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CAT bonds and Pandemic bonds: the World Bank unique experience and the new challenge for the Insurance Industry

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Executive Summary

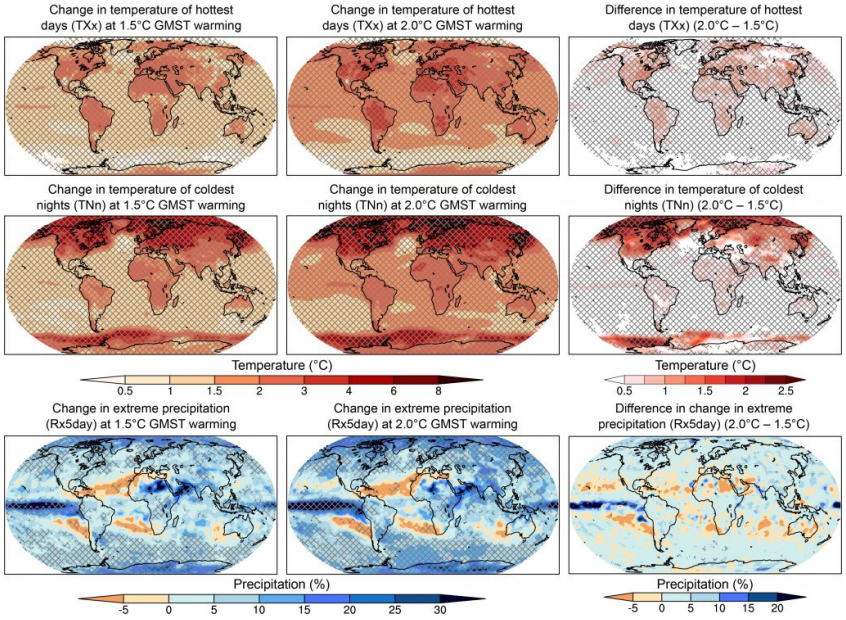
The occurrence that the recent - and still current- epidemiological emergency from COVID-19 may strongly impact the financial and economic systems was the starting point of this thesis. Until nowadays, no specific analyses have been presented on pandemic risk and their repercussions, but essential investigations have been carried out in a more general context. Therefore, this thesis's objective is to provide an accurate analysis of pandemic risk, which has become a consistent risk to take into consideration and the impact it has over economies, aiming at comprehend if CAT bond models could also be used in the context of a pandemic outbreak. In an attempt to investigate this subject in-depth, the methodology adopted for this thesis project conceives, given the lack of bibliography on the topic, also the analysis of original documents of the Pandemic Emergency Financing Facility (PEF) from the World Bank, with the addition of a series of qualitative questionnaire and interviews (some of which are reported together with the elaboration with the authorization of the interested parties), conducted with leading figures in the insurance and financial sector, whose experience with the treated topic helped in the detailed analyses of what were not only the positive aspects, but also, and above all, the problems that the CAT bond structure presented, and how the capital markets and the insurance world could (and should) evolve in the light of the new awareness the COVID-19 has brought.

Climate change and climate hazards.

In this context, the initial question focused on the relationship between climate change and climate hazards, trying to assess and understand what was the context from which CAT bonds were born, what was their history and their application, and then inquired about how the pandemic risk could be compatible with the use of CAT bonds.

Climate change as a consequence of the rising of average global temperatures is an issue that humankind must no longer neglect, being the human race its primary cause. According to forecasts, with the current rates of concentration of all greenhouse gases, there would inevitably be an increase of about 0.1 degrees per decade. By 2050, CO_2 levels present in the atmosphere would likely be more than twice as high as the pre-industrial levels (estimated 550 parts per million dry air particles), already reaching the threshold in 2035. Climate change is a non-linear and systemic phenomenon, affecting different regions in many different

Figure 1- Projected changes in extremes of global warming compared to the pre-industrial period (1861–1880), and their difference.



Source: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty

manners, and the effect on capital (intended as human, physical, and natural) could either be mild or catastrophic. Catastrophes can either been seen as a natural process, as well as a result of human activity. However, the disruption of environmental systems and the deterioration of climatic conditions have strong repercussion over our economies (suffice to say that a 10 percent increase in the wind speed corresponds to a 150 percent increase in damages), causing consequently heavy damages and losses to whom reinsurance and insurance companies are struggling to answer. The analysis of the inherent risks of climate change is essential to better assess the impact over the socio-economic systems and, as a result, over the human race.

According to a McKinsey Global Institute research study, by 2030, the probability of living in a region at risk and experiencing a lethal heat wave at least once will be 60 percent. If no immediate action is taken to counter these estimates, annual climate change losses will amount to 5 percent of global GDP. If historically, these phenomena have always been defined rare, today we can no longer claim so. From a statistical point of view, an average day is warmer and extremely hot days are more likely to occur; in the past, extreme episodes of precipitation were perceived with a probability of 2 percent, while today they are considered regular events and, moreover, although hurricanes have always been perceived as phenomena with an incidence probability of 1 percent, in some parts of the world they could triple by 2040. By 2100, the region's economic losses are estimated at 7.3 percent of local GDP.

Origin and development of CAT bonds.

Consequently, the overall financial sector's role is more important than ever in this framework, thanks to their ability to allocate large amounts of capital to sustainable development projects. Equally important is the role that insurance companies play in this situation. The insurance sector is related to the theme of climate change and climate hazards, both in terms of losses and mitigation initiatives.

Although the (re)insurances help with the recovery, by transferring the covered risk, the traditional post-disaster assistance system is proving to be inefficient and ineffective, discouraging even to adopt preventive actions against climate risk. The insurance industry has a central role in building socio-economic resilience by contributing to risk information and risk pricing expertise and offering innovative risk transfer products and services. The booming demand for natural catastrophe insurance resulted in an increased need for new reinsurance capital. As a result, a new financial instrument called "catastrophe bond", or CAT bond, has been created.

In 1992, Hurricane Andrew hit Florida and the Gulf Coast, causing US$27 billion of damages. Due to the magnitude of the consequences - which led to the failure of different insurance companies and the almost collapse of the entire industry in the United States - and the increasing frequency of natural disasters, institutions have tried to manage this specific set of risks that may disrupt economies all over the world indistinctly. CAT bonds represent an original financial instrument solution that helps not only to transfer catastrophic risks to the capital market but also relieve a considerable share of the significant losses caused by natural disasters: in 2014, environmental damages amounted to US$110 billion globally, 31 of which ensured; a declined, compared to the US$140 billion of 2013. CAT bonds and catastrophe insurance programs were born from the need to mitigate some of the risks the insurance industry face when major catastrophes happen. Despite the important drop reached in 2017 - due to Hurricanes Irma, Harvey, and Maria - new CAT bonds issuance at the beginning of 2018 amounted to US$9.4 billion. Extending CAT bond modeling to cover other risk forms is one of the insurance industry's objectives nowadays. Formally, it is not the (re)insurance agencies that issue these bonds directly. Instead, a Special Purpose Vehicle is created, where the claimhoders automatically became the SPV's sponsors. The risk is then transferred from

the latter to the investors, who will receive regular payments if no predefined event occurs for the bond duration. If, however, a catastrophic event should happen, interests and principal will be lost and donated to the payment of damages incurred by the claimholders.

These instruments are implicitly highly risky, usually with a BB rating; however, they find consensus from all parties because they allow insurance companies to offload much of the catastrophic risk from their portfolios, enabling investors to diversify their portfolios, since they are dependent on the probability of a catastrophic event occurrence, hence are uncorrelated with other risks, and offer very high rate of return.

Climate change and pandemic risk.

A further less investigated consequence of climate change and human action over ecosystems is the increased frequency of new infections. The human race always requires more and more resources to meet its needs. However, the pressure (e.g., deforestation, road and infrastructure construction, increase in agricultural land and pastures, mining, increased urban settlements and land consumption, pollution) we exert on our planet also has consequences for our health. According to recent studies, deforestation, for instance, is recognized as the cause of 31 percent of epidemics in the last two decades.

The human race is not foreign to diseases, especially since it began to organize itself in increasingly complex societies. Pandemics have been occurring, since the 16th century, at irregular intervals, more or less between 10 and 50 years, with various degrees of severity and with several effects on societies, as well as with an unpredictable trend. In recent years, there has been an increase in the frequency of the various pandemics. Since 1918 there have been four pandemic influences, plus the persistent acquired immunodeficiency syndrome.

However, only in the modern age have we begun to pay more attention to the pace of epidemics and pandemics. COVID-19 is only the last episode which humanity had to face. Started as a localized epidemic in China, in Hubei Province, the virus has been able to travel with speed also helped by several distinctive characteristics of our society: population growth and demographic adjustment, globalization and increased mobility, enhanced and changed interactions between humans.

While the insurance industry has learned, over the years, to manage catastrophic risk to offload part of that risk onto the capital market, it also omitted an important catastrophic risk out of the picture, which is pandemic risk.

Truth be told, pandemics and natural disasters certainly have similarities in their effects over societies and have substantial differences in their intrinsic characteristics.

A significant difference could be seen in their life cycles: natural disasters such as hurricanes have very well-timed life phases, with a limited duration. In total, a hurricane has a maximum life span of 10 days. For pandemics, the issue is quite different. First of all, we talk about life cycles ranging from several months to several years. Besides, the evolution of a pandemic is closely related to the characteristics of the original virus. Some viruses, such as Ebola, evolve, once attacked a host, with rapidity, and sometimes even enough violence to not allow the virus to spread quickly. Other times, as in the case of HIV or even, albeit differently, COVID-19, the conditions for transmission between humans are more complex, and the virus itself has a slower evolution.

Furthermore, if a hurricane is essentially born, it grows, and then dies, a virus, especially if it is of animal origin, does not follow this cycle. A virus that has not been eradicated by man thanks to vaccines, once the contagion curve has lowered does not disappear. Rather, it manages to hide, sometimes even to evolve, on a host organism of animal origin until the occasions of contagion between animal to man (and then between man to man).

For pandemics, we refer to four phases: the inter-pandemic phase, the alarm phase, the pandemic phase, and, finally, another inter-pandemic phase.

Another essential difference between the two phenomena, and perhaps the most relevant for this research project, is the range of action that hurricanes and pandemics present. As for any other natural catastrophic phenomenon, if hurricanes remain concentrated in some geographical regions, pandemics, as the name suggests, are not localized phenomena (nor can be localized). The word pandemic comes from the Greek, more precisely from the adjective πανδήμιος, a union of two words (παν, "all" and δῆμος, "people") which literally means "of all people". The European borders, especially the western ones, have optimal conditions for the transmission of a pathogen; at the same time, however, the European countries are among the best-equipped countries to cope with the spread of disease. Therefore, they can react promptly; on the contrary of African countries, which suffer greatly from the lack of an efficient health care system.

Table 1- Natural Disasters vs. Pandemic Outbreaks

	Hurricanes	Pandemic outbreaks
Life Cycle	Finite	Infinte Viruses' intrinsic characteristics
Rage of action	Localized	Global

It is, therefore, challenging for insurance companies to design a product suited for pandemics. The potentially infinite geographical distribution is further exacerbated by the lack of historical data which would allow to develop statistical models.

However, as recent reports unfortunately show, (re)insurance agencies also suffer significant losses when dealing with a pandemic, especially when accompanied by government measures to contain the contagion. In particular, the market is subject to a sharp increase in claims for business interruptions, travel cancellations and event cancellations. In May 2020, Lloyd's announced that the industry's losses from COVID-19 were estimated at $200 billion and more. According to estimates, present business interruption premiums in some markets would need to be collected for over 100 years to cover just two months of COVID-19-relate business interruption cost.

Pandemic bonds: the (single) case of the World Bank.

Can CAT bonds, therefore, be a model for also covering the pandemic risk? Back in 2016, after the latest spread of Ebola, the World Bank adopted catastrophe coverage models to launch a pilot project for financing pandemic outbreaks' recovery focused on the least developed countries, the Pandemic Emergency Financing Facility (PEF). With the use of two windows, an insurance window and a cash window, PEF provided coverage up to US$425 million to spread of certain families of diseases that are most likely to spark epidemics - such as pandemic influenza SARS, Ebola and the Coronavirus family. The PEF provided US$50 million in cash immediately available to address the possibility that one country could not qualify for the insurance window. While the cash window was completely donor-based, the insurance window adopted the CAT bond structure, allowing the World Bank to issue two pandemic bonds, a Class A and a Class B Note with respectively the value of US$225 million

and US$95 million. The principal paid by investors, consisting mainly of dedicated catastrophe bond investors and pension funds, was kept in an ad hoc fund. If certain conditions, including the WHO's declaration of an ongoing pandemic, were met, then the entire principal and the related interests would be retained to allocate the recourses to the world's poorest countries.

Table 2 - Pandemic Bonds Summary Terms and Conditions

	Class A Note	Class B Note
Issuer	IBRD	IBRD
Sponsor	Pandemic Emergency Financing Facility	Pandemic Emergency Financing Facility
Placement/ structuring agent(s)	Swiss Re Capital Markets; Munich Re Capital Markets, GC Securities	Swiss Re Capital Markets; Munich Re Capital Markets, GC Securities
Issue Price (100% of Aggregate Nominal Amount)	US$225 000 000	US$95 000 000
Issue Date	July 7, 2017	July 7, 2018
Maturity Date	July 15, 2020	July 15, 2021
Rate	NR	NR
Risk Modeling/ calculation agents	AIR Worldwide	AIR Worldwide
Bond Coupon	6m USD LIBOR + 6.50%	6m USD LIBOR + 6.50%
Covered Disease	Flu, Coronaviruses	Filovirus, Coronavirus, Lassa Fever, Rift Valley Fever, Crimean Congo Hemorrhagic Fever
Trigger type	Parametric	Parametric
Redemption Amount	The Notes will not be fully repaid id the an even occurs	The Notes will not be fully repaid id the an even occurs

Source: World Bank, 2017

Limits and advantages of the two instruments.

The qualitative interviews conducted to pursue this thesis's aim have allowed an analytical comparison between these two instruments, CAT bonds and pandemic bonds, highlighting the common characteristics, strengths, and weaknesses of both and how to improve them in the future.

CAT bonds were born from the need to allow (re)insurance companies to transfer catastrophic risks from their balance sheet to the capital markets. Furthermore, these instruments have proven over the years to be an effective and efficient risk transfer device. The CAT bonds' market has demonstrated a solid amount of resilience and robustness; however, its performance could also be claimed fluctuant, as they are strictly connected with the occurrence of a natural disaster that makes them return in vogue. Despite some difficulties encountered during the financial crisis of 2008, due to some bonds linked to assets issued by Lehman Brothers, the market is recognized by all as a growing market, especially in the developed countries, and all estimates seem to agree on a positive trend also for developing countries.

In Italy, the insurance-linked market is behind compared to the rest of Europe or the rest of the World. To some, this is due to a low development of the sector on our territory compared to other European countries. Nonetheless, the Italian market also registers positive signs of a market expansion, since almost 5 percent of households and businesses have now purchased a catastrophic risk coverage, compared to the almost zero values of a few years ago.

However, interviews revealed that one of the CAT bonds market problems is the limited size of potential buyers. CAT Bonds are mostly purchased by specialized Insurance-Linked Securities (ILS) investors or by pension and hedge funds. Insurers feel the pressure to expand the market, stimulating the interest of other institutional investors. An important turning point for the development of the market would certainly be the public sector's involvement, as States should strengthen their exposure to catastrophic risks by incentivizing the creation of public-private partnerships. Some countries already envision the collaboration between private and public sector, like the French *Caisse centrale de réassurance* (CCR), government entity supported by an unlimited government guarantee, which provide reinsurance coverage for the *Gestion de l'Assurance et de la Réassurance des risques Attentats et actes de Terrorisme* (GAREAT).

However, one of the most critical aspects of CAT bond is constituted by some pitfalls in its structure. The CAT bond is essentially a collateralized derivative and the link to the probability of an event occurring, which is difficult, almost impossible to predict, is considered a major critical aspect. Extreme events, even currently, are considered rare and unpredictable, their probability of occurrence depends on historical data. In the unlikely event of a specific natural disaster occurring during the term of the bond, part or even the total amount of the assets held as collateral are immediately liquidated and transferred to sponsors. There exists different types of triggers; still, the most used are:

1. the indemnity trigger, which resemble traditional reinsurance, enabling the bond to payout when the insurance company's actual collaterals each the bond attachment point. Unfortunately, these triggers require from two to three years to repay claimholders;
2. the industry loss trigger does not consider the insurer's basis risk, and it bases payouts over an index estimates on aggregate losses, requiring the involvement of a third-party modeler but enabling a faster repayment;
3. the parametric trigger, which is also used for the World Bank's pandemic bonds, covers any losses related to an event based on the probability that that event will occur. The insurer has to select a parameter constituted by an objective measure, strictly related to the specific risk the customer is facing and to the subsequent financial loss. Parametric triggers have to be easily measurable, but, most importantly, quickly and effectively reported;

The World Bank's pandemic bonds were created following the CAT bond structure pattern. As a result, they have reasonably inherited the critical issues that CAT bonds still present.
The choice to adopt a parametric trigger was strongly criticized in the aftermath of the COVID-19, considering the required triggers too severe and restrictive with respect to how a pandemic evolves.

Moreover, if for earthquakes and hurricanes we can count on a robust and extensive historical database dating back 50 and even 100 years, the same argument does not apply to pandemics.
The COVID-19 is the fourth coronavirus in ten years, we are at the fifth major pandemic since 1918 until now, nevertheless so far no one understood that there was a need for a

standardized, clear and transparent system of statistical collection of data on diseases outbreak.

This lack is also due to some important factors, which must be taken into account. First of all, most pandemics arise and develop in underdeveloped countries, where the communication and collection of these data presents objective difficulties and doubts. Third world countries have less capacity than other countries to understand and determine the extent of risk in a timely manner.

It must also be taken into account that a disease requires certain characteristics in order to spread, as we have already seen. In many of the countries where these epidemics originate, movement, and therefore interpersonal relationships, are almost difficult, if not almost impossible. In African countries there are very frequent outbreaks of future pandemics, but the lack of movement means that these episodes remain isolated and localized in certain regions. Viruses such as Ebola, which evolve in a sudden manner, often leading to the death of the victim within a short time from the first symptoms, are therefore difficult to move quickly.

To calculate the ability of a virus to propagate, and, therefore, its probability of occurrence, these factors are crucial.

Table 3 - CAT bonds vs Pandemic bonds

	CAT bonds	**Pandemic bonds**
Structure	Lack of trigger transparency	Inherent lack of trigger transparency
Statistical model	Based on historical data	Lack of historical data, lack of a standardized and organized data collection process and of statistical models
Market	Limited market interest; Potential growth	Limited market interest; Potential growth

Repercussion of COVID-19 over the Insurance Industry.

We are experiencing one of the greatest events in the history of humankind. While the main focus is to address global health, the resulting economic situation is still a significant and urgent emergency that policy makers should be addressing. In advanced economies, economic activity is expected to decline by 7 percent this year and all experts agree that this will be the worst recession since World War II. The economic shock caused by the pandemic is considered by all means systemic and symmetrical. Little use is made of estimates of costs, which probably will not be able to describe the future situation, since the COVID-19 pandemic is still ongoing. The insurance industry has also experienced losses and difficulties. According to Lloyd's, the insurance company paid out claims related to the COVID-19 pandemic for about £2.4 billion, and is expected to reach £5 billion in reimbursements, of which the reinsurance market covers only £2 billion.

The truth is that there is an enormous amount of uncertainty at the moment, and the volatility of the stock market is impacting both the assets and liabilities side of the insurance companies. Traditionally, the insurance industry when dealing with pandemic outbreak have focused on providing customers with life-insurance coverage. However, as has happened after Hurricane Andrew back in 1992, COVID-19 had actually revealed an important protection gap, the Non-Damaging Business Interruption Insurance (NDBI), which has not been considered by the insurance industry since now. The risk has evolved and changed its profile, shifting clients' demand. Currently, the greatest problem is represented by the interruption of non-damaging activity caused by governments' containment measures.

De facto, protection against business interruption is already provided in some jurisdictions, usually as an optional coverage and mainly triggered by physical damage. Beside, while in the event of an earthquake, fire or hurricane, property damage is quantifiable and objective, it is difficult to quantify business interruption losses incurred due to an epidemic.

Since scientific evidence reports that pandemics will become, like natural disasters, a recurring phenomenon, it is important to start discussing now how to develop this market. Positive signs in this sense seem to be coming from all countries, which in these hours are developing projects to prevent a new wave of COVID-19 and future pandemics in the not so distant future. For instance, in France, there is a proposal to establish an insurance program, CATEX (*catastrophes exceptionnelles*), with the French government's collaboration to cover

business interruption losses caused by catastrophic events. This proposal overcome the problem constituted by the parametric trigger of the World Bank's pandemic bonds, because it requires a state administrative action, resulted in the closure of businesses in a given geographic region for a specified amount of time, applying to both businesses directly and indirectly impaired by the administrative order in order to activate payments.

Conclusions.

To conclude, some considerations are to be made for the future, stemming from the new awareness COVID-19 has provided. Although the PEF was originally designed to respond to several viruses, it is clear, unfortunately, that in the case of COVID-19 the system created by the World Bank is not sufficient to capture the evolution of a pandemic over time, having been built on the basis of the Ebola virus, which presents very different characteristics. If new products are to be made, then it is important to better capture this aspect. In addition, when facing an epidemic, the rapid communication of information and data about the epidemic helps to contain economic losses. For this reason, it is argued in this work that there is need to construct a standardized collection of data on diseases, epidemics and pandemics which would enable the construction of a more sophisticated statistical model to use for the determination of the parameter to adopt.

The situation we are currently experiencing has also made clear to everyone that the private (re)insurance sector alone could not sustain the costs of a new pandemic. The pre-financing required to cover the estimates we see today amounts to figures that the private system is unable to provide.

From this point of view, everyone agrees that the ideal solution would be to establish a public-private dialogue for the realization of a partnership, arguing that it would also be the right incentive to develop this new pandemic bond market. For the Euro area, it will be important to discuss the topic also in terms of a shared resilience solutions.

Many are questioning themselves wether to impose this new type of coverage or let SME businesses decide whether or not to acquire it. This is a difficult decision, because, on one hand the obligation would allow the risk pooling necessarily to strengthen the insurance coverage, however, pandemic risk is still considered a remote risks and SMEs do not have the capacity to acquire this type of coverage. Besides, another important issue to consider is the

pricing of insurance premium. If coverage were available at the current status, the price of premiums would be significant, especially for the small and medium enterprises, which are the most affected so far. Also for this reason, a collaboration with the public sector would allow the affordability of the coverage. From an European perspective, initiatives to create a shared resilience solution against pandemic risk are already being discussed; however, this thesis argues that, even though a pandemic is not a localized phenomenon, it would be appropriate for countries to adopt instruments designed to act in a localized manner, taking also in consideration lockdown measures' effects.

Apparently the only mitigation solution to adopt when facing pandemic risk is the increase of preparedness. One of the most important problems the COVID-19 have highlighted was how the western countries were, after all, poorly organized in terms of hospital facilities, and highly vulnerable to the spread of a disease. Hence, it is compelling to finance investment in the health system, for instance, by investing in hospital fields and medical equipment in case of a pandemic outbreak.

Answering to the question if the pandemic bonds were an efficient instrument against the pandemic risk is, in light of the research and the analysis conducted, complex. First of all, an important premise is that PEF's pandemic bonds are the first financial instruments which attempted to capture the pandemic risk and transfer it on the capital markets. Hence, it obviously paid the price of being the first. It was based on CAT bonds' structure, which comprises some problems, and once therefore included the same pitfalls in its own structure.

Among other things, the ultimate goal of the PEF as a World Bank's program was to raise public awareness, it was a vehicle for discussion that also intended to include the private sector, so as to encourage the development of new products. From this perspective, we could say that the PEF has failed. The world had continued to consider the pandemic risk as a rare risk, not enough significant to built a market on its premises. Four years later this belief was proved wrong, and now everyone is discussing on how to prepare for the next COVID-19 wave or the next pandemic outbreak.

Nevertheless, it must be said that pandemic bonds were built to pay out to the least developed countries when a pandemic was officially declared, to financially help them implement their preparedness plans. The African countries, on which the project was focused, have been shown to have intrinsic characteristics of the territory that disadvantage the spread of a

disease, but also that, from this point of view, the project of the World Bank has been successful, going to finance governments to cope with the emergency.

Introduction

This work was born and has developed from an original idea to produce a thesis on the financial instruments in support of environmental policies (the so-called g*reen investments*). During my course of study, the topic seemed to me worthy of development and deepening because it was intimately connected to the current global debate on climate change and how it will affect societies and the world economy of the future.

The temporal coincidence of the start of the work with the worldwide explosion of the coronavirus epidemic (COVID-19) inevitably inspired the opportunity to divert the original project towards the theme of catastrophic risks, particularly those induced by the spread of pandemics and viral diseases.

This inevitable suggestion was shared with the supervisor of my thesis, Professor Federico Merola, whom I thank for his encouragement, suggestions and support.

The connection between economic studies and environmental and natural factors of specific magnitude, such as a pandemic, is not part of the consolidated tradition of economic-financial studies. This may have been due to an instinctive tendency to consider the economy as a separate structure from the canons of social living, which can be somehow regulated regardless of events that affect the foundations of human life.

The initial effects and prospects that manifested themselves on the economy at the outbreak of the COVID-19 epidemic have made evident, on the contrary, the importance of fundamental human events as components of the economic-financial systems.

Human beings are not extraneous to pandemics. On the contrary, the relationship between the human race and disease is ancient and dates back to the early beginnings of human society. The word pandemic comes from the Greek adjective πανδήμιος, a union of two words (παν, "all" and δῆμος, "people") which literally means "of all people". The meaning we give today to the word pandemic is "epidemic with a tendency to spread everywhere, i.e. to rapidly invade vast territories and continents".

In the first part of this study, the focus would be over the analysis of the literature on CAT bonds, which aims to retrace the most important steps of its evolution since its birth in 1992 following Hurricane Andrew, together with an analysis of the structure and market of this innovative risk transfer instrument.

In the second part, the focus would shift toward pandemic risk and how human behavior is responsible of its increased frequency. Indeed, studies underline how climate change and disruption of the environment have increased nowadays the probability of an outbreak of a new disease, changing frequency from every 30-35 years to every 20-25 years or less. Thanks to globalization and the increased interconnectedness we experience on a daily basis, the probability of a rapid pandemic spread increases, as COVID-19 has shown. It has been estimated that economic damages exceed US$10 billion for each outbreak since SARS in 2003, which imply that assessing and mitigating this risk is becoming a significant element to take into consideration.

The third and final part of this paper will focus on an original analysis of CAT bonds and pandemic bonds issued by the World Bank on the basis of interviews, interviews and questionnaires by some of the leading experts in the Italian financial and insurance industry.

1. Chapter 1: Climate hazards and Catastrophe bonds

Global warming has been known to mankind since the late 19th century, but the human race barely ignored the problem until the beginning of the new millennium, when the relationship between carbon dioxide and climate change was even more evident. However, the problem of climate change is an issue that humanity has long neglected: only recently, in the last decade, this issue has been taken more seriously in consideration by governments and institutions, to the point that in 2019 the newly appointed President of the European Commission, Ursula von der Leyen, has introduced a new European program, the Green New Deal, finalized just to the transaction towards a sustainable economy.

Today, estimations say that, since the beginning of the Industrial Revolution, nearly 2.5 trillion tons of carbon dioxide and other greenhouse gases (principally, methane and nitrous oxide) has been released into the atmosphere[1]. CO_2 has the most permanent repercussions over the Earth's atmosphere: one third of CO_2 emissions could persist over one hundred years, and one fifth may endure in the atmosphere for over one thousand years. The concentration of CO_2 in the atmosphere has increased exponentially in recent decades, with record peaks in 2019.

This oversized increase in carbon dioxide emissions does not allow to our planet alone to dispose of the excess, with the most direct consequence of the increase in mean global temperatures.

On average, global surface temperature has risen roughly by more than 1.1 degree Celsius, since 1880[2]; and today warming rate is near 0.2 degree Celsius per decade.

The analyses conducted by NASA and the National Oceanic and Atmospheric Administration indicates that in 2019 global temperatures were the second warmest since the 1880s, second only to those of 2016. This designates the decade just ended as the warmest on record.

According to the forecasts, with the current rates of concentration of all greenhouse gases, there would inevitably be an increase of about 0.1 degrees per decade. By 2050, CO_2 levels in

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1 McKinsey Global Institute, *Climate risk and response. Physical hazards and socioeconomic impacts.* January 2020.

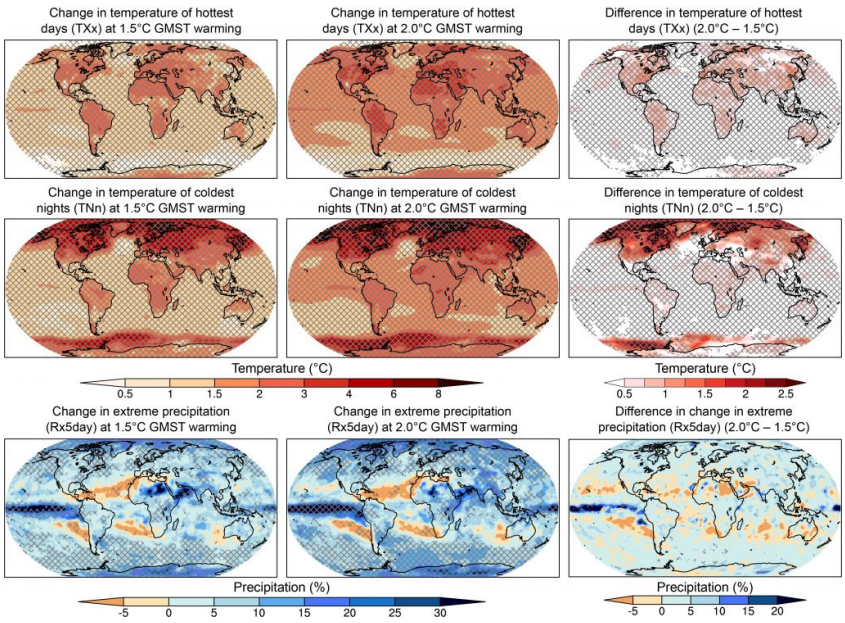
2 For reference, according to Nasa Goddart Institute for Space Studies, the last Ice Age was about 10 degrees Fahrenheit colder than pre-industrial temperatures.

the Earth's atmosphere would be more than twice as high as pre-industrial levels (estimated 550 parts per million dry air particles), already reaching the threshold in 2035.

One of the most obvious direct impact of climate changes is certainly the melting of glaciers, witnessed over the years, or the loss of biodiversity; not to mention desertification, which is spreading to regions with a temperate climate, such as the Mediterranean Sea area, causing significant damage to agriculture (it has been estimated that maize and wheat crops, for example, could fall by as much as 50 percent in the next 35 years). But climate change also has indirect consequences, such as the increase in migration, precisely because of changes in ecosystems.

The impacts of the increase of average temperatures differ in accordance to the different location of regions (extreme heat waves have different effects if they affect regions from temperate climates rather than cold). Furthermore, an increase in mean temperatures by 1.5°C or more entails, for some regions, considerable enhancement in the likelihood of the occurrence and/or increase in intensity of some extreme events, like hurricanes and storms.

Figure 1.1- Projected changes in extremes of global warming compared to the pre-industrial period (1861–1880), and their difference.



Source: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty

The main cause of these critical changes to the global ecosystems is imputable to human activity. The ever-greater empirical evidences of the impact that mankind is having on Earth's balances had led experts to define a new geological epoch: the Anthropocene.

Rising temperatures cause radical transformations to human and natural systems, with severe intensification of different types of extreme events, sea level rise, and biodiversity loss. Climate changes also had an adverse effect on the human species, creating great vulnerabilities especially when biophysical and socio-economic conditions encourage it. The most affected part among global population are the low and middle-income countries, which experience also greater difficulties in counteracting the consequences. On the other hand, there are various ecosystems around the world which are considered at risk of alarming repercussions, as megacities, coastal areas and high mountain ranges.

The absorption of CO_2, hence the increase in global temperatures, is further aggravated by deforestation initiatives. To maintain the same rate of the rapid population growth, the incremental need of higher consumption of animal products, and the higher demand for energy, over the centuries mankind has increased the appropriation of resources, exponentially decreasing the vegetation.

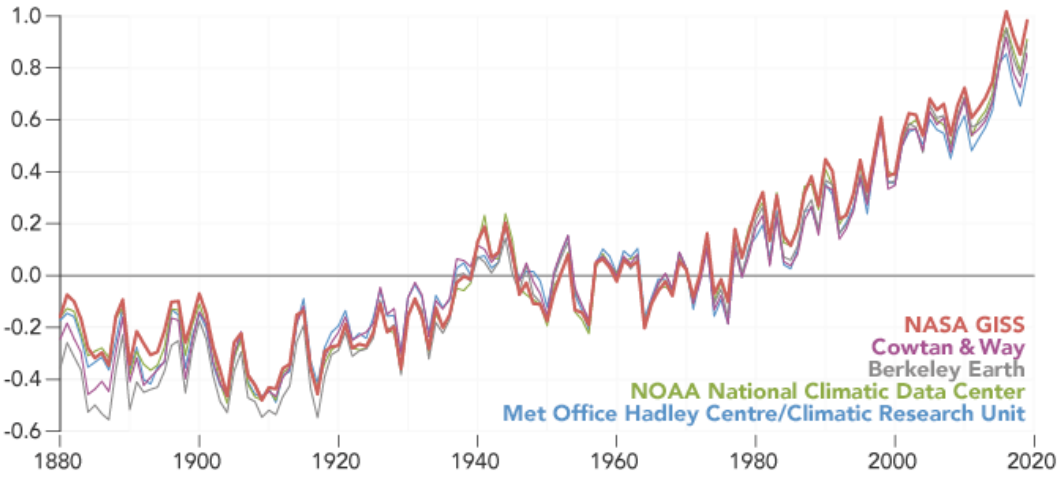
The increased human compulsion to expand had result in an unparalleled environmental disruption, climatic change, and social inequalities.

As early as the late 1980s, politicians became aware of the problem of global warming and founded the Intergovernmental Panel of Climate Change (IPCC), the United Nations Department responsible for Assessing the science related to climate change for policy responses. Subsequently, it was set during the 1992 Earth Summit, the goal of "*stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system*" (Article 2) together with the adoption of the United Nations Framework Convention on Climate Change (UNFCCC). The most important step, however, was the adoption of the Kyoto Protocol in 1997, but entered into force in 2005 without the ratification by the United States. It is the most important implementing instrument of the UNFCC, which provides for quantitative reductions or limitations of greenhouse gas emissions for thirty-eight industrialized countries and the European Union. More recently, in order to counteract all those effects caused by the human

activity and to mitigate climate changes for the sustainability of the global financial system, the United Nations had introduced the 2030 Agenda for Sustainable Development, on the occasion of the Sustainable Development Summit of September 2015. The Agenda - born from the conviction that climate change and sustainable development are two interconnected problems - is an action plan "*for people, planet and prosperity*[3]*";* With the ambitious final goal to "*free human race from the tyranny of poverty"*, the 2030 Agenda sees in the *"eradication of poverty in all its forms [...] the greatest global challenge and indispensable requirement for sustainable development"*.

Following the conclusion of the Agenda, during the Paris Climate Conference in December 2015, the Member States of the United Nations Framework Convention on Climate Change have agreed to pursue the goal of not exceeding the average temperature increase to 2 degrees, and continuing with efforts to limit it to 1.5ºC[4].

Figure 1.2- A World of Agreement: Temperatures are Rising



Source: World of Change: Global Temperatures
https://earthobservatory.nasa.gov/world-of-change/global-temperatures

1.1. Climate Hazards

Studying the inherent risks of climate changes is important to understand the related impact over the socioeconomic systems, and, consequently, to comprehend the aftermaths over human race. While the consequences for human health are easily conceivable, this chapter

[3] UN, *Transforming our world: the 2030 Agenda for Sustainable Development*

[4] *Paris Agreement,* European Commission.

would focus over the economic and financial risks caused by climate change. Later on in this thesis, the effects of climate change over the human race would be investigated.

Climate changes are non-linear and systemic, affecting different regions differently, and the result over the stock of capital (meant as human, physical, and natural) could be either mild or catastrophic.

The most obvious and emblematic risk of climate change is certainly the physical one: either acute or chronic phenomena, which can result in significant losses to economic activities, as the total or partial destruction of infrastructure and tangible assets, or the reduction of raw materials.

Physical risks of climate change should be appraised carefully by governments, because of their repercussion over the economic, financial, and social systems. Strategies should be conceived to manage systematic risks, prompting adaptation and de-carbonization. On the other hand, sudden regulation could disrupt markets and create knock-on effects over the economic and financial systems.

In order to better capture and comprehend the impacts over our economies, the McKinsey Global Institute had analyzed, on the base of geospatial climate hazard data, 105 countries, building a five-system framework (based on five pillars: livability and workability, food systems, physical assets, infrastructure service, and natural capital) and detecting one or more measures for each. What it emerged is that by 2030, all countries observed would register an intensification in at least one of the indicators. For instance, there is a 60 percent probability of living in an at-risk region and experiencing a lethal heat wave at least once. Between 250 and 360 million people would live in regions with a non-zero probability of a heat wave over the minimum threshold for human survival, by 2030. By 2050, they could be between 700 million and 1.2 billion. Absent large-scale adaptation and mitigation actions, it is expected that consequences will further intensify and multiply.

Neutralize climate changes implies a complete reshape of our current model of development, which heavily relies on constant growth of production and consumption on considerably polluting energy sources. It has been estimated that, lacking imminent action, the annual losses arising from the overall climate change costs and risks, would amount to at least 5 percent of global GDP[5].

[5] In comparison, the costs of action associated with reducing greenhouse gas emissions can amount to nearly 1% of global GDP each year, *Finanza sostenibile e cambiamento climatico*, ABI and ANIA

Financial industry plays a decisive role in this context, especially thanks to the ability to allocate capitals in order to produce guidelines for a sustainable development.

Experts have registered in recent years, additionally, a global increase of climate hazards, both in terms of frequency and intensity. An extreme event is usually defined as "*the occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of the observed values of the variable*[6]*"*. There is no accurate distinction between weather and climate events, rather they differ in their time scales: while extreme weather events are usually correlated to changing weather patterns, hence with time frames ranging from one day to few weeks; on the other hand, an extreme climate event require longer time scales, frequently after the succession of diverse weather events, either extreme or not.

For instance, events of extreme precipitation, perceived in the past as a 2 percent annual occurrence, are believed to become a regular event. Statistically speaking, today an average day is hotter, and extremely hot days are more likely to occur. Hurricanes were considered events with a 1 percent of annual probability, however, in some parts of the world the likelihood is expected to double, or even triple by 2040.

It seems, according to scientists, that this unexpected intensification of extreme events is somehow related to the environmental and climate changes. Merely, all human activities which alter the natural equilibria play their part, increasing the vulnerability of ecosystems to natural disasters. Indeed, thanks to globalization, the repercussions of natural catastrophes have a large-scale resonance. Nevertheless, extreme events results weight generously upon supply chains, infrastructures, and populations as well.

Historically, these phenomena have been always considered rare, referred to as "acts of God" or "of Nature", in fact reducing the responsibility that lay on mankind and of the governments and institutions, which have always responded to these events after their occurrence, without foresee a response plan in advance.

However, extreme events have direct consequences over our economies. For instance, the disruption of a supply of one component in supply chain could result in downstream disruptions over the whole chain, which could last, in case of aftermath of a hurricane, for

[6] *Changes in Climate Extremes and their Impacts on the Natural Physical Environment*, in: *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation,* 2012.

months. Not only could the economic consequences be catastrophic in the first place, they could also worsen the more specialized the supply chain is. Business interruption and natural catastrophe are today some of the greatest concerns for business, especially in East Asia and the Pacific.

Today, the 70 percent of natural disasters occur in the Asia-Pacific Economic Cooperation (APEC) region, with annual losses estimated at $100 billion, the increase in the frequency and severity of these events will rise as climate change progresses. By 2100, the region's economic losses are estimated at 7.3 percent of local GDP. And yet, there are some experts who agree that these predictions actually underestimate the real economic consequences that could occur. But everyone agrees that activities aimed at adapting and mitigating climate change can help reduce its impacts and risks. And in this, the role of financial markets with their ability to place capital towards more sustainable development initiatives (like the introduction in 2007 of Green Bonds, "which issue is linked to projects that have a positive impact on the environment, such as energy efficiency, the production of energy from clean sources, the sustainable use of land"[7]) can be decisive, together with that of insurance**.**

1.1.1.Climate Change for the Insurance Industry

The insurance industry is strongly correlated to climate changes, both in terms of losses it suffers whenever these extreme events occur and of mitigation activities.

According to the *Corporate Climate Center* of the reinsurance company Munich Re[8], the losses of the international insurance industry due to compensations attributed to atmospheric events have grown from an annual average of US$10 billion in the 80s, to US$50 billion in the last decade[9]. Compared to an average of 28 percent of global macroeconomic losses, in 2018 the percentage increased to approximately 50 percent. Literature agrees on dividing climate risks into: (i) physical risks, meant as direct and indirect impact caused by the increase in acute weather events, in terms of both severity and frequency; (ii) liability risks, generated by the probability that parties who have been affected by climate changes attempt

[7] definition provided by Borsa Italiana website

[8] According to Lloyd's of London, damage attributable to weather losses worldwide has increased from an annual average of $50 billion in the 1980s to nearly $200 billion in the last 10 years. The Guardian, *Lloyd's calls on insurers to take into account climate-change risk*

[9] Munich Re, *Climate Change: A calling for humanity*.

to request compensation from those they behold as responsible; and, finally, (iii) transfer risks, which arise from the progression towards a lower-carbon economy.

The financial and economic impacts of physical risks, liability risks and transfer risks of climate change are only recently being held into consideration. Furthermore, traditional post-disaster financial assistance is giving evidences of inefficiencies and ineffectiveness, but actually disincentivizing individuals and organizations from taking serious proactive actions against the risks. On the other hand, evidences show that countries with a stronger market-based insurance coverage background recover faster from unprecedented extreme events. Insurance role is to transfer risk from an insured person or organization to an insurer. However, before insuring an extreme weather event, insurers must be able to identify the risk an to quantify it, and of course to bear the costs in the case of extreme events actually takes place. Insurers help societies to recover faster, providing financial compensation for larger disaster losses. The sooner and faster the recovery , the smaller the impacts of a disaster are likely to be in the long run, which helps to make society more resilient. Insurance play a crucial role in assessing, communicating and signaling risks through premiums, deductibles and payments, in order to share information.

Nevertheless, insurance companies alone cannot cope with the situation, which over the years has become increasingly unsustainable for them. In 1992, Hurricane Andrew, a powerful and destructive Category 5 Atlantic hurricane, struck Florida and the Gulf Coast, causing more than $27 billion of damages, the costliest hurricane to ever hit the USA for over a decade, passed only in 2005 by Katrina. Almost thirty years later, Andrew still is one of the most devastating in the U.S. history[10], the most destructive to have ever struck Florida, in terms of structures damages; and it was regarded as the costliest in financial terms - until Hurricane Irma in 2017.

Together with the significant damages to structures, one indirect consequence of Hurricane Andrew was to have exposed the insurance industry system of the time to a certain degree of vulnerability, until then gravely ignored.

Undoubtedly, the insurance industry was unable to respond effectively to the pressing necessities, and the magnitude of the consequences was such as to cause the failure of eight insurance companies, while bringing on the verge of insolvency many others.

10 According to the National Hurricane Center Report released January 26th, 2018.

The insurance industry plays a crucial role in building socio-economic resilience not only by contributing to the provision of risk information and risk pricing expertise, but also by proposing innovative risk transfer products and services.

There are two vital issues related to climate changes that the insurance industry has to face:

- An excessive increase in insurance premium prices due to the consequent growth of claims for repayment caused by natural calamities.
- Risks assessment evaluation would become more challenging if greenhouses gas emission would not be diminished drastically, causing more sudden natural disaster, resulting in difficulties to estimate premiums.

Before 1992, hardly any had foreseen the magnitude of the devastation that a serious storm could cause in the modern age, characterized by large coastal populations and high-value properties. And even those that were able to anticipate it, underestimated the impact a natural phenomenon as Andrew could cause. The market was exposed seriously to catastrophic risks, for which the inadequate availability of coverage, a problem even before Andrew, intensified.

At first, the insurance industry tried to increase capacity by addressing reinsurers less affected. Traditionally, insurance companies engage with reinsurers for various reasons, but mostly because it gives them the ability to immediately pay claims after an unparalleled loss event take place.

However, the extent of the repercussions and the increasing frequency of natural disasters induced insurance companies to reassess the insurance companies' risk exposure in those areas most affected by those types of natural catastrophe. The entire sector reshaped itself in preparation of another natural disaster, driving also legislators, insurance regulators and state government to steel themselves, both financially and physically.

Publicly funded state insurance programs were founded to cover a share of losses specifically related to catastrophic events. An example: the mandatory public catastrophe reinsurance program in Florida. Nowadays, all property insurers in Florida are obliged to buy reinsurance from the state-owned Florida Hurricane Catastrophe Fund, which constitute a stable source of reinsurance, designed only for hurricane losses.

The increase in demand for natural-disaster-related insurance lead to an increase in the need for new capital for reinsurance. In order to raise the availability of capital, it was created a new financial instrument called a catastrophe bond, or CAT bonds.

1.2. Origin and development of CAT bond

The intensification of catastrophic events, their frequency and intensity, together with the damages and disruption of infrastructures and private buildings, has highlighted how the reinsurance industry was not able to give a guarantee on the insurability of damages. This has led to the pressing need to create new forms of coverage from catastrophic risks.

With these circumstances, CAT bonds were created. These bonds, which are a sub-category of a particular set of financial instruments referred to as risk-linked securities, are designed to cover distinctive calamitous event, as hurricanes, fires, earthquakes. The first CAT bonds issued in mid-90s allowed insurers access to broader financial markets and offering institutional investors, such as hedge funds, pension funds, and mutual funds, the opportunity to earn an attractive return on investment uncorrelated with the returns of other financial market instruments in exchange for assuming catastrophe insurance risks.

The CAT bond market has developed gradually, but even today, the United States are the dominant source of demand for CAT bonds[11]. In the aftermath of Hurricane Andrew, there were different attempts to involve the securities markets directly, in order to help finance possible future natural calamities. The very first efforts - the futures launched in 1992 by the *Chicago Board of Trade* and the options issued by the *Bermuda Commodities Exchange* in 1997 - both failed for lack of trading and, within few years, they were withdrawn. The reason for their failure is equally attributable to the newborn market, too thin and young, to the probable emergence of a counterpart risk in the case of a major catastrophic event, and to the concern about excessive basis risk.

In 1995, a new "Act of God" bond was attempted, US$400 million contingent notes issued by Nationwide through a special trust, the *Nationwide Contingent Surplus Note Trust*. The proceeds were then invested in 10-year Treasury securities, and investors were provided with regular coupon payment. However, the structure of these notes resulted in the investors exposure to the ordinary insurers' business risks.

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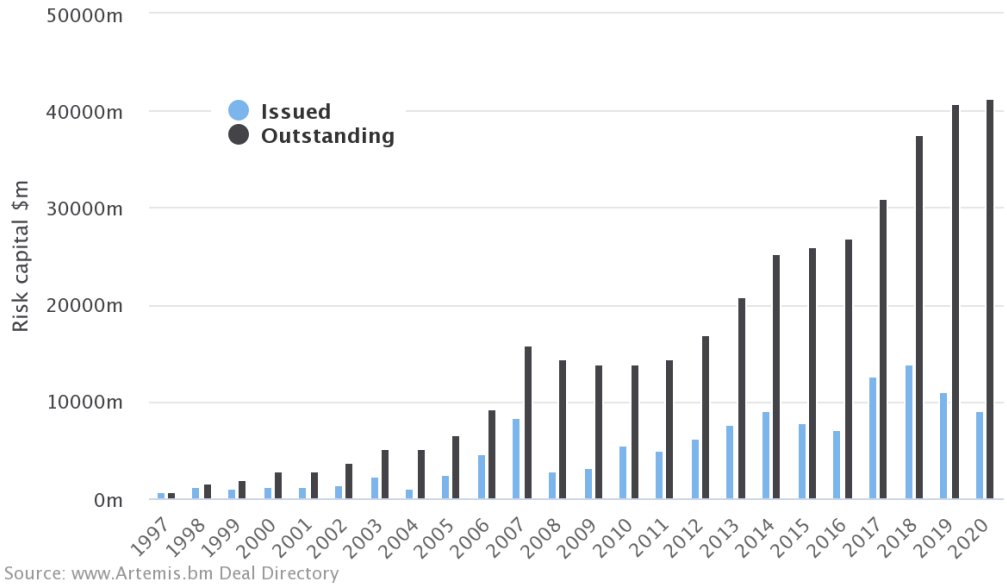
[11] The U.S. windstorm coverage accounts for 25 percent of outstanding bonds, U.S tornado for 5 per cent, and U.S. winter storm for another 4 per cent. U.S. earthquake coverage accounts for another 45 per cent of outstanding bonds, including California, the Central U.S., and the Pacific Northwest.

In the following figure, Figure 3, constructed on the basis of data taken from the Artemis Catastrophe Bond & Insurance-Linked Securities Deal Directory database, it is possible to observe the risk capital, representing the face value of all bonds still in effect in each year, issued and the growth of the CAT bond market and insurance-linked securities over the years.

Figure 1.3: Catastrophe bond & ILS capital issued & outstanding by year



It is easy to notice how the market has grown, starting with a volume amounting at less than US$1 billion in 1997, and reaching nowadays a risk capital volume of over US$40 billion.

In 2007, three different exchanges, the Chicago Mercantile Exchange, the Insurance Futures Exchange, and the New York Mercantile Exchange, launched futures-and-options issues on U.S. hurricane risk, after the hurricane season in 2005.

The structure that has revealed most successful is the CAT bond. The first encouraging CAT bond issue dates back to 1994, amounting US$85 million, by Hannover RE. It was followed, in 1999, by the first CAT bond issue by a non-financial firm, a bond that covered earthquakes losses in Tokyo, by *Oriental Land Company*.

Due to the financial crisis, in 2008, also the catastrophe bonds market had a downturn, although marginal with respect to other markets. The volume rose again starting in 2010 with a volume of US$4 billion, reaching an amount of US$11.5 billion outstanding risk capital, as of 30 June 2011.

At the beginning of 2018, the CAT bond market registered a stable growth, even after what could be defined as the worst period for CAT bond investors in the U.S. market history. 19

different CAT bonds tranches were triggered in 2017, due to the losses from Hurricanes Irma, Harvey, and Maria.

However, despite the historic amount of losses, new CAT bonds were issued in the first half of 2018, reaching $9.4 billion, against the 2017's record.

Nowadays, the insurance industry is investigating for a further development of CAT bond modeling, in order to cover also new types of risks, such as cyber attacks and terrorism risks, but also pandemic risks.

1.2.1. How CAT bonds work

For the most part, CAT bonds are issued in order to cover the "higher levels" of reinsurance protection, as coverage from phenomena with low probability of occurrence, as 0.02 or even less. CAT bonds are not generic financial instruments, but rather they require a geographical, temporal and disaster identification to which they are linked; they provide a higher paid interest with respect to the stock market, as a price for the extra risk.

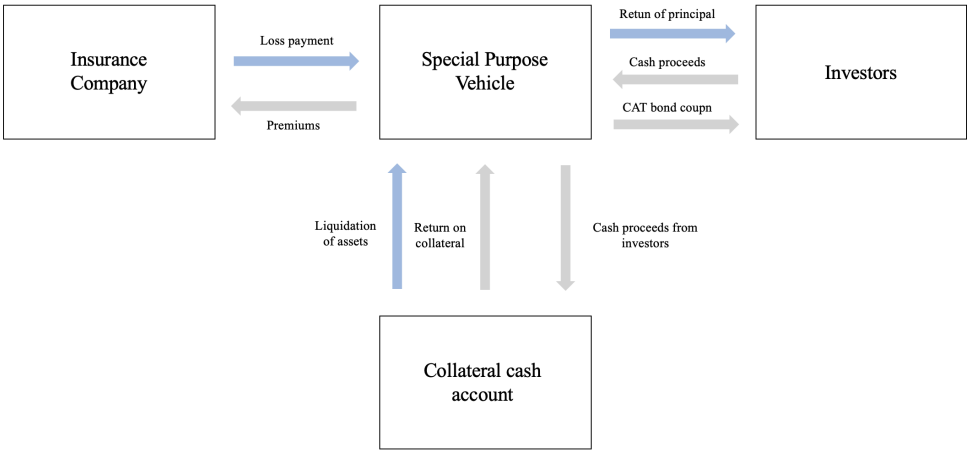
When a bond default occurs (i.e., in this specific case, when a catastrophic event occurs), interest and principal, owed originally to investors, are retained, in part or in their entirety, in order to supply financial resources for claims. For insurance companies CAT bonds are advantageous because they constitute an effective measure to prevent illiquidity consequences from compensation requests after severe natural disasters. On the other hand, investors are attracted by these instruments because of the trade-off between risk and return, and the inverse correlation with the market risk, which allows them to diversify their portfolios.

CAT bonds are issued by insurance companies with the aim to reallocate specific set of risk from a sponsor to the investors, covering losses they could not otherwise cover with traditional invested premiums, thanks to a Special Purpose Vehicle (SPV). Claim holders became accordingly the sponsors of the SPV, by paying the insurance company a premium.

The SPV is therefore responsible to issue the bonds and sell them to investors. The cash collected by the sales are reinvested in the market and stored in case of payout. In reality, CAT bonds' yield's trend is inversely proportional to catastrophes: if no catastrophe happens, investors would receive coupon payments as if dealing with a regular corporate bond for the duration of the life of the security, together with the principal at the maturity. However, if the

covered catastrophe occurs, then the principal would be forgiven and the money used to pay claimholders.

Figure 1.4 - Catastrophe bond issuance structure



Relying on the probability of the occurrence of an extraordinary catastrophic event, these financial instruments are implicitly risky, generally rated BB. Mostly, their maturity is averaging no longer than three years, with a maximum of five.

They require an independent third-party catastrophe modeler to determine the amount of industry losses covered under the deal.

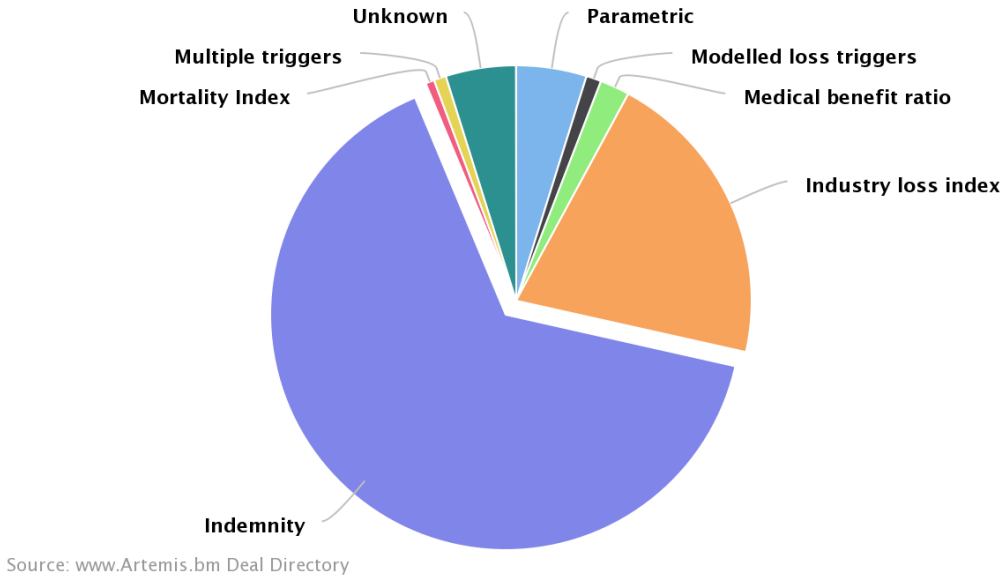
CAT bond structure is characterized by two elements, the bond attachment point and the exhaustion point. The first feature indicates the amount of losses covered by the bond, and at which at least a share of the principal is related. The second one designates the point at which the principal is depleted and investors are not further liable.

A certain amount of CAT bond issues has the possibility to entail *principal-protected tranches*, which allow the warrant of the return of the principal. With principal-protected tranches, the triggering event would impact only the interest and the payments, and possibly the timing of the return of the initial capital invested. This type of tranches has become, in the course of the life of CAT bond, progressively more rare, because sponsors were allowed less level of risk capital than a principal-at risk bond.

1.2.2.Triggers

As above mentioned, CAT bonds are frequently structured as floating-rate bonds, whose principal is lost if predefined trigger circumstances are met. The triggers constitute the most complicated and important feature of a CAT bond's structure, associated to a major natural catastrophe. There exist different types of triggers; however, the most used ones are indemnity, industry loss, parametric and modeled triggers.

Figure 1.5- CAT bond & ILS risk capital outstanding by trigger type



Source: www.Artemis.bm Deal Directory

An indemnity triggered structured CAT bond work similar to traditional reinsurance, refunding claims holders at the occurrence of an event on the base of actual losses incurred. This type of trigger is able to guarantee that the bond will pay out when the insurance company's actual collaterals reach the bond's attachment point. These types of bonds normally takes from two to three years to repay claimholders, after a triggering event, because actual losses must be examined and evaluated.

I. The indemnity trigger is the preferred choice of issuers, because it eliminates the "basis risk" (the risks that covered payments would be inadequately correlated with the insurers losses) they would otherwise bear. The largest group of issuers comprises insurance companies, which account for the sixty percent of all issues in the period 1997-2017. However, it is the least appealing for investors for different reasons. First of all, because

repayments to investors must wait for all claims to be settled, it is likely that investors would have to wait extended period of time after the triggering event takes place. Secondly, it may lead to moral hazards actions, considering that the issuer is not aggravated by the basis risk, hence with little incentive not to underwrite excessive risks, like home located in high hurricane-risk zones.

II. Opting for an industry loss trigger, payouts are based over an index estimates on aggregate losses, caused by the insured catastrophe, to the insurance industry thanks to the involvement of a third-party modeler, like the *Property Claims Service* in the U.S. and the *PERILS* in Europe. Assuming a triggering events take place, because the claims that each issuer must repay may not be exactly equal to their individual share of industry losses, issuers bears entirely the basis risk. Furthermore, investors prefer industry loss triggers with respect to indemnity triggers, because claims are settled rapidly, once the independent third-party service estimates industry losses.

III. In case of a parametric trigger, payouts are measured on the strength of the covered catastrophe, on the base of earthquakes magnitude or hurricane's wind speed. Also in this case the basis risk is beared mainly by issuers, and it is favorable for investors because it requires little or no waiting time before resolution of losses is settled, diminishing the risk of moral hazard.

IV. Lastly, the modeled trigger is like an indemnity trigger, but instead of being based on actual claims it is based on claims estimated or projected by an independent modeling company. Hence, loss resolution after a triggering event can be more rapid than with a pure indemnity trigger, and the issuer retains some basis risk.

In the early stages of CAT bonds market life, various structure were tested. However, only in the last decade this instrument has achieved a more standardized design, due to the necessity to adapt to stakeholders requirements. As of June 2011, the leading type of trigger was the industry index trigger, accounting for a 37 percent of outstanding bonds by volume, followed by the indemnity trigger, which accounted for 27 percent. Nonetheless, as highlighted by the chart above (Figure 1.5), the distribution of triggers of outstanding CAT bonds and ILS

securities today, according again to the Artemis Catastrophe Bond & Insurance-Linked Securities Deal Directory database, the situation is reversed: indemnity triggers are the most proffered choice, accounting for 65 percent of outstanding securities. The second type of trigger is the industry loss index, with 20 percent of outstanding bonds.

The CAT bond issuance process is today fairly standard. Once the trigger and the level of coverage has been selected, the credit agencies evaluate the proposed bond's quality.

The entire amount of the principal flows into the SPV, where it is held other until a triggering event takes place, or until the maturity of the bond.

This practice allows to consistently reduce the counterpart risk, also in comparison with traditional insurance contracts. Because the bond is issued directly by the Special Purpose Vehicle, the sponsors' rating does not affect by any means the instrument, nor it is associated to sponsors' debt. This characteristic, eliminates the risk that the contract would not be honored by a reinsurer insolvent due to other obligations in an unprecedented natural disaster.

The capital accumulated by the bond sale is to be used exclusively for the objectives predetermined by the reinsurance contract, and it is usually deposited into funds created ad hoc. These funds mostly invest in short-term secure titles, in order to mitigate the credit risk.

1.3. Issuers and Investors

As above mentioned, CAT bonds are mainly issued and traded in the institutional investor marketplace, sometimes committed CAT bond funds - which operate like hedge funds - in which individual investors and other institutional funds (like pension and endowment funds) may invest. Generally, there are three main types of issuers of CAT bonds: insurance companies, reinsurance, and state catastrophe funds; each of them makes use of CAT bonds in their own way to unburden themselves from their specific insurance risks, preferring different kind of triggers.

Insurance companies make use of these types of financial instruments to cover part of the risks they bear when they face extraordinary catastrophic events. CAT bonds constitute an alternative to traditional reinsurance, allowing to transfer the risk to the market. Contrary to reinsurance, where it may happen that the reinsurer is not able to pay out after a loss event,

CAT bonds are one hundred percent collateralized and their structure is studied in order to remove counterpart risk.

CAT bonds are helpful to insurers and sovereign States to contain the costs of natural disasters. Catastrophic bonds engage different sources of funding, competing with reinsurance and are able to enforce downward pressure on prices and on volatility, while increasing the capital available for the transfer of insurance risks.

The second largest group of catastrophic bonds issuers is constituted by reinsurers, and generally they assume the risk of policies underwritten by other institutions. To the occurrence of an extraordinary catastrophic event, they have to wait for the original underwriters to estimate their losses, which can further delay repayments. Indeed, their loss experience is more related to the whole industry's experience, due to the fact that their portfolios is constructed on a board cross section of the industry. Reinsurers tend to prefer industry loss and parametric triggers, which can provide faster loss evaluations.

Another group interested in CAT bonds emissions are state catastrophe funds; these funds constitute a response to atypical catastrophic disasters. In the U.S., state funds were instituted in order to assist the catastrophe insurance market. State funds generally takes on numerous private insurers' catastrophe insurance risks, taking as a consequence multiple catastrophe-related tail risks; however, to reduce their exposure, these state funds have begun to take an interest in CAT bonds.

Analogous to primary insurers, state funds, especially in the U.S., prefer the use of indemnity triggers.

Outside the U.S., CAT bonds are used in a different manner, whose aim is to supply with immediate funds for the recovery from the aftermath of a catastrophic event. It is the case of the Mexican' *FONDEN*, which in 2017 - after an earthquake in Mexico City that caused more than $500 million of damages[12] - issued in collaboration with the World Bank a $360 million CAT bond against earthquakes and organs, which allowed it to provide $160 million.

However, there are also other financial institutions categories interested in CAT bonds, as structuring agents; usually investment banks, or the capital market branch of a main broker or insurer, like Swiss Re Capital Markets, Deutsche Bank Securities, Goldman Sachs, Aon Benfield Securities, and Towers Watson Capital Markets. Their scope is to support the issuer

[12] According to Moody's *Investors Services Report*

in choosing the trigger type and the degree of coverage - the attachment and the exhaustion points. They also facilitate the allocation of the bond to investors.

An important role in the CAT bonds framework is played by modeling agents: their role is to evaluate the inherent risk of the catastrophe bond. They either estimate the probability of reaching the attachment and the exhaustion point; but they also infer about the loss in case of a modeled or industry loss trigger. The models are constructed on simulation of different plausible scenarios in which a catastrophic event may occur - paths of a hurricane or locations of the epicenter of an earthquake - and then estimating for each scenario the value of the costs.

Investors of CAT bonds are principally constituted by institutional investors, as pension funds, endowment funds and hedge funds. For an investor, in terms of cash flows, a CAT bonds is not dissimilar to any corporate bond. The bond is acquired with a principal payment more or less equal to the face value, and investors would be given orderly periodic payments. The maturity of the bond, however, is shorter than the one of any regular corporate bond. Usually, a CAT bonds' yield lasts from one to five years, with an average of three years.

The bond defaults only if the covered catastrophe exceeding the trigger point, as stipulated in the contract, takes place. In this case, a pre-established share of the principal is detained in order to cover the issuers' indemnities.

The principal paid by investors is usually retained in highly safe securities, usually a U.S Treasury bonds, in order to guarantee solvability in case covered catastrophe takes place.

The attraction of CAT bonds to investors is two-fold. First and most important is because the risk of CAT bonds is virtually uncorrelated with other risks that investors assume, namely the risk of equity market fluctuations, credit risk, and interest rate risk, and this is the reason why the CAT bond market is likely to remain very attractive to investors for a long time and to grow steadily and rapidly. The occurrence of natural catastrophes is in general uncorrelated with events in the broad economy such as stock market and interest rate movements and inflation. And after some critical issues during the 2008 financial crisis, due to some CAT bond issuance linked to Lehman Bothers' securities, investors' capital is deposited in the safest securities available. The second attraction to investors is that CAT bonds have been offering high rates of interest consisting of the base interest on the Treasury money market funds in which they are deposited, which currently offer only a low interest rate, plus the premium

paid by the issuer for their insurance coverage feature. This interest rate has so far been high compared to the risk of default.

The Special Purpose Vehicle is a structure preferred by both insurers and investors.

For the former, the SPV constitutes a mean to take advantage from tax and accounting benefits (especially when it is located in an offshore location). At the same time, investors require a SPV in order to separate the risk inherent in CAT bond investment from their ordinary business, but also as a mean to mitigate the insolvency risks of insurers. The SPV is hence a measure if not necessary, at least desirable by both sides. The SPV is also sometimes called a “transformer”, because it transforms the investment in bonds by investors into a sale of insurance.

2. Chapter 2: Will pandemic outbreak be another recurring atypical natural phenomenon?

Diseases outbreaks and epidemics are not a new reality for mankind. The human being has coexisted with diseases throughout its entire existence, in particular since he had begun to organize himself in increasingly complex societies. However, only in modern eras humanity has begun to pay attention to epidemics and pandemics outbreaks, recognizing their implicit risk and the damages they could cause in terms of casualties, and of disruption of societal and economic systems.

Cicero once said "*Historia magistra vitae",* and, indeed, ancient history has several references to diseases and epidemics which has influenced societies and, sometimes, even the course of history itself. There are some references of epidemics even in the book of Exodus, when it describes the Plagues of Egypt. In Thucydides' "Peloponnesian Wars", there is the description of the siege of the city of Athens in 429 BC by the Spartans; according to what the author reports, the population of the city was decimated not by the consequences of the war, but rather from a mysterious disease that first spread in Ethiopia, then reached also Egypt, Libya and the kingdom of Persia.

The first known plague outbreaks is the plague occurred under the Byzantine emperor Justinian, in 541-542 with waves up to 750. It is estimated that 25-100 million, roughly the 40-50 percent of the population of Europe, died. The disease spread rapidly to Constantinople, which then recorded 800,000 inhabitants, and subsequently throughout the whole Empire, with catastrophic economic consequences.

By the mid-14th century, the Black Death, probably originated in Central or Eastern Asia, was clearly already known, although its causes (discovered five centuries later) and cures were still a mystery. It is estimated that the European population decreased from 80 to 30 million people, about the 30-60 percent of the European population, and it caused severe religious, social and economic consequences. The plague was a disease that was repeated several times throughout history, with particular episodes such as the London Plague of 1563 or the Great London Plague of 1665.

But the plague was not the only epidemic that afflicted mankind for centuries. Another virus known to humans for centuries is smallpox. With a mortality rate of up to 30 percent, smallpox has accompanied humans for almost the entire course of history, decimating the

world's population. When it first appeared it is not yet known, however the first clinical evidence of smallpox dates back to Ramses V, who died 3 000 years ago; it seems that it emerged as an endemic disease in India and then spread to the rest of the world over the centuries. One of the most famous episodes of smallpox outbreaks happened in the New World, when Europeans carried the virus, which particularly affected the indigenous population whose defenses were very low against new diseases. Smallpox is still today one of the very few disease that humanity has eradicated, thanks also to the discovery of the first vaccine.

One of the most important emblematic episode of pandemics in the modern era is the case of the Spanish flu, which spread during the last months of the First World War. The virus spread along with troop movements on European fronts. According to recent studies, there was a global mortality rate of between 10 and 20 percent, causing between 20 and 50 million deaths worldwide. Some speculate that there were even 100 million victims.

Diseases and epidemics have continued to manifest over the years, sometimes keeping a low profile, others arousing concerns and alarms. In 1957, the flu virus A (H2N2) spread to China for the first time, precisely in the Yunan peninsula, reaching the rest of the world in less than a year, and causing a million deaths. Ten years later, a new flu pandemic appeared again in Asia, renamed the Hong Kong flu, a variation of the flu virus A (H3N2), and claiming again over a million of victims.

Among the most serious pandemics of the modern age is the one caused by the human immunodeficiency virus, HIV, first documented in 1981, but probably of much older origin, which caused, it is assumed, 25 million deaths worldwide.

The spread of the new virus, COVID-19, last winter, is hence just one of different pandemics that humanity have faced most recently. On 11 March 2020, the COVID-19 epidemic was officially declared by the World Health Organization a global pandemic. Although at first it seemed that the disease was confined to China, precisely in the Hubei region, the complexity and technologic development of our society allowed the virus to travel quickly, despite the restraints adopted by the Chinese government to prevent its circulation, reaching in a short time Japan and South Korea, hitting Italy and, subsequently, the whole of Europe and the United States. The damage caused, not only in terms of casualties, (which, at the time this thesis is written, count over 730 thousands, with over 20 million cases confirmed

worldwide[13]), but also in terms of economic consequences are devastating, with a simultaneous shock to both supply and demand from which Countries all over the world are still trying to recover.

Moreover, studies agree that, in all likelihood, it will not even be the last case. Scientists and experts are worried about new pathogens (just between 1960 and 2007, there were more than 1400, 13 percent of which were new or unknown), since our health systems are not yet prepared to face them, and consequently they are more likely to cause a pandemic outbreak.

2.1. Is there a relation between climate change and pandemic risk?

Although pandemics occur, from the 16th century, at irregular intervals, more or less between 10 and 50 years, with different level of severity and different effects over humankind, and at an unpredictable trend, in recent years there has been an increase in the frequency of the various pandemics. Suffice to say that since 1918 there have been four pandemic influences (summarized in Table 2.1 below), plus the persistent acquired immunodeficiency syndrome (AIDS). Between 1980 and 2013, 12 thousand epidemics have affected 44 million people in the world. This trend is attributable to different reasons: population growth and demographic

Table 2.1 - Characteristics of the past four influenza pandemics

Pandemic year of emergence and common name	Area of origin	Influenza A virus subtype	Estimated case fatality	Estimated attributable excess mortality worldwide	Age groups most affected
1918 "Spanish Flu"	Unclear	H1N1 (unknown)	2-3%	20-50 million	Young adults
1957-1958 "Asian Flu"	Southern China	H2N2 (avian)	<0.2%	1-4 million	All age groups
1968-1969 "Hong Kong Flu"	Southern China	H3N2 (avian)	<0.2%	1-4 million	All age groups
2009-2010 "A(H1N1) 2009 Flu"	North America	H1N1 (swine)	0.02%	100 000-400 000	Children and your adults

Source: WHO. *Pandemic Influenza Risk Management*.

13 Data taken from the WHO website, as at 12 August 2020, https://www.who.int/emergencies/diseases/novel-coronavirus-2019

adjustment, globalization and increased mobility, enhanced and changed interactions between humans, disease vectors and animal hosts, and probably environmental change.

This new pandemic is a wake-up call, but even before it the world was experiencing various health emergencies, mostly related to the unbridled use of unsustainable resources and the unbearable pace of development of our society.

Infectious diseases are everywhere around us, as if they were a natural glue between humans and animal species; they are, like us, part of the same complex biophysical networks that are at the base of ecosystems.

How do these diseases spread? COVID-19 is one of many diseases transmitted to humans through animals. The term zoonosis is used to define every animal infection transmissible to humankind, which confirms the Darwinian theory that we all belong to a single animal species. Every time a pathogen jumps from an animal to a human being, taking root in the new organism as an infectious agent, thus causing disease or even death, it is a zoonosis.

COVID-19, Ebola, the bubonic plague and even the Spanish flu of 1918, which appears to have originated from a wild aquatic bird, are all zoonoses, along with all types of human flu, such as Lyme disease and AIDS.

Animal diseases are much more common than rare. According to researchers at Sapienza University, there are about 70 percent of emerging infectious diseases and almost all of them are pandemics that have occurred in modern times, arising from complex interactions between human race and animals, both wild and domestic. Human and animal diseases are strictly connected.

Smallpox, on the contrary, is not a disease with a zoonotic origin; and, indeed, it is one of the very few diseases that mankind has managed to eradicate completely: not being the virus able to hide in the *reservoir hosts* (living organisms that are healthy carriers of pathogens, with which they live without suffering obvious harm), as it happens for the pathogens of zoonoses, it has been possible to exterminate it permanently thanks to the vaccine. Actually, pathogens also behave in accordance to the Darwinian logic, evolving and retreating in the reservoir host, in which they are able to remain anonymous and undisturbed until, due to some disturbance of the equilibrium of the ecosystem in which they live, they make the transition from one species to another, a phenomenon known as *spillover*, going to "invade" the new living organism, with consequences sometimes. Because of the reservoir host an infectious

disease can disappear between one epidemic and the other, making us think, erroneously, that the worst is over. Although spillovers and emergencies are two distinct concepts, they are nevertheless connected to each other. We define the spillover as the moment when a pathogen makes the transition from one species to another, an event well localized over time. On the contrary, the emergency is a process. They are two connected phenomena because it is the spillover that leads to the emergency. All these diseases that pop up one after the other are not mere coincidences, but rather interconnected with each other.

These are the symptoms of two global crises that mankind must contain as soon as possible: one environmental, and the other health related.

A question that arises spontaneously at this point is whether or not there is a relationship between climate change and pandemic risk. The 2030 Agenda launched by the United Nations emphasizes the consequences that the development of human race is having on our planet.

The destruction of the environment, climate change, social inequalities are all symptoms of the same problem. Human race today needs more and more resources to meet its own needs. However, the pressure we are exercising on our planet also has consequences for our health. The most direct consequence, often underestimated or even ignored, is the emergence of infectious diseases. The Emerging Infectious Diseases (EID) have the ability to cause large-scale mortality and morbidity, unsettle trade and travel networks, and even encourage civil unrest.

As the recent episode of COVID-19 has shown us, diseases, especially when they become pandemics, can also have serious economic repercussions. For the first time in our history, in April 2020, the price of oil came to a negative value of less than US$40 per barrel, due to a shock of demand caused mainly by the restrictions and limitations that various governments have adopted to prevent the virus from circulating. Some have seen in this first episode the signal that finally the era of renewable has arrived, others fear a disproportionate response when the emergency will come back.

Can human actions have had an influence on the increase in the frequency and strength of new pandemics? Very little attention has been given to the interaction between climate change and EID, despite the increasing empirical feedbacks in favor of the relationship between these two phenomena of our era.

According to some experts, human activity in this case could also be responsible, if not the only and main cause. There are several studies[14] that seem to suggest that man is behind the increase in the frequency of pandemics in the modern age. As also the insurance company Zurich in the Financial Times pointed out, this succession of epidemics and diseases that we are witnessing in recent years seems to be linked to the destruction of the environment.

Humans are responsible for the disintegration of various ecosystems, where millions of species are mostly still unknown, (e.g. deforestation, road and infrastructure construction, increased agricultural land and pastures, wild animal hunting, mining, increased urban settlements and land consumption, pollution, unsustainable exploitation of fish resources, climate change).

Among these unknown species there is also what experts call *virosphere*, which is composed of viruses, bacteria, fungi and other organisms. With the destruction of ecosystems, more and more new pathogens appear where they should not. When trees are cut down and wildlife is killed, pathogens will actually fly around like dust, disturbed and evicted by their habitual host; they need to find another host not to extinct.

This has led to the origin of new diseases, not only as isolated cases, but also in the form of epidemics and pandemics.

Deforestation is a clear example of how man is interfering with natural ecosystems. Always according to Zurich, deforestation could be the cause of 31 percent of epidemics in the last two decades, as the cases of Ebola, Zika and Nipah seem to show. Because of deforestation, in fact, animals are forced to move away from their natural habitats, to get closer to humans and, in doing so, there are more possibilities for the spread of zoonotic diseases.

Climate change and loss of biodiversity are therefore part of the reasons why viruses are nowadays able to circulate and spread all over the world. Not only the environmental disruption caused by our species is creating new opportunities for contact between humanity and pathogens, but also our technological development and our social models help viruses to spread more quickly and globally.

Again, human actions are decisive in this situation; first, they become decisive in preventing a disease, the pathogen of which -the hazard- is of natural origin, from evolving into an epidemic; Secondly, they are necessary in determining whether an epidemic evolves into a

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[14] Moreno Di Marco et all, *Sustainable development must account for pandemic risk,* first published February 14, 2020

pandemic. Even when a pandemic becomes inevitable and imminent, human actions play their part in establishing its evolution.

Surely we can say that over the years the impacts that these epidemics have had on human life have been thwarted by the progress of medicine and the spread of vaccines, antivirals and antibiotics, although the attack on biodiversity is also an attack on available care. Yet, several elements of our modern society make it easier for viruses and various pathogens to develop and spread. Just think of the globalization of goods and services, but also of people, the mutual interdependence of these factors has a close link with the pandemic risk.

Thanks to globalization, not only today we can experience a higher exchange of products and services (livestock), but also our mobility has increased exponentially compared to only a hundred years ago. Today, moving from one city to another, from one country to another, from one continent to another, has become a matter of hours.

However, thanks to globalization more and more people can visit countries and regions with poor public health systems, move between these countries and high-income countries with far stronger concern on veterinary and human public health. Thus, any pathogen originating in a remote village in Africa or Asia can reach major cities on all continents within 36 hours.

However, some aspects of globalization can actually counteract the spread of pandemics and reduce their risk (e.g. the increase in communications). In addition, technologies to control and monitor EID have increased in recent decades. However, as we have seen, there is a lack of adjustment of the policies that the various governments could adopt on the subject, mostly focused on a posthumous reaction, focusing on outbreak investigation and control and on development of vaccines and therapeutic drugs targeting known pathogens.

2.2. How does pandemic risks impact the insurance sector?

Generally, catastrophic risk's costs are borne by insurance companies (and even more by reinsurance companies).

In recent decades, the insurance industry has organized itself to deal with some of these catastrophic risks. They are phenomena that have always existed and against which, although in recent years their frequency and intensity has been mostly stimulated by human activities, human race usually has no power. However, it seems clear that one of the biggest risks that

insurance companies has to control is precisely that kind of catastrophic risk that until now has been forgotten, which is the pandemic risk.

Pandemics and natural disasters may have similarities, but at the same time there are substantial and decisive differences. First, a hurricane, like any other natural disaster, usually could be localized in specific geographical areas, due also to a certain combination of (meteorological) factors that characterize it.

We can identify three main phases of a hurricane's life cycle: more commonly a hurricane is born, grows and dies. These three phases correspond to several atmospheric phenomena, which together lead to the development of a hurricane: Tropical depression, Tropical storm and Hurricane, and landfall/dissipation. It is the speed of the wind that determines the speed of passage from one stage to another, not the danger itself. A hurricane is formed at a time when the temperature of the ground water increases in such a way as to heat the above air, which consequently rises, until it stops due to even warmer air; the encounter between these two air currents creates an atmospheric inversion. In this phase we create what is called a tropical depression.

When the pressure at the center of the storm drops drastically towards the edges, winds are pushed to form a spiral by the rotation of the earth itself. The wind speed increases in proportion to the pressure. The outermost part of the "eye" is also the one with the highest rainfall, the strongest winds and the highest sea level.

The life cycle of a hurricane lasts a maximum of ten days, when a hurricane eventually dissipates over colder waters or pouring on land, which causes it to lose energy and power. However, once it arrives in populated areas, it becomes one of the most damaging and devastating natural disasters.

On the contrary, pandemics have a much longer life cycle (we are talking about months, if not even years), and, as we have seen, they often do not simply die, but rather hide and remain latent between one acute phase and another. According to the World Health Organization, for pandemics we can identify four distinct phases: inter-pandemic, alert, pandemic, and transition, followed by another inter-pandemic phase. Specifically, the inter-pandemic period refers to the period between one pandemic flu and another, a transitional period that binds not only the various waves of the same viral pandemic, but also several pandemics. The alert period is the period when a new pathogen offensive to the human race becomes identified and

diagnosed. The transition to the next phase, the pandemic phase, which refers to the spread of the disease at a global level, can take place both gradually and abruptly, taking the health systems and policymakers by surprise, resulting in containment and mitigation actions that could block commercial activities. A "final" phase is that of transition, characterized by a re-entry of the emergency, a reduction of the containment and mitigation actions in response to the virus, and the introduction of actions aimed at stimulating hospitalization and growth of countries.

As has already been pointed out in this research, pandemics do not disappear suddenly when the emergency ends, but they remain hidden, they evolve, they wait to return with more force and vigor. Few are the diseases that man has managed to eradicate completely, and we are talking only of those not of animal origin, which instead constitute the majority of emerging infectious diseases.

Another characteristic and fundamental difference between hurricanes and pandemics is that of the range of action. A hurricane, like other natural disasters, is a phenomenon well localized not only in time, but also geographically speaking. As we have seen, once a hurricane reaches colder waters or arrives on land, it loses its power and begins to dissipate, while leaving behind a trail of damage and destruction. Furthermore, to ensure that it develops in the first place, very precise meteorological and physical conditions are necessary. It was relatively easy for insurance companies to arrange to cover the damage caused by the passage of one of these natural phenomena.

Being episodes that are concentrated in crucial areas of the globe, we will hardly find in Italy or in Europe in general, an insurance coverage that also covers this type of damage. On the contrary, in America, as we have seen in the previous chapter, it is a recurrent and well-known phenomenon in some states. The insurance companies located in Florida were the first to be interested in developing a wider market for natural disasters. As the area is one of the most systematically affected by hurricanes and consequent storms, the need to access a wider portfolio to cope with premium payments started from there.

The same cannot be said of a pandemic. The origin of the name itself underlines what is the main feature of pandemics. The word pandemic comes from the Greek, more precisely from the adjective πανδήμιος, a union of two words (παν, "all" and δῆμος, "people") which literally means "of all people". The meaning that we give it today refers to an epidemic disease with the ability to spread to all mankind in an indistinct way, but in reality it was attributed only in

the eighteenth century by European scientists, taking precisely the term "epidemic" used by Hippocrates in IV B.C.

A pandemic therefore has the intrinsic characteristic of having no borders, of being able to depart from Asia and arrive in Europe, passing through Russia, the United States and the Pacific.

People can take containment measures, as we have all seen and experienced in recent months, but this does not actually prevent the virus from circulating (Europe was now out or close to the end of several months of lockdown, when COVID-19 literally invaded the United States with all the strength it was capable of), rather, it slows down the race, makes institutions and health services take time to prepare to face the new wave.

Reasonably, having no borders constitutes as significant problem for insurances. It is quite challenging to insure a single country against a systematic risk like a pandemic risk.

When a disease, whether new or already known, is manifested for the first time in a given location, the chances that it can spread like wildfire not only to the border regions, but also in other parts of the world, becomes a race against time.

In reality, the rate of transmission of a disease depends on various factors. There are diseases that spread faster, moving from one individual to another at a fast pace; others, such as HIV, require more special conditions to be able to be transmitted, and then proceed with relative slowness. The measure that is used to measure the contagion rate is R_0, which, however, may change during the course of the pandemic - at first it tends to rise, and then decrease when the emergency comes back. When the contagion rate remains stable, we speak of an endemic disease. Generally, when R_0 is greater than 1, the virus has the ability to spread quickly without the containment measures being effective. Yet there are also other elements, which determine the spread of a disease, and therefore R_0, some intrinsic to the virus itself, such as incubation time. For example, Ebola has a very short incubation time and a particularly severe severity, which the contagion is very slow. Another element that characterizes a disease is also, precisely, the severity with which it manifests itself, measured by the rate of Morbidity, a quantity very difficult to determine, especially in the early stages of the pandemic.

The pandemic risk is also very difficult to assess for an insurer, since there is a lack of historical data not indifferent. Moreover, the level of technological development plays an important part in determining the impact that a new disease can have in modern times. In 1918, there were no antibiotics and antivirals, realities that seem obvious to us. The impact

that the Spanish flu had then, could be drastically different from the impact that a disease of the genre could have today.

Between 2005 and 2008 there was a renewed global interest in pandemic risk; when in 2009 H1N1 flu pandemic turned out to be less destructive than what was feared, the focus on pandemics and their risks to our communities waned.

Undoubtedly, the diseases spread in recent years can all be considered as missed catastrophes, which have led, according to the Background Paper on the Risk pandemic for World Development Report 2014, to the creation of myths about pandemics that weaken the ability of policymakers to take effective measures to counter pandemic risk. Lowered the look, it has come consequently to miss a more careful and scrupulous vigilance towards those pathogens potentially lethal for the man (and for our economy), going to penalize what should be a preventive preparation towards these risks. As we have noted, the question to be asked is not "whether" the next pandemic will occur, but rather "when" and with what severity it will strike us.

Yet pandemics, especially those caused by new pathogens, have a very important impact on a country's economy, and, because of the interconnection that we experience today, on the global economy. In 2003, SARS costed 10 billion dollars in economic damage, as did the H1N1 pandemic in 2009, and the Ebola epidemic in West Africa in 2013-2016. Some estimate that the losses were in excess of US $40 billion in productivity from the 2003 SARS epidemic, $53 billion from West Africa Ebola outbreak, and from $45 to 55 billion from the 2009 H1N1 influenza pandemic. According to World Bank estimates, a new pandemic flu similar in scale and virulence to that of 1918 could cost the modern economy around US$3 trillion, or up to 4.8 percent of GDP; the cost would be 2.2 percent of GDP for even a moderately virulent pandemic flu. Pandemics have the ability to block trade and tourism altogether, to disrupt the major global economic drivers.

Not to mention the repercussions on the insurance market. In May 2020, Lloyd's announced that the industry's losses from COVID-19 were estimated at $200 billion and more.

In particular, the market is subject to a sharp increase in claims for business interruptions, travel cancellations and event cancellations. The costs of compensation for the entire year should amount to about $750 million, just for Lloyd's. The consequences of the pandemic will affect both the demand and the supply of the insurance market; in fact, the In addition, the

asset side of the balance sheet is also negatively impacted by the adverse market conditions resulting from the economic impact of the response to a pandemic, which limits the supply if insurance.

2.3. Can CAT bond become an insurance's solution for pandemic risk?

The recent pandemic has highlighted the fragilities that already existed in the insurance system, just as in 1992 with Hurricane Andrew. CAT bonds constitute an interesting precedent of risk transfer solution, surely to take into consideration to transfer also pandemic risk. Indee, recent literature seems to confirm that the insurance sector is looking to CAT bonds. However, some considerations are required. Pandemic risk entails a series of economic consequences, together with an extended (non-damage) business interruption risk. Private insurance could not supply coverage for a risk impossible to diversify geographically. Besides, lockdown measures to contain the spread of the virus have further aggravated the situation, increasing the risk of business interruption for several economic activities. According to estimates, present business interruption premiums in some markets would need to be collected for over 100 years to cover just two months of COVID-19-relate business interruption cost[15].

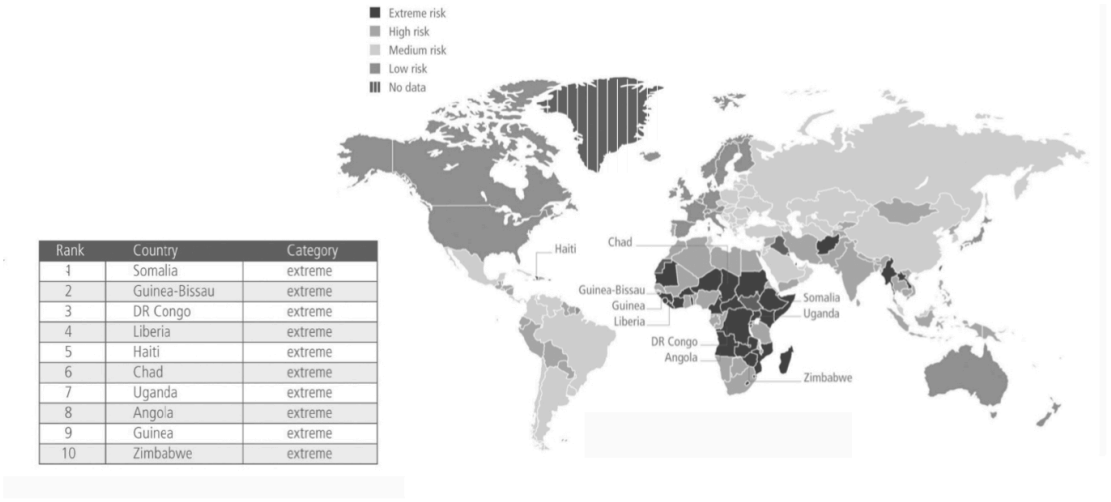
At the basis of insurance there is the concept of risk pooling, the technique of sharing individual risks together in order to reduce risk for the individual. However, risk pooling requires certain conditions to be able to function: homogeneity between individuals with respect to risks, and, moreover, any correlation between risks. In case of non independent risks, the insurer may not be able to provide a reduced average risk, hence to trigger the risk pooling. And when a natural catastrophe or a global pandemic occurs, risks could not be differentiated among individuals, since these events have an impact over a considerable proportion of the population.

Obviously, the private commercial insurance and reinsurance sectors can not be left alone in providing coverage for pandemic risk. Rather, some other responses should be found.

There are four key elements upon which the private and the public sectors should ponder about, as the European Insurance and Occupational Pensions Authority have identified: i) risk assessment; ii) risk prevention; iii) product design; and iv) risk transfer.

[15] as reported in the Staff Paper, *Issue Paper on Shared Resilience Solutions for Pandemics*, by EIOPA, 27 July 2020

Figure 2.1 - Examples of the emergence or re-emergence of infectious diseases



Rank	Country	Category
1	Somalia	extreme
2	Guinea-Bissau	extreme
3	DR Congo	extreme
4	Liberia	extreme
5	Haiti	extreme
6	Chad	extreme
7	Uganda	extreme
8	Angola	extreme
9	Guinea	extreme
10	Zimbabwe	extreme

Source : www.maplecroft.com

Source: Myths and Realities of Pandemic Risk for Insurance, by Michel M. Dacorogna Deputy Group Chief Risk Officer, Scor

Moreover, the effectiveness of the measures taken to contain the contagion changes according to the geographical area, from the socio-economic conditions of the individual countries. For example, European borders, especially Western borders, have ideal conditions for the transmission of a pathogen; at the same time, however, are among the best equipped countries in the health system to cope with the spread of a disease. They therefore have the capacity to respond in a timely manner, on the contrary, for example, to African countries, which suffer greatly from the lack of an efficient health system. Figure 2.1 shows the ability of each country to respond to the spread of a virus effectively and quickly.

Notwithstanding, the contribution of the private sector, would only reinforce public efforts of prevent possible future events to take place.

The insurance system as we know it today presents, as has been highlighted, a serious gap in matters of non-damage business interruption insurance (NDBI). Indeed, European markets lack offer of NDBI insurance, especially if linked to pandemic outbreaks.

However, to be able to construct a sound NDBI risk model associated to pandemic risk, relevant data and risk modeling tools and techniques are fundamental. Data on the pandemic itself and on the lockdown measures could be provided by the public sector, which could be an important ally to build more resilience for the insurance market. Indeed, public authorities and institutions have access to a more substantial data bank related to pandemic outbreaks. Besides, one has to remember that the NDBI risks may arise not only from the pandemic

itself, but also from the decisions taken to mitigate these risks. And to build a more accurate modeling of NDBI risks, there is need to consistent and reliable data. The more accurate the model, the more precise would be the insurers price risk.

Relying hence on current CAT models also to model the NDBI risks related to pandemics could provide a solution to the problem, since some of them also take into consideration business interruption. On the other side, these models may not be enough, since when dealing with a natural catastrophe such as an hurricane or an earthquake, business interruption makes reference to business interruption due to physical damages. Besides, in case of a pandemic also other factors, as the recovery capacity, shall be take into consideration. There is consequently need of more strong model, able also to capture governmental lockdown scenarios.

2.4. The (single) case of the World Bank's pandemic bond.

It is in the interests of each country to have plans for the possibility of spreading an epidemic. Currently, with the testimony of how health systems have or have been close to collapse, we can say that it is a priority for every state to have plans ready in case a new wave occurs. However, even the most prepared country, when crisis will rise, will need to mobilise substantial amounts of funds.

Epidemics spreads require an urgent amount of financial resources and support that many countries, although prepared to fight against possible future diseases, are not able to provide in a timely manner. This spring with the coronavirus spreading was a clear example. After the Ebola outbreak in 2014 in West Africa, which had shown the struggle of rapidly move resource to face health crisis, the Pandemic Emergency Financing Facility (PEF) was developed in 2016, by the International Bank for Reconstruction and Development Association (IBRD), the International Development Association (IDA), and the World Health Organization (WHO) - together with a number of private partners - in order to help eligible countries cope with the increase in the frequency of different outbreaks as demonstrated by the last 30 years, to reinforce national and international systems when facing public health crises.

The IBRD is an international organization held by 189 member countries. It is one of the five institutions of the World Bank Group, together with the International Development Association (IDA), the International Finance Corporation (IFC), the Multilateral Investment

Guarantee Agency (MIGA), and the International Centre for Settlement of Investment Disputes (ICSID). As the the World Bank primary goal is to accomplish the extinction of extreme poverty and foster global prosperity, the IBRD provides loans, guarantees, and technical assistance for economic reform projects and programs. As far as WHO is concerned, it is a specialized UN Institute for Health, founded in 1946 with the aim of achieving the maximum possible level of health for all humankind in the world, as a "condition of complete physical, mental and social well-being".

The PEF has been structured to provide the world's poorest countries with timely financial resources to combat the spread of a disease in a pandemic manner. A fund at zero cost and 100 percent grand-based. At least for this first launch period.

Through the use of two windows, an insurance window and a cash window, the PEF provided an insurance coverage availability up to US$425 million for the spread of certain disease groups that most likely could trigger epidemics - like pandemic flu, SARS, Ebola and the Coronavirus family. The original idea was that these insurances had to pay quickly, within a few days of meeting the criteria that indicated their urgency, predefined by the WHO - such as, but not limited to, the number of deaths or registered cases. Along with the insurance window, the PEF provided also $50 million of immediate available money to deal with the eventuality that one did not meet the established criteria for the insurance window. The Cash Window actually covers a broader range of infectious disease outbreaks, and also the case of a single-country outbreak. It is completely financed through contributions from donors, the PEF Contributors, so that eligible entries shall not have the burden of costs. This innovative solution was born not only as a tool to raise and distribute funds for key responders, but also as an initiative for the creation of a global market for pandemic insurance instruments, going to imitate, and expand, the insurance market for natural disasters.

The PEF was launched with an initial period of three years, starting in July 2017 until June 2020. It is a pilot project, with the flaws that every young project brings with it. But the World Bank has already stated that it wants to extend work also for a second period.

As previously explained, when a pandemic strikes, it has no boundaries that can contain it, especially in an era like ours, where globalization and technological development allow people and services (and, consequently, viruses, bacteria and pathogens of all kinds) to reach comfortably every corner of the Earth.

All the countries around the world suffer from the consequences of the spread of a disease and the costs that they incur. However, the countries with low incomes and weak and deficient health systems are the ones that, as a rule, pay the highest price, being the ones that with the most difficulty manage to organize themselves efficiently during times of crisis.

For this reason, the World Bank and the WHO have identified countries that already have credentials for the International Development Association (IDA). Although for this initial period Eligible Countries are not obliged a formal request for access, as are covered by default. However, governments are invited to prepare early plans for the response to possible pandemic outbreaks.

With the funds provided through the PEF, the eligible countries will have the opportunity to face the health crisis at the time of need. The funds would be used to support all required activities, as but not limited to, the hiring of new work force, the acquisition of medicines and medical equipment indispensable, finance logistics and supply chain, but also for services, transport and all costs related to communication and coordination of emergency response activities. For this reason, at the time of the application for funds (which must take place at the occurrence of the criticality), the requesting countries have the obligation to present their prospected plans to apply in case of a pandemic emergency.

The PEF's objective is not, however, to finance country-specific preparatory projects. Rather, what the PEF is prepared to do is, in addition to supporting economically disadvantaged countries, to create a global market for pandemic insurance instruments.

2.4.1.Governance Structure

The internal governance structure is composed of different bodies: the Steering Body, the PEF Coordinator, and the Trustee. To support them in daily operations and through the pursue of the PEF goals, there is also the Treasury Manager, embodied by the World Bank (IBDR) and with the responsibility to issue Pandemic Bond(s) or purchase Pandemic Insurance(s).

The implementation of the PEF measures are entrusted to the Eligible Countries and PEF-accredited Responding Agencies.

Born as financing arrangement, the PEF includes a trust fund (the "Trust Fund") as a financial intermediary fund, which is administered by the IBRD as Trustee. The IBRD is also in charge to purchase catastrophe insurance coverage(s) from, or issue catastrophe bond(s) to the private

sector, which shall provide the Trust Fund through the IBRD, agreed-upon payouts (to the implementation of pre-agreed parametric triggers, which are based on public and observable figures). Subsequently, the resources collected would be allocated among eligible Responding Agencies and Countries. For PEF-eligible countries is intended those countries ("IDA Countries") which meet IDA's criteria for funds, or even IBRD's.

The Steering Body is responsible for overseeing the operations of the PEF, and it consists of a maximum of seven representatives of the Contributors, with voting powers, and representatives of the World Bank and the WHO, without voting powers. There may also be representatives of (i) other Responding Agencies, (ii) PEF Eligible Countries, and (iii) civil society organizations. The Steering Body is supported in its day-to-day operations by the PEF Coordinator, which perform secretariat services and technical assistance.

2.4.2. The Financial Structure

As already mentioned, the PEF is provided with two windows, each of which provide funds to eligible countries, the PEF Insurance Window and the PEF Cash Window.

Under the Insurance Window, the funds would be allocated by making use of the relevant amount of proceedspaid out or made available through the issuance of a Pandemic Insurance or a Pandemic Bond. The window provide an initial targeted coverage of US$500 million, financed both through (re)insurance markets, by means of a Pandemic Insurance, and thought the use of a Pandemic Bond, which will be purchased or issued by the World Bank Treasury, the Treasury Manager of the PEF. The proceeds received by both those two solutions would be transferred and held in the Trust Fund, and taken upon consideration exclusively for the use of the Insurance Window.

The activation of the payments is restricted to certain specific criteria, in accordance with the Activation Criteria. The Activation criteria are first of all based on pre-determined parametric triggers, based on publicly available and observable data; secondly, they feature differences for the variousdiseases covered, but are generally based on the epidemiological characteristics of the disease, as the outbreak size (determined by the number of cases and deaths), the growth rate of the outbreak and the spread.

As stated in the PEF Operations Manual, the principles used for the Insurance Windows distinguish between cases of influenza A virus/new or novel influenza A virus and non flu

outbreaks. In the first scenario, there is need of a) at least 5000 confirmed worldwide within 42 days from the start of the outbreak, b) plus the ratification from the World Health Organization of the sustained or effective human-to-human transmission; c) the Growth rate shall be greater than zero after the first 42 days, with a mean greater or equal to 0.265.

Only if both conditions are met, then the pandemic is recognized and the coverage would be allocated 100 percent of the maximum US$275 million.

Conversely, for non-flu pandemics, the conditions change, and the required period is decreased to 12 days after the start of the event, with at least two countries infected (either IDA or IBRD); a Total Case Amount and Total Confirmed Deaths Amount respectively equal or greater than 250; and a Growth rate greater than zero. The Insurance Window makes a distinctions also for the the Pandemic Bond/Insurance Payout Amounts in accordance to the disease, the severity of the outbreak and the geographical spread. The maximum amount is US$275 million for Flu, US$150 million for Filoviruses, US$195.83 million for Coronavirus, and US$75 million for other Covered Diseases; and only in the case of Flu, the payments is provided in its entirety when the triggers thresholds are reached; while for the other covered diseases payments are made in tranches, as the outbreak evolves (see Figure 2.3 below).

For those who are not able to satisfy insurance criteria, they may make request to have access to the Cash Window, which will provide funds from other applicable resources available in the Trust Fund. The Activation Criteria for this Window follow sequential three-step process, which consist in i) pathogen type; ii) epidemiological thresholds; and iii) technical assessment. As already said, the PEF purpose is to provide financial assistance to countries in order to efficiently respond to outbreaks of viral pathogens; however, the PEF Cash Window exclude from its coverage all those pathogens which do not constitute a serious threat, hence all non-viral pathogens, plus all those which are currently endemic[16] in human populations.

The PEF Cash Window was designed to provide a more flexible and easily triggered financing mechanisms, with respect to the Insurance Window. For this reason, an epidemiological threshold, based on publicly available historical outbreaks data, is taken into consideration for its Activation Criteria. Two main epidemiological features are required: first, the number of laboratory-confirmed cases have to reach the pathogens thresholds; secondly,

[16] Intended in the PEF Operation Manual "as a continuous sustained human-to-human transmission of pathogens in the global human populations"

Figure 2.2 - Pandemic Bond/Insurance Payment Amounts

Coronavirus Maximum. Coverage: $195.83m	**Pay-in based on: *Aggregate Number of Confirmed Deaths within IBRD/IDA Countries***		
	At 250	***At 750***	***At 2,500***
Regional (outbreaks affecting 2 to 7 countries)	29% (US$56.25m)	57% (US$112.5m)	100% (US$195.83m)
Global (outbreaks affecting 8 or more countries)	34% (US$65.63m)	67% (US$131.25m)	100% (US$195.83m)

Filoviridae Maximum Coverage: $150m	**Pay-in based on: *Aggregate Number of Confirmed Deaths within IBRD/IDA Countries***		
	At 250	***At 750***	***At 2,500***
Regional (outbreaks affecting 2 to 7 countries)	30% (US$45m)	60% (US$90m)	100% (US$150m)
Global (outbreaks affecting 8 or more countries)	35% (US$52.5m)	70% (US$105m)	100% (US$150m)

Other diseases *(Rift Valley, Lassa Fever, Crimean Congo)* ***Maximum Coverage: $75m***	**Pay-in based on: *Aggregate Number of Confirmed Deaths within IBRD/IDA Countries***		
	At 250	***At 750***	***At 2,500***
Regional (outbreaks affecting 2 to 7 countries)	30% (US$22.5m)	60% (US$45m)	100% (US$75m)
Global (outbreaks affecting 8 or more countries)	35% (US$26.25m)	70% (US$52.5m)	100% (US$75m)

Source: PEF Operations Manual

there must be strong evidences that the cases are epidemiologically related, arising from a unique outbreak.

Table 2.2 - Country Allocation Ceiling Example 1

	Country A	**Country B**	**Country C**
Number of Cases at the time the Activation Criteria are met	20	30	50
Population	100	300	600
Country Allocating Ceiling	$17.35	$30	$52.5

Source: PEF Operation Manual

2.4.3. PEF Allocation Guidelines

The process for the allocation of the PEF funds is designed in order to be fast and flexible, so that Eligible Countries and Responding Agencies may act tempestively to contain the outbreak. Again, it presents differences between the Insurance Window and the Cash Window.

2.4.3.1.Insurance Window

In the Insurance Window case, the PEF Operation Manual takes into consideration various scenarios; In case there are three or more eligible countries requesting funds after a non-flu disease outbreak, there is a general formula used to calculate the amount of funds to be allocated to each country.

Country Allocation Ceiling for Country A $= Z * [0.75 * (CC_A/CC_T) + 0.25 * (P_A/P_T)$

Where:

- Z is the Pandemic Bond/Insurance Payout Amount received in the Trust Fund
- CC_A indicates the Confirmed cases in Country A as on date of activation of insurance payouts criteria
- CC_T are the Confirmed cases in all affected Eligible Countries collected on date of activation of insurance payouts criteria
- P_A is the population of Country A
- And, finally, P_T indicates the sum of all Eligible Countries affected

Table 2.3 - Country Allocation Ceiling Example 2

	Country A	Country B	Retained by the Coordinator
Number of Cases at the time the Activation Criteria are met	20	30	
Population	100	300	
Country Allocating Ceiling	$25.375	$44.625	$30

Source: PEF Operation Manual

In a scenario in which the insurance payout amount to $100, Country A, with 20 confirmed cases, over a population of 100, would then receive a $17.35, the lesser of the amounts requested by all Eligible Countries.

If, instead, there are less than three PEF-eligible countries affected by the outbreak, first of all the PEF Coordinator shall preserve 30 percent of the total Pandemic Bond/Insurance Payout Amount in order to be prepared in case of allocations to new countries, in which the diseases may not be already reached the required threshold for the Activation Criteria. The formula above is then corrected by multiplying the Pandemic Bond/Insurance Payout Amount, Z, by 0.7.

Country Allocation Ceiling for Country A $= 0.7 * Z * [0.75 * (CC_A/CC_T) + 0.25 * (P_A/P_T)$

From the example above:

Table 2.4 - Country Allocation Ceiling Example 3

	Country A	Country B	Country C (Scenario A)	Country C (Scenario B)
Number of Cases at the time the Activation Criteria are met	20	30	10	50
Population	100	300	200	600
Country Allocating Ceiling	$25.375	$44.625	**$20.75**	**$30**

Source: PEF Operation Manual

Now, two possible scenarios would be presented to the PEF Coordinator

Let's assume that within 30 days after the date of the allocation to be made to the two countries, it follows a new application for the same outbreak. In this case, the Country Allocation Ceiling would be lower of:

- The amount determined by the formula: Country Allocation Ceiling for Country C $= Z * [0.75 * (CC_C/CC_T) + 0.25 * (P_C/P_T)$, where T = A+ B+ C;
- The amount retained by the Coordinator;

The table below presents the possible outcomes according to two possible situations for Country C.

Table 2.5 - Country Allocation (Flu)

Country Population	Allocation (US$)
Less 1 million	5 million
Equal or greater than 1 million, but less than 10 million	10 million
Equal or greater than 10 million, but less than 30 million	15 million
Equal or greater than 30 million	30 million

If, however, there is no new application from other country, hence the retained amount of the Pandemic Bond/Insurance Payout Amount is not allocated within the 30 days period, the Coordinator could either distribute the amount to the countries, ether one of them or both, which have already received PEF funds, if the rate of contagion after the required 30 days remains unchanged or continues to increase; or, in case the rate decreases, it may make available that sum for other PEF-related businesses.

It may happen that countries need to renovate their application request, and the program allows for multi requests. However, countries which have already received an allocation under the previous activation, the number of confirmed cases used for calculation must be counted starting from the date of the previous activation.

This was the process for non-flu outbreak. In case, instead that Activation Criteria for Flu pandemic outbreaks are reached, the PEF Coordinator instantly retains 40 percent of the Pandemic Bond/Insurance

Payout Amount held in the Trust Fund, in order to later distribute this amount among Responding Agencies. The remaining 60 percent would be allocated in accordance to the following table.

The underlining principle is the “first come, first served” one, with all the Request for Funds applications received on the same date as considered received at the same time; yet, in case remaining amounts are not sufficient to fulfill all applications requests, then the above mentioned formula is used to pro-rate the remaining amounts until its exhaustion.

2.4.3.2.Cash Window

The Cash Window allocation process is designed to be much faster and flexible. Any Eligible countries may initiate a requests for funds allocation, with the exception of the rare occurrence that in such country has been excluded from IDA's disbursements; or even in case of a novel influenza subtype, in which case it is required an applications from the World Health Organization. Responding Agencies, however, may make request for funds only on behalf of countries.

Requests could be submitted at any time during the outbreak by multiple countries, and one country may submit it more than once for the same outbreak. It will be responsibility of the Steering Body to set a financial limit to the total amount an applicant may receive.

Unless in cases of extreme strong evidences, it is responsibility of each individual country to reach the threshold to trigger the Activation Criteria.

Within 48 hours from the Requests for Funds, an external experts would valuate the request and provide the PEF Coordinator with a recommendation, usually, between US$1 million and US$5 million. If the Steering Body approve it, then the cash would be disbursed to the Responding Agencies, prior indicated by the country, which in turn would provide the country with the funds.

No matter the window a country apply for, PEF funds have to be used uniquely with the aim to efficiently and effectively respond to an infectious disease outbreak, in line with each individual response plan. It may happen that funds are not fully used, either because the emergency drop, or because it is officially declared ceased. In such cases, funds shall be returned to the PEF Trustee, regardless of the original window.

2.5. AIR Experts Risk Analysis

The IBRD relied on the AIR Worldwide Corporation as an independent consultant, responsible for assessing the probability of loss of the Notes (the Pandemic Bonds) due to Eligible Events in Covered Areas and around the world. The AIR Worldwide Corporation was founded in 1987 and, thanks to their independent software, provides catastrophic risk assessment assistance and advice to numerous insurance and reinsurance companies.

An event is considered "eligible" with respect to a particular Class of Notes and the Relevant Virus:

- For Class A Notes: Flu or Coronavirus
- For Class B Notes: Filovirus, coronavirus, lassa fever, rift valley fever, and Crimea Congo hemorrhagic fever.

AIR's estimations of probability distribution of losses due to Eligible Events are based on a probabilistic simulation model, the "AIR Pandemic Model", which generates thousands of simulated infectious disease outbreaks events, in accordance with their specific probability of occurrence, and apply the associated characteristics to datas of population.

AIR's duty was to i) provide estimates of distribution of losses caused by Eligible Events; and ii) evaluate probabilities of attachment, exhaustion, ad expected losses.

2.5.1.AIR Modeling Approach

The available data for outbreaks in the past is not suitable for a direct estimation of probability of future outbreaks and their severity. This is due to the fact that first, the relative infrequency of pandemics before have produced a scarcity of historical data, and second, the risk of a pandemic outbreak constantly evolves, in accordance to migration of animal species, populations, medical technologies and achievements, and other related features.

Consequently, AIR makes use of an alternative methodology based on epidemiological and statistical simulations techniques. The software created integrates the essential characteristics of epidemics, then offers a mathematical representation of the properties of these epidemics to assess their potential morbidity and mortality. The results are formulated in probability distributions, supplying inferences of possible outbreaks, as well as probability of occurrence in case of different levels of morbidity and mortality.

However, it must be remembered that the results calculated by the AIR Model must be considered for what they are: estimates of events that under no circumstances can represent reality in a completely accurate manner. The spread of a disease depends on countless factors that determine its probability, rate of spread, virulence and transmission. No model of outbreaks can ever come to represent the reality of the facts with absolute certainty. The model developed by AIR is based on data taken from published technical papers, historical catalogs of past events,, scientific theories published on journals and so on.

Even the human reaction to the spread of a new pandemic can change its course. Just think of the effects that the lockdown extended for several months last spring have had on the

emergency situation of several countries. The loss probabilities computed by the AIR Model shall not be considered as predictive of future catastrophic events, neither shall be taken for granted the severity that may occur in such events.

3. Chapter 3: CAT Bonds vs Pandemic Bonds

Several experts from the insurance and financial sector were interviewed for the purpose of this thesis. The content of each interview is reflected in the analysis conducted and presented in this chapter. Among the interviewees we can count Dr. Carlo Segni and Dr. Dario Focarelli, who formally gave their consent for the publication of their interview, which can be found in Annex II.

Dr. Carlo Segni joined the World Bank in 1999, and has studied natural disaster risk management solutions, longevity and mortality risk transfer and infrastructure financing. He has worked on several World Bank initiatives, including Mexican FONDEN 2009, 2012 and 2017, CCRIF, the Pacific Risk Insurance program, the Philippines Regional Pool transfer and the Pandemic Emergency Financing Facility (PEF), the Four Countries CAT bond (Pacific Alliance). Thanks to the help of Dr. Carlo Segni, I was able to reconstruct some fundamental steps that led to the creation of the pandemic bonds.

Dr Dario Focarelli is the General Director of ANIA since September 2012, already in 2004 Director of Economics and Finance and Chief Economist of ANIA, as well as Member of the Executive Committee of Insurance Europe (EIOPA). Previously, he worked for the Study Service of the Bank of Italy where he was responsible for research and economic analysis on the financial market, with particular focus on banks and insurance.

Thanks to their experience, In this chapter is presented a more detailed analysis of both the catastrophe bond instrument and the pandemic bond, as well as an interpretation of how the insurance world and capital markets in general should evolve in order to be able to deal with what is, clearly, an emerging and pressing systemic risk.

3.1. CAT Bonds, the experts' point of view

Catastrophe bonds are part of a broader set of financial instruments referred to as Insurance-Linked Securities. These risk management instruments were created to allow insurers to transfer part of their risk to the capital market; still, investors are interested in them because of their distinctive feature, the relationship with an extreme event whose probability of occurrence is rather low. This characteristic is able to diversify investors' portfolios, and their market has grown steadily over the years. The increase in the market is closely linked to the

rise of climate change phenomena and extreme catastrophic events, and, as a matter of fact, experts anticipate in future decades a modest increase in Atlantic hurricane risk[17], which CAT bonds should be able to capture and reflect into their pricing models. Higher prices would consequently indicate an increase also in the returns for investors.

Catastrophic risks weight greatly on the the insurance sector in general, and, in particular, on the reinsurance companies, through which these risks are mainly mitigated, also thanks to the ample liquidity provided by central banks and the low, almost negative, returns in the markets, which have enhanced their capacity to deal with them in recent years.

Generally speaking, the demand for these instruments has registered an increase both for privates and businesses in developed countries. However, in many other countries a wide insurance gap still exists, that experts expect to be covered in the near future. In Europe and in the rest of the world, the market is well established, while Italy remains slightly behind, also due to the fact that the insurance sector in Italy is less developed with respect to the rest of the world. While for the public sector it is a matter of already unbearable debt, privates in Italy are less prone to insurance coverage because of the complexities of the mechanisms. Therefore, the structure of the insurance sector is not favourable for the market. Despite everything, even on this issue our country is making progress, and today almost 5 percent of private homes are insured against at least one catastrophic risk, with respect to the almost near zero percentage of few years ago.

The World Bank also have started to take an interest over catastrophic events back in 2006, working on insurance pools mostly regarding winds and earthquakes. As natural disasters like earthquakes and hurricanes alone can be extremely devastating for developing countries, the situation is aggravated by the lack of insurance penetration in these areas of the World. And indeed, according to World Bank data, only the 1 percent of losses caused by natural disasters in developing countries between 1980 and 2004 were insured, compared to the 30 percent in developed countries, leaving those governments to deal with the burden of the aftermath.

At first, the Bank created in 2009 the MultiCat program, for which the World Bank Treasury acted as an arranger, allowing clients to sponsor catastrophe bonds in a more efficient perspective, in terms of both time and cost. In 2009 and again in 2012, the program allowed

[17] Steve Evans, September 25, 2020. *CAT bond& ILS coupons should compensate as climate increases hurricane risk: Twelve Capital.* Catastrophe bond & ILS news and articles from Artemis.

the Government of Mexico to sponsor catastrophe bonds covering both earthquake and hurricane risks, efficiently transferring a pool of disaster risks to the capital markets.

It became clear, however, that the next necessary step to make was to allow the Bank to issue bonds not ranked AAA, since insurance-linked securities like catastrophic bonds are ranked much lower.

In order to do so, the new Capital at Risk Notes program was launched in 2014, which allows the Bank to issue securities in which investors' capital could be lost in part or in its entirety. Under this program, the Bank launched its first bond in June, a three-year World Bank catastrophe bond related to hurricane and earthquake risks in sixteen Caribbean countries. The bond enabled the Bank for the first time to provide reinsurance to the Caribean Catastrophe Risk Insurance Facility (CCRIF), a risk-pooling facility designed to limit the financial impact caused by catastrophic events, as in the case of earthquakes and hurricanes, by promptly ensuring availability of financial liquidity when a policy is triggered. The bond is covered by an offsetting “catastrophe swap” with the Caribbean Catastrophe Risk Insurance Facility. If a natural disaster of sufficient intensity should occur, the bond’s principal will be diminished, while a comparable amount will be paid to CCRIF, in accordance to the terms of the swap. In case no such event take place, the bond would regularly pay investors at the end of the three years.

3.1.1.Limits and advantages of CAT bonds

According to respondents, in general CAT bonds are still an effective risk transfer vehicle (but not a risk mitigation or prevention instrument), whose market in the past has shown resilience and improvement in terms of efficiency and liquidity. Everything seems to indicate its growth for the near future, also because of the increase in climate change and the extreme events in recent years. There are, however, some limitations which offer some grounds for improvement for the future.

Limits of the structure.

An important pitfall is constituted by the structure of a CAT bond which is, essentially, the structure of a collateralized derivative. As explained in the first chapter of this writing, in traditional catastrophic bonds, the sponsor is the exposed part, which stipulates an insurance

contract with the SPV; the SPV is the issuer of the bonds, whose proceeds are invested in highly rated securities, held in a collateral trust. The issuer is responsible to bestow the return on this collateral, together with the sponsors' insurance premiums, to investors, in the form of periodic coupons on the bonds. On the off chance a specific natural disaster occurs during the term of the bond, part or even the total amount of the assets held as collateral are immediately dismissed and promptly transferred to sponsors. In case the event does not occur, the collateral assets are regularly liquidated on the maturity date of the bonds and the money is paid to the investors. A very critical part of CAT bonds is their link to the probability of occurrence of an event, which is something difficult, almost impossible to predict. Extreme events, even at present, are considered rare and unpredictable, their likelihood of happening depends on historical data. Selection of a triggering mechanism is still a much controversial topic, each type of event offers different returns and pitfalls. . According to Artemis Q2 2020 Catastrophe Bond & ILS Market Report, the majority, roughly 77 percent or $2.9 billion of total issuance, of ILS and Cat bonds issued in the second quarter of 2020 had an indemnity trigger structure, while $715 million of issuance adopted an industry loss trigger and $100 million of issuance preferred a parametric trigger.

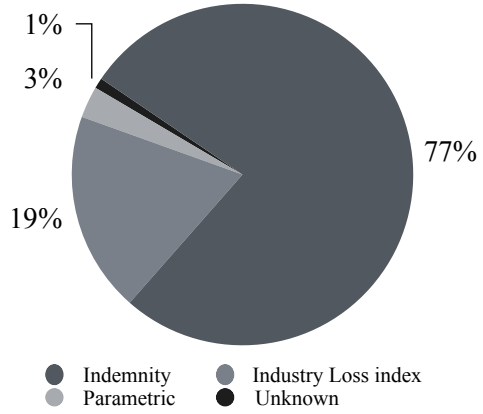
Limited size of the market.

Together with the evaluation of the probability of a specific event, another limit is constituted by the limited size of the potential buyers. Currently, the categories most interested in the trading of CAT bonds are hedge funds and other funds. Still, they require a much higher return than reinsurance. Insurers hence feel the pressure to expand the market, and to stimulate the interest of other institutional investors.

Table 3.1 gives a clear empirical example of how the market is currently very narrow. The data comes from the World Bank website and refers to the recently, issued four Cat Bonds by the World Bank itself, which will supply the Government of Mexico with financial protection of up to $485 million against losses from earthquakes and named storms for four years. These bonds represent the largest CAT bond transaction for Mexico since 2006 with the longest tenor. It was 1.5 times oversubscribed with a total of 38 investors participating[18].

[18] World Bank Press Release, March 9, 2020; World Bank Catastrophe Bond Provides Financial Protection to Mexico for Earthquakes and Named Storms.

Figure 3.1 - Second Quarter 2020 ILS issuance by trigger type



Source: Artemis, *Q2 2020 Catastrophe Bond & ILS Market Report*

Table 3.1 - World Bank's Catastrophe Bonds

	Investor Distribution
ILS Specialist Fund	61%
Asset Management	16%
Pension Fund	15%
Insurer/ Reinsurer	8%
	Geographic Distribution
Europe	52%
North America	42%
Bermuda	5%
Asia	1%

Source: World Bank Press Release, March 9, 2020; *World Bank Catastrophe Bond Provides Financial Protection to Mexico for Earthquakes and Named Storms*.

Furthermore, cat bonds have experienced throughout their lives a rather fluctuant progress, with some problems in 2008 caused by the investment in underlying assets later proved risky as they were issued by Lehman Brothers.

CAT bonds are financial instruments that tend to come back into vogue whenever a natural catastrophe seems to happen and trigger them.

Intervieweds recognized how important is for the future development of this instrument a greater participation of the public sector into the scheme, as States should strengthen their exposure to catastrophic risks by incentivizing the creation of public-private partnerships. Some countries already envision the collaboration between private and public sector, like the French *Caisse centrale de réassurance* (CCR), government entity supported by an unlimited government guarantee, which provide reinsurance coverage for the *Gestion de l'Assurance et de la Réassurance des risques Attentats et actes de Terrorisme* (GAREAT).

3.2. Pandemic Bonds

In 2014, in the African continent erupted again new Ebola episodes which alarmed the World Health Organization. Even if the Ebola virus is known from some years now, we still do not know what was the origin of the outbreak, neither which is the reservoir host in which the virus normally hides.

A substantial difference between catastrophic events and pandemic outbreaks: while catastrophic events such as earthquakes present monetary and financial risks, for pandemics

the most important risk factor is constituted by delays in implementing measures and protocols to contain the virus and to finance the recovery. The later action is taken, the more the situation worsens, reaching an amount of losses that can no longer be recovered, regardless of the financial measures that are subsequently implemented by governments.

Having the World Bank worked with CAT bonds for many years before, it was immediately recognized the necessity to adapt that instrument to this new situation. It was then asked to insurance agencies if there was a parametric trigger which could be used to intervene immediately, in order to contain the damage as much as possible.

The goal was to obtain a trigger that would allow to intervene as soon as possible, taking into account the evolutionary trend of the virus. The most pressing need was to have a parametric system of data collection and conditionality, such as the number of countries affected, the number of infected people and the mortality rate of new diseases. Triggers of this kind are very complex to manage. The longer the transactions were delayed, the more the cost of the interventions would multiply its amount. With an insurance program of a "limited" value, risks of an infinite magnitude could be contained.

3.2.1.Pandemic Emergency Financing Facility ’s structure in summary

Briefly summarizing what was said in the previous chapter, the Pandemic Emergency Financing Facility (PEF) is composed of two windows, the Insurance Window and the Cash Window. Even if presenting similarities with traditional reinsurance, the PEF slightly differs from it, paying out when the event occurs and not after. This is because the aim is to sustain countries financially and transferring pandemic risk away.

While the Cash Window is designed to promptly and flexibly fund developing countries in need of financial assistance during a disease outbreak, the Insurance Window allows participants to have access, basically, to the proceeds of the two pandemic bonds issued by the World Bak itself (the details of the bonds as expressed in the previous chapter are summarized in Table 3.2 presented in Annex II).

The Insurance Window was conceived by the World Bank Treasury in collaboration with the private reinsurance market, specifically, Swiss Re and Munich Re. In particular, Swiss Re Capital Markets acted as the unique book runner, while it share the role of joint structuring agents of the securities with Munich Re, which is also co-manager toter with GC Securities.

The unique independent modeler consulted, defined as the Event Calculation Agent, was AIR Worldwide Corporation, which has developed a probabilistic simulation model, the AIR Pandemic Model, able to supply estimation of losses distributions caused by triggering events, calculating probabilities of attachment and expected losses to the Notes. As pandemic risk factors evolve over time, mainly due to biological and ecologic factors (like the host immunity capacity and the influence climate changes have over the environment and animal reservoirs) but also human behavior, the AIR Pandemic Model aimed to capture those features in order to simulate thousands of potential infectious diseases outbreak events in compliance with their estimated relative probability of occurrence.

The model computed a stochastic event, by taking into consideration key ignition parameters, like the virulence, the transmissibility capability, the availability of developed vaccines and medicines, the annual and location frequency, and of course the morbidity and mortality of the viruses. The model also made use of an updated version of the Susceptible-Exposed-Infectious-Removed ("SEIR") epidemiological model replicating local and global disease transmissions.

Eligible countries will receive PEF funding when an outbreak reaches predefined threshold levels, as number of deaths, the pace of the disease and if the disease trespasses international borders. The PEF is provided with parametric (or index based) triggers, determined on the basis of publicly available data reported by the WHO

3.2.2. Limits and advantages of pandemic bonds

The World Bank's pandemic bonds have suffered, first of all, of one big issue, which is the fact that these instruments have been the very first securities ever trying to capture pandemic risk, and all the interviewed experts agreed on making this premise. They have, therefore, paid the price of having been the leading pioneer in a completely new market, which is, truthfully, starting to develop today. Moreover, as seen before, pandemic risks have some intrinsic characteristics which make it particularly difficult to apprehend in a single instrument, being a symmetrical systemic risk, causing asymmetrical effects in a generalized manner. .

Moreover, pandemic bonds presented also some important structural problems, some inherited from CAT bonds.

Limits of the structure.

The most important one, was the lack of clarity and transparency on how the parametric measures were computed.

In traditional commercial property insurance commonly a premium is paid in return for coverage for losses caused by the occurrence of an event (say, fire). The actual payment to the policyholder is made only after costs assessment and investigation. Parametric instruments such as CAT Bonds have the purpose to cover any losses related to an event, based on the probability that that event will occur. Depending on the probability of occurrence, it is an instrument completely separated by any physical asset.

A parametric insurance product needs two fundamental components:

a. A triggering event, unforeseen and specifically decided previously. For catastrophe related bonds, the parameters used for earthquakes is usually magnitude, for instance.
b. It must be supported by a payment mechanism decided *a priori*, that allows a pay-out in case a pre-settled index threshold is reached or even exceeded, regardless of the effective physical loss incurred.

Traditionally, the insurer has to select a parameter constituted by an objective measure, strictly related to the specific risk the customer is facing and to the subsequent financial loss. Parametric triggers have to be easily measurable, but, most importantly, quickly and effectively reported. In Table 3.4 are reported the main characteristics of both types of insurance, traditional and parametric, showing their differences.

Critics have claimed that the criteria chosen for the insurance window turned out to be too strict to effectively mitigate pandemic risk, especially since pandemics often do not present a linear and clear, but rather chaotic and unpredictable evolution, as COVID-19 has amply demonstrated in recent months. Some argue that it would have been more appropriate to design a scheme that would provide funding for the prevention of an epidemic, taking action long before cases escalated rapidly.

Table 3.4 - Main differences between traditional and parametric insurances

	Traditional Insurance	Parametric Insurance
Payment trigger	Actual loss of or damage to physical asset	Probability of occurrence of an event above threshold
Recovery	Compensation for actual losses	Pre-agreed payment structure based on event parameter
Basis risk	Policy conditions, deductibles and exclusions.	Correlation of chosen index, the pay-out, and the loss sustained.
Claims process -loss assessment and payment	Complex and based on loss adjuster assessment.	Transparent, predictable, based on a parameter or index, quick settlement.
Term	Annual	Single or multi-year
Structure	Standard products	Customized product with high structuring flexibility.

Source: Swiss Re

Limits of statistical data available.

Another problem was related to lack of statistical data. On earthquakes and wind, one can associate events with losses, also having historical data going back to 50, or even to 100 years; on pandemics data are missing, so there were - and there is even today - a lack of sufficient statistical measurements, able to capture pandemic evolution.

Even the parametric insurance system is generally based on objective measurements, insurers and insured still have data that are incontrovertible, that are managed by third parties with a certain level of certainty, as in the case of wind, of which data are collected and organized by the National Weather System. As of now, on pandemics only the WHO provides this type of service, utilizing a monitoring system, which publishes data called Disease Outbreak News, or DONs, a daily system, which gave a sort of standardization of its works, although statistics are not always included.

As a matter of fact, the COVID-19 situation has shown clearly for the first time the need for a systematic data collection structure, which had never happened before now. For the insurance systems, this type of data collection is essential. Insurers need to assess with confidence what the risks consist of in order to calculate the premium accurately. To understand even a small part of the objective risks they are required to cover, they need to estimate the probability that these cases will occur, to have matches with historical series, to see if there are any

precedents, and what the evolution of the virus has been, as well as the evolution of any other pandemic.

The data assessment system on which the PEF was based was not complete, rather quite incomplete. WHO published DONs mainly on a case by case basis, therefore do not provide historical series useful for insurers. The structure for an insurance model was principally tenuous, back in 2016.

A big problem was the fact that being focused on developing countries there were doubts about data reporting, an important and essential aspect of the structuring of the instrument.

Limits caused by the political risk.

Another fundamental aspect, which is often ignored when it comes to the pandemic bonds, is a very strong political risk. If an epidemic or pandemic breaks out within a developed country, the capacity to manage the health system is different from that of a still developing country.

Politics has a huge impact over this type of emergency. A big concern for the World Bank was that the risk was very focused on the African continent, where the ability to detect a risk and understand it is much lower. They therefore have a very high political risk.

Limits caused by the intrinsic characteristics of pandemics.

Surely, it must also be recognized that in any insurance system a basis-risk percentage is always implicit, and that in a complex framework such as pandemics and parametric bonds, the issue becomes even more challenging. Not to mention the fact that the pandemic has another difficult element, namely the issue of geographical distribution.

Pandemics and epidemics are two very distinct phenomena; the latter remains localized, while in the first case we deal with a broader phenomenon, which comprises more countries. At the time, the definition of pandemic on which the PEF was based required at least three countries presenting a minimum of one contagion.

A strong critique was also focused on the choice to design a program which would fund governments only on the off chance a pandemic outbreak occurred, instead of deciding for a financing facility that could help developing countries to prepare in case an event so catastrophic took place. However it must be said that the critics have missed the main point of the PEF. The whole purpose of the PEF was to raise awareness about preparedness for pandemic risk. Eligible countries for PEF's financing under the Insurance Window have to be

all members of the International Development Association. In order to have access to the funds, however, they are strictly required to present a pre-designed protocol of preparedness against epidemic and pandemic outbreaks. Every IDA country intending to partecipate should have presented a preparedness protocol containing all the measures indicated by WHO and World Bank - something which does not exist even in developed countries. At the end, the insurance model chosen was completely irrelevant. It was simply a statistical forum, a discussion vehicle between the public and the private sector, to create risk awareness and assess disadvantaged countries to prepare for a pandemic risk.

The greatest risk is to be caught unprepared when a situation like COVID-19 degenerates. Preparedness protocols may consist of even small initiative, like the creation of isolation spaces fo those who present ambiguous symptoms, in order to prevent other hospital patients to get in contact with the infectious disease. A virus like COVID-19 presents symptoms in common with many other not legal diseases. The availability of an isolated area could have helped hospital to manage the situation in a more safely way. The preparation is an essential element of the mitigation issue, and therefore shall not be separated by the product itself, especially in view of future pandemics.

The World Bank went also a step further, allowing all its loans, no matter the objectives, to be earmarked on demand to face emergency in case of pandemic outbreak, so that countries could have access to the broadest amount of fund available, with an incredible administrative flexibility. Today, all the Bank's loans have this clause for pandemics and natural disasters.

Respondents agreed on the distinction between the preventive instrument and the pandemic bond. Pandemic bonds are a very new instrument, presenting a structural problem, at first it is necessary to understand the aims of such instruments. Generally speaking, these tools are really effective only in the occurrence a pre-defined event; besides, the PEF was born following an outbreak of Ebola to cope with a possible future epidemic in the Third World. However, the real problem is how the event is actually calculated, you have to go to determine what are the parameters, which is a bit of a problem that also exists for CAT bonds.

Many criticisms leveled at the PEF were actually directed at the fact that the calculation of the trigger was unclear. Pandemic bonds as tools that act ex-post can be useful in some countries, used in a localized way. However, for a global pandemic outbreak, as in the case of COVID-19, there is no pandemic bond that holds.

There are also other interesting instruments that could be much more useful from the point of view of prevention, not related to the world of insurance. For instance, after the economic and social impacts caused by the COVID-19 virus, CDP have decided to issue a dual-tranche COVID-19 Social Response Bond, which falls within the CDP's Green, Social and Sustainable Framework in line with the International Capital Market association's Social Bond Principles. The interment's earnings will be fully used to finance intervention whose aim is to fight against the emergency, and to sustain Italian enterprises, specially SMEs; also financially supporting the healthcare facilities.

The big difference between a CDP's bonds and an insurance is that the insurance takes the risk of an event, and therefore the responsibility to compensate for a damage in the face of an event, covering itself by this risk going to download it to investors. CDP, on the other hand, targets investors to seek financing for preventive measures, a transaction which entails a counterpart risk, a credit risk. Basically, the classic structure of the green bond, which ultimately serves to fund this type of interventions, and which takes the form of the social bonds, not to be confused with the social impact bonds. These types of instruments allow to involve foreign investors and capital, to take them to countries where there is a need to make extraordinary interventions of prevention. CDP has issued several of them. The social bond is in all respects a loan, a normal bond. The social name comes from the fact that it has the so-called use of proceeds. CDP is committed as a broadcaster to tell how they will use the money.

This type of structure is always aimed at prevention, construction, improvement. It is made before the occurrence of an event. The financial nature of ILS instruments is quite different. They transfer risks, similar to derivatives, in a collateralized form. The triggers should be associated with the probability of occurrence of the event that goes to cover. Theoretically, the investor should understand from the formulation of the trigger, if the risk you are taking has a more or less high trigger and consequently a higher or lower remuneration (the trade-off between the insurer who wants to get rid of the risk as soon as possible - low triggers - and the investor who tries to get it as high as possible). In fact, there is an implied conflict of interest between the issuer and the investor. So the problem of triggers is very related to the risk assessment itself. By choosing a trigger with an extremely high probability of occurrence, the remuneration required by the investor will also be high.

3.3. Consequences on the insurance sector caused by COVID-19 outbreak.

The current COVID-19 pandemic had, as expected, and still have strong consequences over global economy, which, accordingly to World Bank estimates, it would shrink by 5.2 percent in 2020.

Indeed, experts agrees on saying that we are dealing with the worst recession since World War II. While the principal aim is to address the global health, the consequential economic situation is still an important and alarming emergency the policymakers ought to face. In advanced economies, economic activity is expected to decline by 7 percent this year, with both domestic demand and supply, trade, and finance expected to fall; while in emerging and developing economies, the forecasts estimate GDP to contract by 2.5 percent.

Around the world, policymakers have been attempting in limiting the impact the pandemic outbreak and the controlling measure could have over countries' economies. As of June 2020, the fiscal policy support enacted far outperform measures adopted during the 2008-2009 global financial crisis. However, despite the efforts each country is employing, assessments of the situation drive everyone to affirm that the world will find itself in recession this year.

The economic shock caused by the pandemic is considered by all means systemic and symmetric. There is little use of estimates, which will probably fail to describe the future situation, as the COVID-19 pandemic is still going. Many the businesses activity directly affected by the crisis, with particular mention of the tourism sector which is still one of the most affected.

However, across the world, also the insurance sector have registered its losses and difficulties. According to Lloyd's, the insurance company have paid claims related to COVID-19 pandemic for about £2.4 billion, and is expected to reach £5 billion of payouts, of which only £2 billion are covered by the reinsurance market. In its Half Year Results report, Lloyd's confirmed that the market combined ratio - the measure of success of an insurance company, which captures the relationship between the amount of money it pays out and the amount it receives in payments - of 110.4 percent (which means that for every dollar of premiums, they had to pay $1,104 dollar of claims). Furthermore, to the economic losses it must be added some backlash consequences of the COVID-19 crisis. Indeed, it seems that the liquidity and the solvency of the insurance industry have proven to be quite robust, also thanks to the nature of the insurance business, which is the only sector which receive its payment before the

relative service is required. Rather, the reputation of the industry is suffering, due to a lack of consistency and clarity in communication throughout the whole sector, together with some biases and misunderstand from the citizens of the role the insurance companies plays in extraordinary events like the one we are witnessing this year. Nevertheless, the whole industry has guaranteed a continuity of the services, which was something not given since no one could expect the magnitude and the extent of this crisis, which strongly affected the (re)insurance industry too among other business activities. The main problem the whole industry is facing right now is the great amount of uncertainty it is experiencing. As a matter of fact, the element of uncertainty is quite important.

There is an essential need to understand what would be the future impacts over economies. The reality is that this huge amount of uncertainty, and volatility in the equity market, is affecting both the asset and liability sides of insurance companies. They do not know if this is an event which would go beyond the 99.5 confidence level in Solvency II. The fact that we are living one of the greatest event in history is evident to all. The insurance sector has always concentrating itself in providing assistance to customers by providing them different life-insurance product when dealing with a pandemic outbreak.

As it happened after Hurricane Andrew back in 1992, COVID-19 has revealed a significant protection gap, on which institutions and insurance and reinsurance companies must intervene.

As the risk have changed its profile, the situation have shifted the focus from the need of life-insurance products, to a Property&Causality perspective, which concerns travel insurances, event cancellations, and, most importantly, business interruptions. As of today, the biggest issue the whole industry have to face is indeed the non-damage business interruption caused by the containment measures adopted. On this matter, uncertainty at the moment is even more persistent as countries have reacted to the coronavirus pandemic emergency in different ways, offering different solutions. The problem is that there are different products which terms are not clear, subject to interpretation, augmenting the uncertainty which characterize this historical moment, financially speaking, with repercussions over the reputation of (re)insurance companies.

Still, in this particular moment the insurance industry will have to face different challenges in order to provide costumers with risk transfer products able to mitigate systemic risk such as pandemic outbreak, for the current emergency, and even more for future outbreaks.

In addition to the changed condition of the insurance market, also customers, as already said, have changed their requests. Lloyd's have conducted in those months a series of interviews to experts and executives in order to understand what are, in light of the current COVID-19 crisis, the changed needs of their customers. What it emerged is that both insurers and brokers should focus in the following months on how to strengthen society's resilience, protecting customers as they restart their businesses, especially in the short run (a summary of the results is presented in Table 3.6 in Annex II).

3.3.1.Non-Damage Business Interruption and the EIOPA

The COVID-19 outbreak have highlighted an important protection gap since now not considered or undervalued by the insurance industry, losses caused by non-damage business interruption insurance (NDBI).

This type of coverage is strongly related to catastrophe risk insurance programs, which often focus on property damage, both in case of residential and commercial buildings. As a matter of fact, protection against business interruption is already present in some jurisdictions, usually as an optional feature, triggered by physical damage. However, since now this type of cover was not considered a priority for the majority of insurance's clients, hence it was not generally acquired. Besides, non-damage business interruption pose an additional problem to the equation: while in case of earthquake, fire, or hurricane, damages to properties are quantifiable and objective, it is difficult to quantify the business interruption losses incurred because of a pandemic outbreak.

Demand is changed now, and the industry is trying to understand how to supply new products to its customers for the future. There is an increasing need to provide new forms of protection against systemic risks, starting with a greater understanding of pandemics and other systemic types of risks, and the aim is to join efforts with governments and the business side in order to develop products able to depict those risks. Systemic risks are challenging to forecast and assess, and are so large in scale they render traditional risk mitigation and transfer methods

unfeasible, requiring financial resources far in excess of the global (re)insurance industry's asset pool. As the pandemic has shown, when a systemic event occurs, given the limited commercial cover, governments step in to protect their citizens. Although the global insurance industry does not have the capacity to absorb systemic catastrophic events ('black swan' events) on its own, it can help develop national or regional structures that could provide protection. As stated before in this writing, various countries have started to discuss possible solutions which can be proved effective for the next COVID-19 waves or for future pandemics. All over Europe and the world, working groups were set up in roder to accelerate the process.

In France, for example, it has been suggested to establish an insurance program, CATEX (*catastrophes exceptionnelles*), funded by SMEs paid premiums, with government support, covering business interruption losses caused by catastrophic events, which overcomes the problem of parametric triggers. Indeed, the peculiarity of this proposals is the choice to activate payments basing on state administrative action, resulted in the closure of businesses in a given geographic region for a specified amount of time, applying to both businesses directly and indirectly impaired by the administrative order. Beside, in order to achieve a broader coverage, CATEX would accompany either commercial property or business interruption coverage.

In the United Kingdom, industry representatives working groups have already presented four different coverage program proposals, three of which developed by the Lloyd's market: a government-backed reinsurance pool, *PandemicRe*; a short-term insurance program, *ReStart* program, targeting business interruption coverage for small companies in case new waves of COVID-19 outbreak occurs; a medium-term *Recover Re* program, collecting premiums for NDBI events, including future waves of COVID-19; and finally a long-term instrument, *Black Swan Re*, which is a reinsurance pool supported by a government guarantee.

In confirmation of how much is necessary this collaboration between public and private, the European Insurance and Occupational Pension Authority (EIOPA) too seems to be moving in this direction. EIOPA, indeed, suggests to adopt solutions to non-damage business interruption risk which entails different risk owners, creating opportunities to transfer risk between layers. This proposal arises from the need to create solutions that provide for the

participation of all parties involved, even policyholders, on the scale of four fundamental elements, i) assess the risk; ii) plan mitigation and adaptation initiatives; iii) develop a new product; iv) find a mechanism which enable to share the risk.

A solution engaging all the layers would reduce the risk of moral hazards, yet, to be efficient, agreement on risk retention levels should be clear and transparent for all layers. Some of its suggestions include (all proposals and further details are presented in Annex III):

A. The establishment of a of an European expert group focused on risk modeling and data sharing;
B. The creation of a platform for public and private coordination on prevention measures;
C. Targeting NDBI products at small and medium enterprises;
D. Impose a mandatory coverage for NDBI insurance;
E. Develop capital markets solutions for diversifying pandemic risks;
F. Establishment of a national/EU funding mechanism for pandemic risk coverage.

The European Union would play the role of risk prevention promoter, responsible for both encouraging and coordinating measures taken at national level, finishing financial support, through financing or a reinsurance system. To avoid further increasing economic fragmentation between Member States as a result of a pandemic crisis, the EU would also intervene at national level.

3.4. What could we learn for the future.

The COVID-19 outbreak, as devastating as it was, would undoubtedly teach a lot on how to be prepared for the next pandemic.

I. A product so designed turned out to be poorly suited and slow to keep up with the disease. For the future, it would be better to develop more appropriate and relevant statistical models able to predict how and with which pace the situation would evolve from an epidemic and a pandemic. We must learn how to predict these phenomena, most importantly because it appears now clear that these outbreaks occurs every 20-25 years. The statistical model used back in 2016, when the Bank was starting to design the PEF, estimated the risk for what is today known as COVID-19 not insignificant, but rather about 11-12 percent, with the potential to create endless losses. Of course, at the time no

one believed it, still today we know that this is the fourth coronavirus in the last ten years, the fourth pandemic in a decade.

I.A. The PEF was designed to respond to different viruses, in order to have a broader coverage. It became clear, unfortunately, that for a virus like COVID-19 the system created by the World Bank is not sufficient to capture in time the evolution of a pandemic; after all, it was constructed on the basis of the Ebola virus, which has a much slower transmission pace, allowing for prompt intervention. A new product should consider this aspect and should try to capture viruses characteristics into their triggering parameters.

II. It is important to start to discuss now on how to develop this market, and it seems that, at this very moment, in many countries solutions are being studied. COVID-19 experience have made also clear that the private (re)insurance sector alone could not support the weight of another wave or a new future pandemic. The private system is not able to pre-finance the estimates that we see today. The PEF, as its ultimate goal was to raise awareness, was a discussion vehicle intending to include also the private sector, so to incentives the development of new products.

II.A. A public-private partnership would not only be desirable, but it would also be the right incentive to develop this new pandemic bond market. It is vital to bring the discussion also to institutional and European level, even if the challenge to build a product attractive to investors with an adequate appetite for risk and able to evaluate this asset class as well, will slow down the process. The current situation we are living has prompted all parties involved to start studying new solutions which, together with health experts, virologists and, in general, the scientific community aims at finding mechanisms able to predict the frequency of these events. The biggest challenge facing the insurance industry as of now is to conceive models capable of capturing the effects of outbreaks more localized, but also more extended in time, in order to overcome the difficulty presented by geographical distribution, and to take account also of the effects caused by the reactions of governments, even considering not to

adopt a total lockdown.

II.A.1. A systemic risk is unbearable for the insurance industry alone, as we have seen in the second chapter of this thesis. Generalized systemic risks are very difficult to mutualize and diversify, almost impossible for insurances to cover, also because of the capacity needed to sustain risks of this entity, which could drain global insurance financial resources. Besides, also the issue of the pricing of premiums has to be considered, and so far the whole sector agrees on stating that, in case the coverage is available, the premiums would be significant fro what many customers so far have considered a remote risks. This pone the insurance industry in a difficult situation, in which it must concentrate and cooperate to develop new products and structures in those areas where protection gaps exist today to support business recovery over the short-term post lockdown, and provide greater resilience over the medium to longer term.

II.B. The biggest problems were created by a poor preparation of hospital facilities. For the near future, it might be necessarily to identify a similar system to pandemic bonds for the financing, for example of field hospitals. Beside, there is the problem of medical equipment, which becomes quickly and easily obsolete and is no longer usable between one pandemic and another. It would therefore be desirable to devise a system which would cover all the aspects of a pandemic, ex-ante preparation and ex-post financial support. To this end, two very different products such as the Social Bond of *Cassa Depositi e prestiti* and the Pandemic Bond of the World Bank, could complement each other, going on one hand to meet all of households and businesses' needs, that, if an event occurs, they are still covered; On the other hand, with instruments such as the Covid Bond or the Social Bond issued by CDP could help to mitigate this category of risk - especially since preparedness is the only mitigation activities that could actually work.

Conclusions

Having reached the closure of this thesis work, it is possible now to draw conclusions about the topics covered in this paper.

First of all, it is important to state that the reality of climate change, and in particular of natural catastrophic events, is an issue that touches mankind in an increasingly close and urgent way, which must be addressed promptly. Greenhouse gas emissions are increasing at an accelerating pace, causing concern to governors around the world. Although proposals for early action have flourished in recent years; on September 28th, 2020, at the start of Climate Week, the Climate Clock appeared on a Union Square skyscraper, with the aim of making people reflect on how much time the world has left to act before an irreversible climate emergency irreversibly alters human existence. Still we are far away from reading the goal.

Climate change is also the main driver of the increase in the intensity and frequency of extraordinary climate events. The probability that a catastrophic event of natural origin will occur has increased significantly compared to the values of a few years ago. Suffice it to say that this year's hurricane season is considered by experts to be the most active since 2005. Since the beginning of this year, to date, the number of hurricanes that have occurred is already almost equal to the number that the National Hurricane Center predicted for the entire year. The repercussions on the global economic system are obviously directly proportional to the intensity of these events. For this reason, the insurance and reinsurance industry, which was the most affected after the occurrence of an event, has developed a financial product capable of capturing risks and transferring them to the capital markets. This is how climate and disaster risk insurances are born, with the main purpose of intervening to assist the regions affected by these phenomena. One of the main device adopted by insurance companies is the CAT bond, which allows insurers to transfer the risk.

However, another catastrophic disaster of natural origin caused, as scientific evidence seems to indicate, by climate change is the increased pandemic risk. We have seen that pandemic risk has intrinsic characteristics that make it particularly complicated to capture within a financial instrument and to mitigate.

Before COVID-19 (which is now the fourth coronavirus, and the fourth pandemic outbreak in the last decade), the only attempt to mitigate and transfer this risk was made by the World Bank in 2016, with the issuance of two pandemic bonds focused on third world regions.

CAT bonds and pandemic bonds have, being one based on the other, obvious structural similarities. However, pandemic bonds have also inherited from the previous instrument its weaknesses, in addition to their own. A summary representation of these differences and similarities is provided in the table below.

One of the most important structural aspects is the choice of the trigger used. If for CAT bonds there are different types of triggers to choose from, and the most popular one seems to be the indemnity loss, for World Bank pandemic ponds, the choice fell on parametric triggers. This choice is motivated by the nature of the pandemic itself and its consequences, which can hardly be quantified as for winds and earthquakes.

However, it is precisely this aspect that has raised the most doubts and perplexities, especially on the part of investors. The choice made appears not to be too clear and transparent, giving room for too many interpretations. Most importantly, another very important critical point is the complete lack of a database containing historical data on which to build a statistical model. Moreover, pandemic risk also carries a considerable amount of political risk, which is difficult to ignore. Experts seem to agree that a country's ability to respond to a pandemic has an influential effect on the costs and funding for recovery. The World Bank's pandemic bond was focused on countries with a high political risk, hence with a low capacity to cope with an emergency of this magnitude.

One aspect in common of the two instruments is their posthumous intervention purpose, i.e., both serve as a resource of funds after the occurrence of an event.

COVID-19 has amply demonstrated that there is a protection gap that not only (re)insurance agencies, but also, and above all, governments must reflect on. If in these days we are witnessing the birth of new financial instruments that aspire to mimic the World Bank’s pandemic bonds, as the *Black Swan Re* or the French program CATEX, it is also true that there is an urgent need to take some corrective measures:

The pandemic risk has very complex intrinsic characteristics, such as the problem of geographical distribution. It is unthinkable for the private or public sector alone to face the costs of a global catastrophic event such as COVID-19. The estimates we see today make it a very clear concept. The formation of PPPs would therefore be desirable in order to face the

problem anyway. Although a pandemic is not a localized phenomenon, it would be appropriate for countries to adopt instruments designed to act in a localized manner,

Since one of the greatest limitations of the World Bank's pandemic bonds has been the lack of a standardized, systematic and statistical data collection system that would allow the efficient development of predictive statistical models, it would be appropriate to organize oneself in this way so that we have a globally uniform system; If on the one hand a collaboration between public and private is necessary, it is not unthinkable at that point the idea of building a risk-sharing solution at European level, since Europe, by geographical and cultural conformation, is one of the most suitable territories for the spread of a virus, as has been demonstrated. Obviously, in that case the responsibilities and burdens of each layer should be clearly and transparently defined. Financial instruments such as pandemic bonds and CAT bonds are instruments that aim to act ex-post an event occurs. Yet, as emerged from the interviews, the most important part of mitigating this risk is the investment in preparation. There is no way, no statistical model that holds, to accurately capture the evolution of a disease, especially if we are dealing with a new virus, which scientific studies say may happen more and more frequently. It is therefore necessary to think about the idea of being able to integrate for a purpose two very different instruments such as the Covid Bond of CDP and the pandemic bond.

Table - CAT bonds vs Pandemic bonds

	CAT bonds	**Pandemic bonds**
Structure	Lack of trigger transparency	Inherent lack of trigger transparency
Statistical model	Based on historical data	Lack of historical data, lack of a standardized and organized data collection process and of statistical models
Market	Limited market interest; Potential growth	Limited market interest; Potential growth

ANNEX I - INTERVIEWS TRANSCRIPTIONS

1. Dario Focarelli's interview transcription

Q: Could you tell me your perception of disaster risk and its importance for insurance companies?

If we talk about Italy, it is a growing burden as the demand for coverage of families and companies from these risks is increasing. By now almost 5% of private homes are insured against at least one catastrophic risk against the almost zero values of a few years ago. The demand for insurance for companies is also growing.

While demand in developed countries is growing steadily, on the other hand, the insurance gap in countries is still very wide. In perspective, it is precisely the emerging countries where the demand for coverage could increase significantly.

Q: How strong is the need to mitigate such a risk for the insurance world?

The retention capacity of insurance companies directly is quite stable and relatively small. Mitigation largely takes place through the global reinsurance market, which offers a high capacity, especially in recent years characterized by very large central bank liquidity and very low, if not negative, market returns.

Q: What are the usual ways to mitigate this risk? Is CAT bond an effective way? What are the limits of such an instrument in your opinion?

Certainly. It is a market that is improving in terms of efficiency and liquidity. Some problems were experienced in 2008 when the underlying assets were also invested in risky assets (bonds issued by Lehman). In my opinion, the situation has improved a lot.

However, one limitation is the still limited size of potential buyers, who are essentially hedge funds and other funds, which often require a much higher return than reinsurance. The predominant theme in recent months is therefore to make this market attractive for institutional investors as well.

Q: What are your expectations regarding the evolution of the CAT bond market?

I believe in a development perspective, especially if public-private partnerships are strengthened around the world and if countries try to reduce their exposure to catastrophic risks.

Q: Has the current pandemic had a heavy impact on insurance companies? Which ones?

Disruptive as for the entire economic system, especially in terms of premium income. In some countries and in some sectors, we have seen a sharp increase in claims, estimated at $50 billion. It is also true that other sectors, such as motor insurance, have seen a reduction in claims, at least during the lockdown period.

Q: Did insurance companies put in place tools to specifically mitigate pandemic risk or other pandemic-related risks?

In reality, the only protection from this risk was essentially exclusion from coverage.

Q: Have there been cases of pandemic bond issuance by insurance companies in the past?

To my knowledge, the only pandemic bond ever issued is the one emitted by the World Bank**.**

Q: Could pandemic bonds in the future be an increasingly useful tool for insurance companies to mitigate the direct and indirect impacts of a pandemic in the light of the experience we are experiencing?

It is very difficult technically, due to the intrinsic characteristics of the pandemic, since it could affect the entire planet at the same time. But the fact that in many countries - as reported by the OECD - solutions are being studied in which the private insurance market supports the States, makes it clear how relevant the issue is.

Q: Could pandemic bonds follow the example of CAT bonds for the insurance world?

If PPP schemes start out, then the pandemic bond market will certainly emerge, although I think it will be a rather long road, due to the difficulty of finding investors capable of evaluating the stock and with an adequate appetite for risk.

Q: Pandemic is a symmetrical risk with asymmetrical effects. Therefore, the World Bank had an easy time preparing a pandemic bond for countries with asymmetric social infrastructure. But a generalist pandemic bond, i.e. one dedicated to more developed countries, what differences should it have?

The World Bank bond is clearly very interesting, but it was a small bond that covered limited needs in developing countries. Clearly a generalist bond would need to raise much but much more capital. It would be far larger in size and more difficult to appeal for investors.

Q: What are the statistical bases for evaluating the suitability of pandemic bonds or insurance programs for pandemic risks?

The insurance market is trying to figure out with health experts, virologists and the scientific community in general how to predict the frequency of these events. These days, there seems to be a growing consensus that episodes of this kind can occur every 20-25 years. While before COVID-19 a return risk of at least 33 years was imagined. If this is confirmed, it is quite clear that our economies will have to adapt quickly to these events.

Q: Since the pandemic will certainly be among the excluded risks of many future policies, especially but not limited to business interruption, are there any ways to bring these excluded risks to specific general coverage programs?

The only way is to stimulate the interest of reinsurers, who at the moment - understandably - seem to have a very cautious attitude.

Q: In insurance companies' statistical bases how did the pandemic enter before 2020 and how does it enter now?

I add to what has already been said that they are trying to model the effect of i) outbreaks more limited in space but more extended in time; ii) government reactions not focused on total, but partial lockdowns.

2. Carlo Segni's interview transcription

Q: How was the pandemic bond born? On what did you base yourself?

In about 2006-2007 we started designing and issuing derivatives on catastrophes, working on insurance pools especially on winds and earthquakes. Even before 2014, when the Ebola crisis started, the World Bank had already started issuing more bonds (e.g. Mexico, CCRIF). In 2013 we created a parallel program parallel to the Bank's issuance one to allow the Bank to issue bonds that were not necessarily AAA - of course, catastrophic bonds have much lower ratings, and the World Bank was not authorized to issue bonds that were under AAA rating. Hence, the birth of a parallel program, called Capital at Risk Notes (CAR). The program has quite extensive disclaimers that explain investors that, if an event happens, the capital could be lost. In 2014 Ebola breaks out, I remember that we have been called a couple of times in meetings and the thing that mainly amazed me was that if anything, a pandemic was a catastrophe with a significant exponential curve of losses across time, contrary to other catastrophes like earthquakes, for example, that provokes immediate and definitive losses. Losses from pandemics grow with time, and are a function of preparedness, economic development, trade and travel patterns, and importantly, policy response, appropriation risk and delays (the later you intervene and worse it is).

So we tasked ourselves to simply ask insurances and statisticians if it was conceivable to design a trigger that would allow us to intervene as soon as possible. The objective, referring to the evolution of Ebola of the time, was to have a trigger that would allow us to intervene as early as June. The longer we waited, the more the costs increased. We needed a parametric system, a new model, and data was the main issue, as well as a robust history of events to build a model for insurance.

Q: How do you respond to criticism about the chosen triggers? What are the limits of this device?

I would like to make a premise: PEF was the first time that assessing pandemic risks on an analytical basis, involving the capital and insurance markets in a transaction, was brought to

the attention of the world. And it definitely paid the price of novelty and the unanswerable question on why buying insurance. In this market you need to find the balance between costs, the desired coverage and minimal basis risk, which is naturally a complex exercise for new perils with little history. The viruses and pathogens considered are different, and this was a choice made specifically to allow PEF to cover a fairly wide range of pandemics. Not to mention the fact that the pandemic has another difficulty coefficient, namely the question of geographical distribution. Pandemics and epidemics are two distinct phenomena, the second one remaining localized, while in the first case we are talking about a wider spread, over several countries. In addition, we had no statistical data. On earthquakes and wind there is a long history of observations on events and losses, sometimes going back to 50 or 100 years. Pandemics are rare events in history, getting more frequent, but rare and even today there are sufficient statistical measurements.

Another key aspect is political risk and economic development. If an epidemic or pandemic breaks out within a developed country, the response capacity of the health care system may differ sharply from Africa, where the core of pandemic risk resides. Least developed economies have naturally less physical and fiscal capacity, so they are less prepared to detect and contain an outbreak. On the contrary though, a less developed country is not as economically developed, so people travel and interact less, thus reducing the risk of an outbreak becoming a pandemic. Last, policy response may be sharply influenced by politics, as we can see now with COVID.

Just imagine that one of the biggest causes of delay on Ebola was pure bureaucratic administrative measures, which required the direct involvement of the former US President, and, in the end, a month and a half of administrative delays cost billions.

The parametric insurance system is generally based on objective measurements and observations. On pandemics as of today WHO and few others provide data collection and monitoring services, namely DONs, Disease Outbreak News, which gave us a sort of stable source of data which we could standardize and make commercial/insurable. Actually, with the Covid-19 we have for the first time the need for a systematic data collection and detection infrastructure, something global, apolitical, a global good. Insurance systems to calculate the premium must first understand what is the probability that certain cases may occur in a certain

place, look at historical series, see if there are similar cases previously reported, and what has been the acceleration, the evolution of any other pandemic, to understand a little 'what is the objective risk. This data evaluation system was not complete. WHO published very confusing DONs, case-by-case, we had no historical series that could be used. The structure for an insurance model was also weak.

Q: If there is a positive trend for pandemics, a market for such catastrophic events should be created. What can the insurance industry take/improve from PEF for the near future?

PEF was not necessarily designed as an insurance model. Rather, the goal of PEF was to create public awareness. We wanted to make everyone complicit or at least aware of the risks. We used insurance to put the private sector into a broader discourse, but PEF was created on the basis of any insurance tower. The insurance tower basically says that with a minimum budget, you can cover conceptually endless losses. With pre-financing you create liquidity that, when there are warnings of a small outbreak, you immediately throw in the middle to try to stop it immediately. Then you build in the organizational evolution of an epidemic, you create a system that triggers when the risk is between 50% and 20%. All this had to be put into a statistical system where you had to go to a donor and tell him that the loss at some point was almost infinite, and the probability of loss before reaching that level is also high. Our statistical model in 2016 identified the COVID-19 risk as not insignificant, but about 11/12% (with possible infinite losses). No one believed it. The idea, however, was to make policymakers aware that 11/12% exposure can cause infinite losses, bringing private individuals into the equation.

Q: And the statistical models you adopted?

We contacted three modelling firms when we sterted the project: Air Worldwide, which is the one we used; RMS and and Metabiota, founded by Nathan Wolfe. This experience was very useful , especially in developing a model capable of being commercialized with the private sector.

That said, there are important issues at the political level. Many countries have problems with budget allocation for the development of a response infrastructure, in the provision of vaccines, instruments and infrastructure, and implementation of new diagnostics and therapies. Coronaviruses are difficult, they are too fast and with very high risk. The biggest problems seemed at the time the lack of preparation, the quality of the health systems in many countries to cope with a quick contagion, and the ability of a virus to travel so quickly across communities and nations. Statistical models can capture the risk of potential events, but much is dependent on all above constraints and variables.

To cope with all these questions, statistical models can observe the history, and build on strategic assumptions. I noticed a nice work that built on three layers of metadata, calculating the intensity of night light as a measure of the economic development of a country; air traffic data, because travel is an important factor in the ability of a virus to propagate, and cellular traffic data, which measures the intensity of the connections between social groups, and thus a proxy again of the ability of a virus to propagate. Paradoxically, Africa has a higher risk of outbreaks, but a lesser probability of an outbreak to become a pandemic because of travel patterns. COVID in China, for example, was definitively another story, a combination of population density, travel, trade, etc.

Q: What can we learn from PEF for the future?

The goal of PEF was to provide a fast delivery mechanism, but also to raise awareness and encourage pandemic risk preparedness by also involving the private in the equation. PEF funds are available to the poorest countries, which commit to implement changes and preparedness plans in accordance with WHO standards. Each country should have a preparedenes plan and protocol. Many African countries have put plans into practice, and in reality they consist in sometimes simple actions . The insurance model was the vehicle for the public and private sectors to create risk awareness. Those who are criticizing the initiative may have overestimated the main objectives and the outcomes of the initiative. I remember the President of the World Bank once mentioning in a meeting that irrespective of the outcome, PEF opened a new dialogue, something never discussed before.

Importantly then, the World Bank too changed its protocols and went one step further, introducing clauses in each and every loan that allow countries to use the undisbursed funds of projects to cope with emergencies such as a pandemic. This was unprecedented, an incredible flexibility for the administrative standpoint.

Q: Is it possible, in your opinion, to adopt PPP programs to address the problem of pandemics?

In my personal view, we must encourage discussion of pandemic risks, interface with experts, continue to prepare protocols and create all the administrative flexibilities that do allow to quickly respond to crises such as COVID. We must move away from the pure financial problem and perhaps use the insurance system only as an objective estimate that allows to monitor real risk. Insurance and the private sector do not have the capital and balance sheet to cope with a COVID crises, but they can bring rigor and discipline, and can stimulate flexibility and preparedness. And a statistical model, as well as the data infrastructure that feeds the model, can tell you a lot. In addition, and this is very important to me, the governments must act as a whole. We saw how important the social safety systems are, their ability to reach those in need, the informal sector, to allow people to survive in a lock down without being forced to leave the house for basic needs.

ANNEX II - PEF'S TERMS AND CONDITIONS

Table 3.2 - Pandemic Bonds Summary Terms and Conditions

	Class A Note	Class B Note
Issuer	IBRD	IBRD
Sponsor	Pandemic Emergency Financing Facility	Pandemic Emergency Financing Facility
Placement/ structuring agent(s)	Swiss Re Capital Markets; Munich Re Capital Markets, GC Securities	Swiss Re Capital Markets; Munich Re Capital Markets, GC Securities
Issue Price (100% of Aggregate Nominal Amount)	US$225 000 000	US$95 000 000
Issue Date	July 7, 2017	July 7, 2018
Maturity Date	July 15, 2020	July 15, 2021
Rate	NR	NR
Risk Modeling/ calculation agents	AIR Worldwide	AIR Worldwide
Bond Coupon	6m USD LIBOR + 6.50%	6m USD LIBOR + 6.50%
Covered Disease	Flu, Coronaviruses	Filovirus, Coronavirus, Lassa Fever, Rift Valley Fever, Crimean Congo Hemorrhagic Fever
Trigger type	Parametric	Parametric
Redemption Amount	The Notes will not be fully repaid id the an even occurs	The Notes will not be fully repaid id the an even occurs

Source: World Bank, 2017

Tabella 3.3 - Distribution by Investor Type and Location

Distribution by Investor Type	Class A	Class B
Dedicated Catastrophe Bond Investor	61.7%	35.3%
Endowment	3.3%	6.3%
Asset Manager	20.6%	16.3%
Pension Fund	14.4%	42.1%
Distribution by Investor Location	**Class A**	**Class B**
US	27,9%	15.0%
Europe	71.8%	82.9%
Bermuda	0.1%	2.1%
Japan	0.2%	0.0%

Source: World Bank

Table 3.5 - Payout Conditions for Class A and Class B

		Rolling Confirmed Case Amount	**Growth Rate**	**Growth Rate Mean**	**WHO Report**	**Total Confirmed Death Amount**	**Confirmation Ratio**	**Geographic Spread**
Class A	*Flu*	Greater than or equal to 5000	Greater than zero	Greater than or qual to 0.265	Yes	/	/	/
	Coronavirus	Greater or equal to 250	Greater than zero	/	Yes	Greater than or equal to 2 500	Greater than or equal to the Confirmation Ratio Threshold	Either Regional or global
Class B	Filovirus, Coronavirus, Lassa Fever, Rift Valley Fever, Crimean Congo Hemorrhagic Fever	Greater or equal to 250	Greater than zero		Yes	Greater than or equal to 250	Greater than or equal to the Confirmation Ratio Threshold	Either Regional or global

Source: PEF Prospectus

Where Confirmation Ratio is computed as follows:

$$CR_t = \frac{RCC_t}{minRTC_t,_{750}}$$

- CR_t is the Confirmation Ratio related to such Eligible Event;
- RCC_t is the Rolling Confirmed Case Amount
- RTC_t is the Rolling Total Case Amount
- And the Confirmation Ration Threshold is equal to 20.00% for Class A Note, and equal to 33.33% for Class B.

ANNEX III - EIOPA's SUGGESTIONS ON SHARED RESILIANCE SOLUTIONS

Suggestions	+	-	
Establishment of an EU expert group for data sharing and risk modeling	• Provide standards and/or harmonization • Collective need, collective effort • PPP - it would need deliverables and governance structures	• Interests may vary • Low efficiency • A lot of company data (which are confidential)	
Use of current cat models to model NDBI risks related to pandemics	• Current cat models provide risk modeling for (1) life and/or mortality associated with pandemic events or (2) business interruption coverage largely as a function of the material damage loss calculation (some include consequential BI losses of interdepend parts of the production chain)	• It might not be sufficient • BI vulnerability do not differentiate between loss of profit and loss of revenue coverage • Do not adequately capture factors driving the expected duration of interruptions (most commercial cat risk models considering pandemics do model mortality risks, for example, but do not make the link with BI losses)	
Reflect prevention measures in NDBI insurance premiums and policy conditions	• In particular if this is a pre-condition for insurance coverage, it would contribute to the affordability on a long-term basis and support the resilience of the European economies by minimizing risks and losses	• Policyholders may have difficulties in assessing the true value of costly risk prevention measures vs. the insurance premium spent. • Insurers may lack tools and data to measure the efficiency of the prevention measures and reflect the effect in the premium or policy conditions.	
Create a platform for public and private coordination on prevention measures.	• Prevention of misalignment of measure take at different levels • More efficient and targeted risk reduction, which would promote the recovery from the pandemic • Could range from containment measures (incl. testing, modelling, contact tracing or lock-downs to contain the spread of a disease) to measures for strengthening the public health system • Combination from public and private sector knowledge could result in more optimized containment measures	• Sectoral interests, the need for expedient action and the lack of a holistic risk assessment across the market made such coordination difficult. • The interest of the market and public interest may also not coincide	

Provide simple and transparent NDBI coverage for pandemics	• Quit coverage and understanding for policyholders • Clear statement of conditions a) triggers, b) scope c) exclusion • if the premium is risk-based, it can be used as a transparent indicator of the risk and thus for monitoring how the risk evolves over time • Reflect risk prevention measure in the premium • Bundling the cover with other existing products for the affordability of the product and simplification of access	• Accumulation of the risk • Some negative economic consequences result from administrative decisions rather forms he actual pandemic, since pandemic risk differs with respect to other systemic risks • Lack of data • NDBI is a complex matter with respect to a simple product • If offered with other products it may not be very transparent • Need of specific policy conditions • More thought needs to be given to current definitions of BI coverages as different aspects of BI-related losses, such as loss of turnover, loss of profit, increased cost of working etc. need to be reflected in the NDBI product. Combining an NDBI coverage with typical BI coverage could be difficult to handle if there is different reinsurance and state protection cover for the NDBI part.	
Target NDBI products at small and medium enterprises	• SMEs do not have the financial capability to withstand any sustained shut down of activity	• All size companies have been affected • Interconnecotvity of the economic losses makes it difficult for companies to survive the iris • Covering more across may help to mutualism the risk	
Offer parametric Insurance	• quick settlement as the payment structure has been pre-agreed based on an event parameter or index value • It avoid complexity based on loss adjuster assessment • Hybrid solution can be created, where the product is parametric but the waiting period is variable, depending on risk measures and mitigation adoption • Use parameters to calculate the compensation (see CATEX)	• parametric trigger is typically an objective parameter • Possible significant basis risk • Clear and legally binding definitions of triggers • Difficult to link to risk managemtnachievments at company level since based on external parameter • Trade off between fairness of coverage vs need for swift pay-ou	

Require mandatory cover for NDBI insurance	• Assumption: insurers would be required to develop insurance products to cover BI risk in pandemic • It could mitigare adverse selection • Less importance of lack of awareness and behavioral aspects preventing consumers to buying insurance • Full range of commercial enterprises, regardless the size	• Less exposed policyholders would subside more risky profiles • Would not ensure affordability: high risk based premia will reflect high risks • Could be expensive • Collected premia may still be not enough to cover NDBI losses for future pandemic	• Some elements of public enhancement may be needed as part of the subsequent layers of risk transfer.
Implement national insurance and reinsurance pooling	• Increase market capacity by diversifying risks among a broader base of insurers • Providing capacity for buying reinsurance cover in particular for extreme risks • Pool can be of temporary nature; Can be constituted as private or public-private entities • Promote sharing of risks and knowledge among different market participants and/or with the public sector. • Incentive for prevention measures	• Nation pools are usually limited geographically to the member state. • Limits in diversifying risks to their liabilities an assets in the event of a systemic or pan European pandemic • The scale of current pooling arrangements for NAT CAT or terrorism is very small compared with the potential losses of a pandemic	
Develop capital markets solutions for diversifying pandemic risks	• Layer of risk transfer and diversification in addition to (re)insurance solutions	• May be correlated with traditional financial markets • The experience of natural catastrophes bonds may therefore not apply in creating a pandemic risk solution • Industry loss warranties, based on industry loss experience instead of insurer-specific losses, may allow for diversifying risks across sectors. However, insurance linked securities (ILS) are complex and expensive to structure, more so than conventional insurance.	

Set a blueprint for national pooling arrangements	• the EU can facilitate and coordinate the establishment of national or regional insurance pool initiatives • Stimualtion of development of national programs • Minimisation of the overall disruption effect of a pandemic risk a EU level • Limit the risk of economic fragmentation across the EU • Identification of best practices can help in identifying triggers for the payment of losses at national level as well as the scope of coverage of national insurance or reinsurance pools	• May reflect challanges specific to the member state like insurance penetration social and labour markets, economic conditions • Interdipendenza	
Establish a national/EU funding mechanism for pandemic risk coverage	• Provide framework • Incentivize insurers and national governments' risk prevention and risk sharing	• If non-coordinated, it may be difficult to implement in a coordinated manner • Public funding-type solutions, which were not risk-based, would disincentivise the private market from developing risk-based insurance solutions and investing in risk reduction (moral hazard • Difficutlies to assessing risk retention at different layers • May prevent a fair and on-site treatment across the EU	
Design a European reinsurance solution for pandemic risk coverage	• the EU would act as the reinsurer above a certain threshold of accumulated losses at national level, in return for a % premium • It would require insurance-based risk assessment and modeling • Objective triggers for involving this fourth line of defence could be e.g. a fixed percentage of GDP to be covered by an EU guarantee sourced from EU Member States committed guarantees.	• The solution depends on the capacity if insurers, and state-level support, limited int he ST • The investment risk of the EU reinsurance entity also correlates with the financial markets	

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