27 European Parliament resolutions between 1994 and 1999. The article 174 was, finally, reconsidered in the article 191 of the Treaty on the Functioning of the European Union (TFEU) that sets "(1) Union policy on the environment shall contribute to pursuit of the following objectives: - preserving, protecting and improving the quality of the environment, protecting human health, prudent and rational utilization of natural resources, promoting measures at international level to deal with regional or worldwide environmental problems, and in particular combating climate change. (2). Union policy on the environment shall aim at a high level of protection taking into account the diversity of situations in the various regions of the Union. It shall be based on the precautionary principle and on the principles that preventive action should be taken, that environmental damage should as a priority be rectified at source and that the polluter should pay. In this context, harmonization measures answering environmental protection requirements shall include, where appropriate, a safeguard clause allowing Member States to take provisional measures, for non-economic environmental reasons, subject to a procedure of inspection by the Union. (3) In preparing its policy on the environment, the Union shall take account of: - available scientific and technical data, environmental conditions in the various regions of the Union, the potential benefits and costs of action or lack of action, the economic and social development of the Union as a whole and the balanced development of its regions".

At a first glance the article 191 could induce an interpretation of the precautionary principle as a simple guide to the action in facing environmental risks only. Moreover, the notion of the precautionary principle, originated a large scientific and political debate in the European Union and internationally. In 2000, the European Commission in wiping out any strict interpretation of the precautionary principle and settling the debate about its application, issued a legal note: the Communication of the Commission on the precautionary principle or Comm2000. The Comm2000 aimed at solving the decision-maker's "dilemma of balancing the freedom and rights of individuals, industry and organizations with the need to reduce the risk of adverse effects to the environment, human, animal or plant health". The Comm2000 "fourfold aim is to: outline the Commission's approach to using the precautionary principle, establish Commission guidelines for applying it, build a common understanding of how to assess, appraise, manage and communicate risks that science is not yet able to evaluate fully, and avoid unwarranted recourse to the precautionary principle, as a disguised form of protectionism" (2000, 2). In the interpretation of the Commission the precautionary principle is not a preservative approach to the assessment of scientific data but a guide to actions whenever "potentially dangerous effects deriving from a phenomenon, product or process have been identified, and that scientific evaluation does not allow the risk to be determined with sufficient certainty" (2000, 3). Significatly, the application of the precautionary principle is not restricted to environmental problems, but provided for human health problems when scientific evidence is insufficient, inconclusive or uncertain. The EU Commission's interpretation was reinforced by European Court of Justice sentences (i.e. BSE).

3 Extreme Events and Rational Decision-Making Rules

Global risks involving human health are characterized by irreversibility and uncertainty. Irreversibility breaks the temporal symmetry between the past and the future. In the case of macroscopic events, the notion of irreversibility can be associated to the arrow of time and according to the second law of thermodynamics, this arrow of time implies a positive mean entropy generation. An extreme event, such as the coronavirus outbreak, may induce irreversible events, such as deaths or permanent physical limitations to humans, or involve very high costs in terms of resources or time required for restoration to the preexisting state. Uncertainty means that consequences involved by extreme risks are ambiguous, fuzzy or vague. In turn, this implies that a risk cannot be characterized by a reliable and additive probability, but rather by interval of probabilities, probability judgements (likely, almost sure, unlikely, almost impossible), a capacity or non-additive measure. The vagueness of the notion makes it difficult to translate the precautionary principle into a well-defined decision rule that includes standard categories for risk evaluation such as the extent of damage and the probability of occurrence. In particular, it is well known that decisional rules based on the expected utility maximization, i.e. bounded expected utility function, underestimate extreme risk or, at worst, can be insensitive to them. Chichilniski (2009) showed that in the axiomatic representation of choices by the expected utility theory, the monotone continuity axiom (i.e. a small change in probability does not alter the order of choices) implies the insensitive to rare events. Catastrophic events have imprecise and very small probabilities and expected utility approach is not able to order choices with respect to them.

The standard evaluation criterion is based on mathematical expectation of possible consequences fails in evaluating the CoVid-19 outbreak. A possible solution is the application of the maximin criterion (Wald 1950), but this approach systematically overestimates the worst consequence inducing a totally preservative choice or "better safe than sorry" (Sunstein 2003). Recently different approaches were introduced to make the precautionary principle a rational decision rule in a situation characterized by scientific uncertainty, irreversibility and catastrophic consequences. Since the lack of full certainty is not a justification for inaction and preventing a potentially harmful situation, new versions of the precautionary principle can be connected to the notion of cost effectiveness by which alternative actions are evaluated using the standard cost-benefit analysis (CBA).

Chichilnisky, in a risky setting axiomatizes a new functional that is sensitive "to both small – and large – probability events" (2000, p.222). Chichilniski introduces a so called a 'topology of fear' (2009, 812). She introduces "a new axiomatization of subjective probability requiring equal treatment for rare and frequent events, and characterize the likelihoods or subjective probabilities that the axioms imply. These coincide with countably additive measures and yield normal distributions when the sample has no black swans. When the sample includes black swans, the new likelihoods are represented by a combination of countable and finitely additive measures with both parts present" (Chichilniski 2009, 184)[1].

Differently, Basili (2006), Basili and Franzini (2006), Basili et al (2008), Basili and Chateauneuf (2011) and Jeleva and Rossignol (2019) define operational decision rules assuming that the decision-maker has a Choquet Expected Utility with a non-additive capacity.[2] All the decisional rules based on the Choquet Expected Utility are able to include the decision-maker's attitude, i.e. optimism or pessimism, with respect to assessment of extreme events. In particular they introduce a notion of the precautionary principle that is a combination between extreme outcomes (the worst and the best cases) and the mathematical expectation (ambiguity neutrality) of all the possible consequences, weighted by the quality of information about the possible events (reliability of the probability distribution attached to future states of the world).

Basili and Franzini (2006) define an operational notion of the precautionary principle based on the α-MEUcriterion and evaluate the optimal choices against the menace of the human avian flu pandemic. The α-MEUcriterion is a convex combination between maximin and maximax criteria. These respectively conservative and dissipative evaluations are combined on the basis of the decision-maker attitude toward reliability of her assessment about the

[1] Let Ω be the set of possible future states of the World, $\Sigma = 2^{\Sigma}$ the power set, or the set of all subsets. Given $A, B \in S \subset \Sigma$, where S is a partition of Σ, and $A \cap B = \varnothing$, $\mu : \Sigma \to (0, \infty)$ is a function. Then:

μ is *monotonic* if $\mu(A) \leq \mu(B)$ for all $A \subseteq B$;

μ is *additive* or *finitely additive* if $\mu(E) = \sum_{i=1}^{n} \mu(E_i)$

whenever $E = \Pi_{i=1}^{n} E_i \in S$ for $I = 1, 2, ..., n < \infty$

A measure μ is *countable additive* if for any countable collection of disjoint events $E_{i=1}^{n}$ $\mu(\cup_{i=1}^{n} E_i) = \sum_{i=1}^{n} \mu(E_i)$.

Let P be probability distributions on (Ω, Σ), or $p \in P : \Sigma \longrightarrow [0, 1]$ and $\sum\limits_{i=1}^{n} p(E_i) = 1$.

[2] A measure $v \geq 0$ is a positive capacity on (Ω, Σ) if $v : A \in \Sigma \to v(A) \in \mathbb{R}$, where $v(\varnothing) = 0$, $v(\Omega) = 1$ and $A, B \in \Sigma$ such that $A \subseteq B \Longrightarrow v(A) \leq v(B)$. A capacity v is convex if $v(A \cup B) + v(A \cap B) \geq v(A) + v(B)$.

For $X : \Sigma \to \mathbb{R}$, an act, for every X and v, the Choquet integral of X with respect to v denoted $\int X dv$ is defined by $\int X dv = \int_{-\infty}^{0} (v(X \geq t) - 1) dt + \int_{0}^{+\infty} v(X \geq t) dt$.

occurrence of events (ambiguity attitude).[3]

Basili (2006) introduces a a new formalization of the PP based on variations in the decision-maker *status quo or reference point*, as in the Cumulative Prospect Theory (CPT) where the decision-maker has a different attitude with respect to losses and gains. The new formalization of the PP "rests on the idea that the decision-maker has a whole set of outcomes,which he/she considers as a reference set to compare the consequences of her choices, so that in contrast to the CPT, the reference point is not a single outcome but a set of outcomes. Indeed, the new notion of the PP is a characterization of the behavior of the decision-maker who perceives genuine ambiguity with respect to unfamiliar losses and gains and neutral ambiguity regarding more familiar outcomes (customary outcomes). That is, it is assumed that the decision-maker overestimates catastrophic losses (pessimism) and windfall gains (optimism), but she is ambiguity neutral with respect to the subset of familiar outcomes (Basili 2006, 1724).[4]

Basili and Chateauneuf (2011) define an operational notion of the PP by a functional defined through quantiles. They define an interval of events that the decision-maker considers familiar, in some sense ordinary with respect to her experimented life, and two tails that include extreme events, such as events with very small probabilities of occurring and very large consequences either positive (windfall gains) or negative (catastrophic losses). So doing they are "able to take into account both asymmetric attitude with respect to ambiguity on extreme events (optimism with respect to windfall gains and pessimism with respect to catastrophic events) and decision-maket's attitude considering entropy as a rule of inference, when information is ambiguous and scanty" (2011, 1101).

[3] If Ω is a finite set of states of the world, the set Σ of all subsets of Ω, $X, Y \in X$ are acts such as $X : \Sigma \to H$, H is the set of consequences, $u : H \to R_+$ is a bounded utility function, and P is a unique nonempty, weak*-compact and convex set of countably additive probabilities on the measurable space (Ω, Σ), then a weak preference relation can be represented by the functional:

$V(X) = \alpha \min_{p \in P} \int u(X(s))p(s)ds * (1-\alpha) \max_{p \in P} \int u(Y(s))p(s)ds$

for $\alpha \in [0,1]$

[4] Assume $X : \Sigma \to H$, H is the set of consequences or real outcomes and let $(m, M) \in R$ be the subset of outcomes (both losses and gains) that the decision-maker conceives as customary, where $m \leq 0 \leq M$ (usually $m < 0, M > 0$). Let υ^* and υ^-be capacities on Ω. Define $I(X)$ as:

$I(X) = \int_{--\infty}^{m} (\upsilon^-(x \geq t) - 1)dt + \int_{m}^{0} (p(x \geq t) - 1)dt + \int_{0}^{M} p(x \geq t)dt + \int_{M}^{+\infty} p(x \geq t)dt$

If $I_{\text{catastrophic}}(X) = \int_{--\infty}^{m} (\upsilon^-(x \geq t) - 1)dt$; $I_{\text{customary}}(X) = +\int_{m}^{0} (p(x \geq t) - 1)dt + \int_{0}^{M} p(x \geq t)dt$; $I_{\text{windfall}}(X) = \int_{M}^{+\infty} p(x \geq t)dt$

then $I(X) = I_{\text{catastrophic}}(X) + I_{\text{customary}}(X) + I_{\text{windfall}}(X)$.

If the decision-maker is symmetric with respect to risk, i.e. $|m| = M$, and has the same degree of ambiguity (full ambiguity) for familair and unfamiliar outcomes, then:

$I(X) = \gamma E(X) + (1-\gamma)\left[X_{\min} + X_{\max}\right]$

Deatils in Basili 2006 and Basili et al 2008.

In a two-period model Jeleva and Rossignol (2019) assume that agents have different ambiguity attitude and preferences are represented by *neo-capacity* or Choquet expected utility with non-extreme-outcome-additive (Chateauneuf et al 2007), or a "convex combination of an additive capacity and a special capacity that only distinguishes between whether an event is impossible, possible or certain" (Chateauneuf et al 2007, 540).[5] Jeleva and Rossignol consider individuals differentiated in terms of attitude towards uncertainty and degree of optimism or pessimism and show that the PP "is applied more often if the decision-maker has an intermediate optimism index and if the scientific research is more efficient at reducing uncertainty because this increases the value of waiting...that an elected decision-maker will apply the precautionary principle less often than the socially utilitarist optimum; this effect is increased with a change of decision-maker from one period to another" (2019, 385).

In a nutshell, all these approaches are weighted combinations of consequences attached to possible events. As a consequence, these approaches provide decisional rules suitable for useful implementations of the precautionary principle in situations that entangle both more reliable consequences and extreme outcomes.

4 CoVid-19: The Pandemic Disease

The new coronavirus that has been spreading around the world causes a respiratory illness that can be severe, In early December 2019 unknown severe pneumonia cases appear in Wuhan the capital of the Hubei province and rapidly spread throughout China. In 29 December 2019, the new coronavirus disease was identified as a severe acute respiratory syndrome and called SARS-CoV-2, because of genetic similarity to SARS-CoV, the Severe Acute Respiratory Syndrome appeared in 2003. SARS-CoV-2 is also similar to MERS-CoV (Middle East Respiratory Syndrome coronavirus) first reported in Saudi Arabia in 2012 and spreads to 27 countries with 858 deaths. coronaviruses are naturally hosted in animals and are able to infect humans (species leap). SARS-CoV-2, SARS and MERS are included in the large family of *Coronaviridae* and have genetic similarity from 79% (SARS-CoV-2 and SARS) to 50% (SARS-CoV-2 and MERS). Crucially SARS-CoV-2 has a very large similarity (96,2%) with the bat *betacoronavirus* of the sub-genus *Sarbecovirus*. Some animals, such as pangolin, are considered probable virus reservoir for human infection, but some scientists suggest that cross-species transmission is due to Bungarus multicinc-

[5] Let $N \subset \Omega$ be a set of null event, such that $\upsilon(\Omega \backslash N) > 0$ and $\delta, \alpha \in [0,1]$, a neo-additive capacity $\upsilon(. \mid N \ , p, \delta . \alpha)$ with an α *degree of optimism* such that $\upsilon_\alpha^N(E) = \{0$ if $E \in N$; α if $E \notin N$ and $\Omega \backslash E \notin N$; 1 if $\Omega \backslash E \in N$, is defined as

$\upsilon(E \mid N, p, \delta, \alpha) := (1-\delta)p(E) + \delta \upsilon_\alpha^N(E)$.

The Choquet expected value of an act X with respect to a neo-additive capacity $\upsilon_\alpha^N(E)$ is:

$\int X dv := (1-\delta) E_p[X] + \delta \left\{ \alpha \min_{p \in P} \int u(X(s))p(s)ds + (1-\alpha) \max_{p \in P} \int u(Y(s))p(s)ds \right\}$.

Deatails in Chateauneuf et al 2007.

tus (Chinese krait), a highly venomous species of elapid snake (Benvenuto et al 2020).

SARS-CoV-2 or CoVid-19 has a median incubation period of 4 days (2-12 days, rarely 14 days). Analysis indicate that SARS-CoV-2 evolved into two major types L and S and "although the L-type (70%) is more prevalent than the S-type (30%), the S-type was found to be the ancestral version. Whereas the L-type was more prevalent in the early stages of the outbreak in Wuhan, the frequency of the L-type decreased after early January 2020" (Tang et al 2020).[6] CoVid-19 basic reproduction number $R_0 = 2,5 - 3$ ($R_0 > 1$ means epidemic) and its case fatality rate equals to $3\% - 4\%$ (in China it is about 4%, but in Italy close to 8%). In the case of a seasonal flu $R_0 = 1,3$ and the case fatality rate close to 1%, but the pandemic Spanish flu in 1918-1919 had a case fatality rate equals to $2\% - 3\%$ (40-76 mil of deaths).

4.1 Measuring the cost of the CoVid-19.

There exists some studies about expected costs of a new pandemic disease. World Bank refers to previous pandemic diseases, such as the Spanish flu 1918-1919, and estimate that the global product (GDP) could reduce about 5%. In A world at Risk (2019), WHO and World Bank estimate the total cost of a new pandemic upwards between 2.2%-4.8% of the global GDP. Another study evaluates the consequences of a pandemic disease on the base of pandemic severities and in an extremely severe scenario income losses could reduce the GDP about 12%. In a recent study, Fan et al show that "in terms of the percentage of global income, our estimate of total pandemic related losses (0.6%) falls within the corresponding Intergovernmental Panel on Climate Change's estimates of the costs of global warming, i.e. 0.2–2.0% of global GDP" (2018, 131). The International Monetary Fund (IMF) puts in evidence the asymmetric costs of a pandemic and sets that even "when the health impact of an outbreak is relatively limited, its economic consequences can quickly become magnified. Liberia, for example, saw GDP growth decline 8 percentage points from 2013 to 2014 during the recent Ebola outbreak in west Africa, even as the country's overall death rate fell over the same period" (Bloom et al 2018, 46). In The Global Macroeconomic Impacts of COVID-19: Seven Scenarios, McKibbin and Fernando (2020) examine the economic impacts of different scenarios regarding the spread of COVID-19 on macroeconomic outcomes and financial markets in a G-cubed model, a global hybrid dynamic stochastic general equilibrium (DSGE) models and computable general equilibrium (CGE). The G-cubed model was introduced by McKibbin and Wilcoxen (1999, 2013) and extended to the G20 countries by McKibbin and Triggs (2018). The G-cubed model considers "pandemic scenarios where the epidemiological shocks occur in all countries to differing degrees. Scenarios 1-6 assume the shocks are temporary. Scenario 7 is a case where a mild pandemic is expected to be recurring each year for the indefinite" (McKibbin and

[6] This is not a news. In the avian flu epidemic were idntified two subtypes of strain: Highly Pathogenic (HPAI), associated with high mortality in poultry (kills 90–100% infected chickens), and Low Pathogenic (LPAI), less severe or no illness in poultry.

Fernando 2020, 9). The lowest scenario (S4) of a pandemic outbreak determines 15 mil of deaths and reduces global GDP by $SU2.4 trillion, but a serious outbreak (S6), similar to the Spanish flu, induces 68 mil of death and reduces global GDP by over $US9trillion in 2020. In The Economics in the time of CoVid-19, Baldwin and Weder di Mauro consider the effects of the CoVid-19 pandemic on real and financial economy. In particular they evaluate the effect of pandemic on the global manufacturing sector that is expected to be affected by a triple hit: direct supply disruptions, supply-chain contagion will amplify the direct supply shocks and "demand disruptions due to (1) macroeconomic drops in aggregate demand (i.e. recessions); and (2) wait-and-see purchase delays by consumers and investment delays by firms" (2020,4). In this study, the economic impact worldwide of the novel coronavirus epidemic is expected between 2% and 6% of the global GDP. Barro et al (2020) assume that the 1918-1920 Great Influenza Pandemic as a plausible worst scenario for the CoVid-19 outbreak. Considering data for 43 countries, they estimate "150 million deaths today. Further, that death rate corresponds to estimated declines in GDP and consumption in the typical country by 6% and 8%, respectively. In addition, the pandemic was associated with sizable declines in real rates of return on stocks and short-term bills".

All the above estimates of economic losses provide evidence, in terms of cost-benefit analyses, of the reasonable adoption of the PP as the ex-ante costs of prevention certainly outweigh the ex-post of a global pandemics. Morever investment in prevention increases GDP as for investments in R&D, medical devices, social protection, training and education.

5 Facing institutional failures on CoVid-19

There are two main sources of institutional failure in the case of the CoVid-19 pandemic: inertia at the national level of Governments in preparing for and mitigating the effects of global health emergencies and inertia at the supranational levels, for institutions like the EU Commission, as long as they waive the precautionary principle as a guide-line for policy actions and the recommended approach in facing uncertain catastrophic events.

It is well known that pandemic is an extreme event, but in any case a probable event not *a black swan*, in fact based on the historic incidence of three influenza pandemics over the last century, scientists set that "the estimated probability of a pandemic remained >1 every 80 years" (Balicer et al, 2005, 1281).

World Bank and WHO (2019), on the base of recent epidemic events, put in evidence the high impact of respiratory pathogens and the greater risk of pandemic from natural pathogens. They set that "preparedness and response systems and capabilities for disease outbreaks are not sufficient to deal with the enormous impact, rapid spread and shock to health, social and economic systems of a highly lethal pandemic, whether natural, accidental or deliberately released. There is insufficient R&D investment and planning for innovative vaccine development and manufacture, broad-spectrum antiviral, appropriate non pharmaceutical interventions" (2019, 28). Moreover, "despite the high cost-benefit ratio of emergency preparedness, governments continue to neglect it. World Bank and WHO analyses indicate that most countries would need to spend on average between US$ 1-US$ 2 per person per year to reach an acceptable level of pandemic preparedness. Considering the benefits to economic growth (not counting the enormous cost to human life), investing in health systems to implement the IHR (2005) would yield a positive return on investment in all plausible scenarios. A yearly investment of US$ 1.9–3.4 billion to strengthen animal and human health systems would yield an estimated global public benefit of more than US$ 30 billion annually, a return on investment of 10 to 1 or higher. Preparedness capacities and systems are global public goods-all countries benefit from every country's investment" (2019, 31).

Around the World, national governments have been found completely ill-prepared by CoVid-19 outbreak. This is puzzling, as, in the last two decades, human beings have faced some serious epidemic diseases (BSE-vCJD, Avian Flu, Ebola) and a pandemic swine flu that induced thousands of deaths and enormous economic losses. In the Annual review of diseases prioritized under the Research and Development Blueprint, the WHO (2018) put MERS and SARS at the top in the list of priority diseases. The blueprint identifies those diseases that generate a public health risk because of their epidemic potential and for which there are no sufficient countermeasures. Mreover the blueprint invites to develop "countermeasures for multiple diseases or for families of pathogens". Countermeasures for containing an epidemic diseases are both active (R&D, vaccines, antiviral, drugs etc.), and also passive, i.e. hospitals, and tool for avoiding exponential spread of a disease (chlorine alcohol to disinfect and ffp2/ffp3 masks for people in infected areas). It is evident that single European countries were not ready to face the pandemic, even with respect to passive strategies. Unpreparedness is the consequence of lackness of a national security and safety strategy with respect to catastrophic and extreme risks. In EU, at the best of our knowledge, The Netherlands, and to some extent the UK, has a national chart or risk matrix focusing on so called 'vital interests', i.e. territorial security, physical security, economical security, ecological security, social and political stability, in orderto prevent societal disruption by intentional, man-made and natural menaces. Possible menaces and threats are assessed (*what we face*), national capabilities evaluated (*what we need to have)* and policies arranged (*what we do*). The result is the Risk Diagram, a very simple chart that represents in the Cartesian plane, with consequence on the ordinates and probability on the abscissas, the strategic threats. Not surprisingly, pandemic disease is in top right-high side of the chart (very-probable catastrophic consequences). Shortage of medical tools such as ventilators ICU (Intensive Care Unit), chlorine and masks, even for doctors and nurses, is not an unforeseen misfortune but consequence of the unforgivable political failure in applying proper risk analysis to uncertain problems.

If possible, there is a greater responsibility on the outbreak of CoVid-19, the failure to implement precautionary measures facing the epidemic diffusion of the novel coronavirus in China. This political and institutional responsibility falls on the EU Commission's head.

Chronology of events exhibits that there was some time window to take precautionary principle seriously and to introduce a general ban to incoming people and travels from China and, what was more efficient, a quarantine period for travellers and business people returning from China.

In other terms, the EU Commission should have applied the article 191 TFEU or the PP at least from late January. In fact, on 31 December 2019, the WHO China Country Office was informed of cases of unknown etiology detected pneumonia in Wuhan City, Hubei Province of China. From 31 December 2019 through 3 January 2020, a total of 44 case-patients with pneumonia of unknown etiology were reported to WHO by the national authorities in China. During this reported period, the causal agent was not identified. On 7 January 2020, the Chinese authorities identified and isolated a new type of coronavirus. On 11 and 12 January 2020, WHO received further detailed information from the National Health Commission China that the outbreak was associated with exposures in one seafood market in Wuhan City and China shared the genetic sequence of the novel coronavirus for countries to use in developing specific diagnostic kits. On 13 January 2020, the Ministry of Public Health, Thailand reported the first imported case of lab-confirmed novel coronavirus (2019-nCoV) from Wuhan, Hubei Province, China. On 15 January 2020, the Ministry of Health, Labour and Welfare, Japan (MHLW) reported an imported case of laboratory-confirmed 2019-novel coronavirus (2019-nCoV) from Wuhan, Hubei Province, China. On 30 January 2020, WHO declared the outbreak of COVID-19 a "Public Health Emergency of International Concern" (PHEIC).

At the best of current knowledge, the first case of CoVid-19 in the EU was a German businessman on 24 January 2020. On 27 January the businessman informed the company about her illness. On January 28, three additional employees at the company tested positive for CoVid-19. All the patients with confirmed CoVid-19V infection were admitted to a Munich infectious diseases unit for clinical monitoring and isolation (Rothe et al 2020). This information was not shared with other EU countries.

It is clear that there is an unjustifiable misinterpretation of events and unexcusable delay in applying measures for the outbreak control. After fews weeks the scenario turned to be completely different as the containment of the pandemic appeared very difficult, since in the case of the CoVid-19 with a $R_0 = 2-5$, "to achieve control of 90% of outbreaks, 80% of contacts needed to be traced and isolated" (Hellewell et al 2020).

6 Strategies against the CoVid-19 pandemic

At the end of March the policy issue is no longer about the outbreak prevention but, very unfortunately, about the pandemic containment. The situation reports n 62 (WHO) posted: 292,142 confirmed cases and 12,784 deaths ($global\ fatality\ rate \sim 4,4\%$) in the World. In China 81,498 cases, 82 new cases, 3,267 deaths and 6 new deaths ($fatality\ rate \sim 4\%$), Republic of Korea 8,897 cases and 104 deaths ($fatality\ rate \sim 1,2\%$) and Italy 53,578 cases, 6657 new cases, and 4,827 deaths, 795 new deaths ($fatality\ rate > 8\%$).

Several approaches have been outlined also following several, alternative appraisals of the evolution of the virus. The main point is that the coronavirus has generated distinct effects in different countries and on different parts of the population in different periods: some people show no symptoms but turn to be able to actively spread the virus; other people show very weak symptoms similar to a normal flu; other people show symptoms similar to an aggressive flu; a small part of infected people need critical assistance for pneumonia (about 10% need intensive unit care) and a smaller size of the population (WHO estimates about 3%-4%) faces deadly consequences.

Such an incredible variety of effects has indeed generated a remarkable delay in policy interventions. This variety has generated ambiguous policy evaluation in many countries based on the potential effects of the virus on the single individual health rather than on the social impact of the critical exposure of a significant part of the population (about 10% of infected people) on the sustainability of the national health systems in terms of providing medical equipment and care for critical treatments.

On the contrary, the variety of the expected effects should have suggested the deployment of a package of selective measures targeted to the different parts of the populations exposed to the virus according to the evolution of the same. This means acknowledging that it is possible to design, at the same time, different measures in different parts of the national territory according to the local evolution of the contagion.

One of the main policy points to be addressed refers to the sustainability of the national health system to cope with an increase of infected people needing, at the same time, intensive unit care for critical pneumonia. In this, respect, WHO suggested as a best reaction strategy, that of slowing down the size of the contagion in a given period of time.

Three main stylized models of the outbreak management have emerged so far to slow the outbreak: The "Asian model", the "Italian model" and the "English model". China is not considered because of it is the country where the virus originated and other specific, political and social, peculiarities make its practices nonrecoverable.

All these models share the existence of strong national health services, have experienced previous outbreaks (avian and swine flu, BSE-vCJD), have test, isolation and treatment protocols.

6.1 The "Asian model"

South Korea and Singapore, that experienced an epidemic of SARS in 2003, were early invested by CoVid-19 outbreak, at the end of January. Their strategy against the CoVid-19 was simple and can be summarized with the words of Kim Dong-hyun of the Korean Society of Epidemiology: "from the containment phase, we tried to implement case isolation and case tracking, and this was done in a very aggressive manner".

In February and for long South Korea (51 mil of inhabitants) had the high number of confirmed cases outside the China. Republic of Korea's strategy was based on testing large numbers of people in an attempt to identify infection 'hotspots' and 'special care zones' where were located extra medical supplies and staff and realized specific disinfection policies. Republic of Korea tested 15,000 persons a day or about 320,000 citizens, i.e. 35-37 tested per confirmed case, free of charge. Then confirmed cases were put in quarantine, monitored and tracked down by smart phone alerts. Singapore reinforced the tracking of affected people by using CCVT and introducing a fine of up to $10,000 or up to six months in prison, for breaking quarantine order. At the same time Singapore introduced financial support for people who are isolated: up to $100 per day for self-employed workers and government facilities for people not self-sufficient.

On 21 March 2020, Republic of Korea had 98 new (daily) cases, and 2 new deaths. Singapore 432 confirmed cases, 40 new cases, and 2 total deaths.

As a consequence the "intrinsic growth rate was estimated at 0.6 (95% CI: 0.6, 0.7) and the scaling of growth parameter was estimated at 0.8 (95% CI: 0.7, 0.8), indicating sub-exponential growth dynamics of COVID-19" (Shim et al 2020). Then ordinary life have not changed and everything is almost equal to before the CoVid-19 outbreak.

6.2 The "Italian model"

Italy was hit by the CoVid-19 outbreak in mid February, but very likely the virus was spreading in some Regions since January: Lombardy, Veneto and Emilia-Romagna (new industrial triangle). Occurrence of the epidemic in North Italy does not appear a chance but it has been envisaged as the probable consequence of the commercial inter-connections and relationships (supply-chain) between those Regions with China. The same destiny hit industrial regions (landers) in Germany, i.e. Bavaria, and France. In the new Italian industrial triangle the exports/GDP rate is 40% similar to some German landers one. This common aspect shed a light about the disease carriers: businessman were the modern sailors and traders, who spanned the CoVid-19 disease, not tourists. Crucially they violated the travel ban by triangulation with other countries and spread the CoVid-19 in North Italy.

Italy first introduced a ban for direct flies from China, then tested symptomatic people, and introduced quarantine for confirmed cases and hospitalized severe and acute patients. From the beginning there was a difference (anomaly) with respect to Asian countries: a very large number of deaths, three time China's rate of mortality. These measures failed in preventing and containing the spread of CoVid-19. More severe measures for containing the outbreak were introduced: social distancing and complete lookdown areas (11 municipalities in Lombardy and Veneto). Nevertheless the outbreak did not slow, then the Italian Government closed school and universities and suggested use of smart-working everywhere was possible. All these measures appeared to be ineffective and CoVid-19 disease rapidly spread over the country. On 10 March, the situation was: 9,172 total confirmed cases, with 1,797 new ones, and 463 total deaths, with 97 new ones. Italy was declared 'protected area' and then any non essential commercial activity was closed, people invited to stay at home and travel discouraged or forbidden. New measures appeared not sufficient to break the exponential diffusion of the outbreak. On 22 March 2020, Italy registered 5,986 new confirmed cases and 625 new deaths. What is worst intensive care units (IUCs) collapsed, ventilators for UIC were scarce and masks depleted, also for doctors and nurses.[7] Moreover some Regions in South Italy faced the nightmare of an unmanageable situation because of uncontrolled escape of people from North Italy.

Only on 22 March 2020 some change in the rate of contagion was registered with a drop at 10% of the daily increase. Dowd et al (2020) analyze the combination between this strategy of containing and tackling of the Covid-19 outbreak and another peculiarities of the Italian population could overflow severe and critical cases and increase the case fatality rate. Italy has one of the oldest population in the world and it is characterized by particular social habits: close inter-generational relations, extensive commuting between North and South of the country, coresident or proximity among clan and families. Dowd et al consider age structure and intense social network relevant in "COVID-19 transmission chains that begin in younger populations may have a low number of severe cases and thus go longer undetected with countries thereby slow to raise the alarm". Dowd et al set that "once community transmission is established, countries that have a high level of inter-generational contacts and coresidence may see faster transmission to high-fatality age groups as seen in Italy".

Given CoVid-19 basic reproduction number $R_0 = 2,5 - 3$ and a case fatality rate equals to $3\% - 4\%$, assuming that actual anomalous Italian case fatality rate covers a large number of asymptomatic and unconfirmed cases (Italy only tested 3-5 people per confirmed case), the CoVid-19 trend in a business as usual (BAU), i.e., 81% none or light symptoms, 14% with serious symptoms and 5% with severe or critic symptoms, assuming the UK estimation of 40 millions of infected people, could induce some million of hospitalized people and hundred thousands of deaths.

Date about the CoVid-19 outbreak put in evidence that France, Spain and Germany retraced the Italian steps.

6.3 The "English model"

On 13 March 2020, the UK Government concluded that a severe epidemic disease was inevitable and impossible to contain it. They expected that 60% of the population to become infected and build herd immunity through the wild virus.

[7] "In Italy between March 1 and March 11, 2020, has consistently been between 9% and 11% of patients who are actively infected. The number of patients infected since February 21 in Italy closely follows an exponential trend. If this trend continues for 1 more week, there will be 30 000 infected patients. Intensive care units will then be at maximum capacity; up to 4000 hospital beds will be needed by mid-April, 2020" (Remuzzi and Remuzzi, 2020 Lancet).

They abandoned population testing and contact tracing to identify and seclude clusters of infections; they recommended only testing cases in hospital, self-isolation for people with symptoms and people older than 70 years. A secret document of the Public Health England reported by The Guardian (15 march 2020) sets that the coronavirus epidemic in the UK will last until next spring. Because of the pandemic disease as many as 80% of the population are expected to be infected with Covid-19 in the next 12 months, up to 15% (7.9 million people) may require hospitalization, 2 mil of persons in IUCs and more than 500 thousands of deaths, with a case fatality rate of 1%. If the mortality rate is higher deaths could overcome a million.

The UK strategy appeared as a bet against Nature, a very uncertain and dangerous lottery that could conclude with a catastrophic loss, at least, but more likely end with the apocalypse.

On 22 March UK had 5,683 cases with 665 new ones and 281 deaths with 104 new ones, case increased 5 times and deaths increased 26 times in a week, only. As a consequence the UK Government partially back away from its own plan and set to close schools, universities, restaurants, theaters, etc. Just as the UK Government announced new measures, Dutch adopted controversial 'herd immunity' strategy. The Netherlands will aim to develop immunity to CoVid-19 among its population by allowing large numbers, those are considered least at risk, to contract the illness at a controlled pace. Given an epidemic dynamic similar to the English one, the Dutch Government was betting on a smooth epidemic curve among groups assuming a natural capacity to contrast the virus, but if Covid-19 reproduction number does not collapse to less than 1, without targeted antiviral and vaccine the epidemic is out of control.

7 Concluding remarks: selective interventions and the need of mixed strategies

In the actual situation of the pandemic CoVid-19 outbreak, the Asian model (best strategy) cannot be applied at least in countries in which the number of confirmed cases is large and spread on the ground. In fact, it well known that positive cases are only the emerged part of the iceberg, about 30%-50% of infected people, so that monitoring and strict quarantine of ill persons are impossible. We think that to flatter the contagious curve, in countries with an explosive outbreak induced by an exponential growth trend in some clusters and a sub-exponential growth rate elsewhere, the best strategy is a combined strategy. In hotspots with exponential growth rate of infected persons, where generalized test procedure is not possible because of large population (millions of inhabitants), experience shows that contagious could be spread by some type of professions: doctors, nurses, policeman, priest, nuns etc. Many scientists think that some hospitals in Italy, such as Codogno, Casalpusterlengo and Lodi, acted as amplifiers in the spread of Covid-19, at the beginning of epidemic. Facing uncertain and incomplete knowledge, all those groups of people should be tested, of course symptomatic persons and close friends and relatives, also. Testing a large number of people could require mobile clinical laboratories, such as in South Korea, but to overcome this lack Governments could convert all the private clinical laboratories, i.e. they are thousands in Italy. Positive people should be put in strict quarantine. At the same way, elderly, older than 70 years, should be quarantined, in order to prevent the collapse of UICs in hospitals. Schools, universities and any non essential commercial activity have to be closed, people forced to stay at home, measure of social distancing reinforced, in order to prevent a "squeezed 'sandwich' generation of adults who care for both the old and young", and travel discouraged or forbidden. Quarantined people should be monitored and tracked with fine and imprisonment for violators. For staging emergency hospitals and avoiding shortage of essential medical devices, factories should convert production lines to manufacture vital and essential tools, such as ventilators and masks (ffp3 mask should be distributed to population because is only way to break the contagious among humans when they go to markets or crowed place). Military personnel used to facilitate essential production and disinfect streets and places. Finally, the Governments should introduce financial support for people who are isolated, for self-employed workers and facilities for people not self-sufficient.

The adoption of some form of the PP entails comparing ex-ante specific costs of prevention (and somewhat deterrence) with the ex-post total costs of the management of the health emergence and economic and social recovery.

There are some rational operational rules based on non expected utility theory able to evaluate costs and benefits of alternative measures under scientific uncertainty, irreversibility and extreme events. These new coherent approaches are suitable implementations of the precautionary principle and give more realistic scenarios to choose best strategies in dynamic and ambiguous situations, such as CoVid-19 pandemic.

Pandemics further magnifies the risk and the opportunity costs of neglecting the PP as it generates a "tragic outcome" that actually is a mix of "tragedy of the commons" and "tragedy of the anti-commons". Indeed, on the one side each country coming later in the chain of the pandemics may free ride to some extent on the measures adopted by other countries to stop the contagion. On the other, absentia supranational coordination upon the policy measures adopted by each country, may actually weaken or outweigh, the efforts made at national levels.

The European approach, in this respect, has been so far, almost nonexistent. Germany and Italy have been the first European countries registering some contagions, while Italy in one month reached a level of deaths greater than China. Italy called first for local and then for national lockdown. It seems that much more local lockdowns were needed in order to avoid further spreading of the virus. Other European countries seem following the same path.

One lesson that does emerge is the need of a comprehensive policy package: (i) supranational coordination; (ii) selective local lockdowns; (iii) strict monitoring and inspection of people movement for at least a short period of 3-4 weeks (also through personal data collection under public control and fulfillment of GDPR constraints and rules); (iv) specific and selective single quarantine (using for instance hotels); (v) massive use of test (pharyngeal swab) in order to detect people to be shifted to quarantine.

There is no just one policy solution for the pandemic containment. Our proposal is to design a comprehensive policy approach by taking stock of the main lessons learnt so far from different national experiences

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