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How to Reconcile Pandemic Business Interruption Risk With Insurance Coverage *

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Abstract

In the face of major risks, the financial capacities of private insurers are rapidly reached. Reinsurance is used to ensure an acceptable (and also imposed by regulation) solvency ratio. Yet standard reinsurance can also be unable to provide an adequate level of compensation. For major risks such as natural catastrophes, a risk transfer can be operated to the financial markets through securitization. The today well-known cat bonds, cat options, or swaps permit the issuer (a state prone to earthquakes, an insurer exposed to different major risks) to win on the financial market while loosing on the physical one following a cat. A pandemic is a cat. Unfortunately a nat cat risk management strategy based on securitization cannot be identically replicated for a pandemic cat. In this paper, we discuss the main differences between nat cats (also technological disasters) and pandemic catastrophes in terms of the economic losses. Risk correlation, basis risk, moral hazard, failure of world mutualization are mainly at stake. Then we propose a coverage strategy of the pandemic business interruption risk that combines self-insurance, insurance contracts, double triggered pandemic bonds and contingent public debt, each tool being mobilized with regard to their opportunity, transaction and management costs. We also discuss the outline of an adequate hybrid risk management governance by answering the question 'Who shall issue what?'

Keywords: pandemic risk, operational losses, (re)insurance, securitization, corporate risk management.

JEL Classification: G11, Q54, G22.

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1 Introduction

During the last quarter of 2019, some national newspapers in Europe started pointing out what was considered at this moment as a kind of contagious and virulent flue in the chinese town of Wuhan. At the beginning of 2020, the World Health Organization (WHO) alerted Europe about the high probability of being hit by this so-called CORONAVIRUS, today COVID-19, in the forthcoming weeks. Everyone knows what happened next. The exponential increase of infected people, the threat that hospitals be no longer able to welcome sick patients in the resuscitation units, and the alarming forecasts of deaths if nothing were done accelerated the announcement of lockdowns by governments¹: At the end of March 2020, more than 50 countries in the world decided a national quarantine, forcing the half of the world population to stay at home (more than 3.4 billion of people). The world economy stopped, the international financial markets collapsed, and the 12th of March several stock exchange places registered their largest point-loss ever. It was a black thursday as in 1929. The comparison with the Great Depression stops there. While in 1929 (as in 2008) the trigger was a financial crisis that propagated into the real economy, the 2020 financial crisis came from a pandemic, a sanitary event, which affected the real economy by stopping production and sales. Nonetheless, it is not the COVID-19 virus that stopped the economy, but rather all the governments that have mobilized to fight against it.²

Hence one may wonder whether the hedging mechanisms at work today for catastrophes such as natural (nat cats) and/or technological catastrophes, namely for major risks, can be extrapolated to the huge economic losses induced by a pandemic.

Pandemic Business Interruption risks and nat cats have common features: both are human and economic catastrophes in urbanized areas, both are hard to mutualize because of their systemic characteristic³ and, as a direct consequence, both quickly push insurers to their financial

¹In China, three towns in the province of Hubei, considered as the cradle of the pandemic, were placed into quarantine from the 22nd of January, totalling more than 20 million of people: Wuhan, Huanggang and Ezhou.

²In this paper, we do not consider the different strategies decided by the countries to fight against the pandemic. Some interesting results about the efficiency of more or less strict confinement strategies and of confining, or not, only some specific population (the eldest one for instance) are addressed in [Brotherhood et al. \(2020\)](#), [Gollier \(2020b,a\)](#), [Pollinger \(2020\)](#) and [Miclo et al. \(2020\)](#) among others. All these papers use the standard SIR (Susceptible-Infected-Recovery) model proposed by [Kermack and McKendrick \(1927\)](#). More economic literature on the optimal COVID strategies can be found in the real-time papers published on the CPER Website (Centre for Economic Policy Research, 'COVID Economics': <https://cepr.org/content/covid-economics-vetted-and-real-time-papers-0>).

³With a much bigger issue for pandemic risk since it is not limited to a given geographic area, contrary to nat cats.

limits. In the meantime, a pandemic can last for a long time as long as vaccines are not yet available (Covid-19 and its variants are still circulating in 2021), while an event 'nat cat' can be attached to one day, or at most several consecutive days⁴. Besides, while prevention measures are relevant in the very short run to fight against a pandemic⁵, essentially protection measures, which impacts the severity of losses but not the probability of the event, can be decided whenever a nat cat is announced in the very short run⁶. Beyond the long-lasting effects and the moral hazard attached to the pandemic business interruption risk one must also consider a correlation issue. When a nat cat occurs, there is no reason to observe a higher likelihood of a financial crisis, and symmetrically. When a pandemic occurs, financial markets are affected. Thus, it is possible to lose money simultaneously in the real economy (when the activity is stopped for instance) and on the financial markets.

When focusing on the insurance activity, it is important to notice that the business interruption risk is embedded in many corporate insurance contracts. Nevertheless, the trigger of the interruption must be an accident or, in some contracts, an administrative decision of closure limited to the concerned firm. Hence the mutualization principle at stake for Property and Casualty (P&C) Insurance is still relevant to insure those business interruption risks. When considering simultaneous business interruption of many firms of different sectors, such as what is being observed during this COVID-19 pandemic, P&C contracts can no longer cover this risk: mutualization is no longer possible and the capital needs may be much higher than the insurers' available equity or reserves.

In this paper, we discuss all these points. We show how they can be partly circumvented to transform the today hardly insurable pandemic business interruption risk into a risk that can be reasonably hedged when considering simultaneously different tools and an appropriate risk management system. These tools are self-insurance and portfolio diversification, standard insurance, insurance-linked-securities with different triggers, and contingent debt. The hedging system that we propose is composed of three layers of coverage and, for each layer, a specific actor is in charge: the private sector, insurers, reinsurers and banks, national governments, and international bodies.

⁴We make the difference between an event 'nat cat' and the consequences from a nat cat, which can still be observed several months after the event

⁵Wearing a mask, keeping sufficient distance from the others are prevention measures as they permit to make decrease the probability of being individually infected.

⁶Actually, wearing a mask in order to avoid the pandemic or to control its severity can be considered simultaneously as a prevention and a protection measure.

We consider exclusively the operational losses borne by firms because of the administrative decisions taken by countries in order to stop the virus. They are defined as the gross margin lost by the firm because of either a slowdown or a stop of its activity compared to a usual (good) sanitary situation. Said differently, it corresponds to the gross revenue minus variable charges (fixed charges such as wages being excluded from the evaluation). In the paper, we will use indifferently the expressions "operational losses" and "economic losses" when they concern firms or sectors.

In the global risk coverage system we propose, the first layer of coverage of a pandemic business interruption risk is composed of self-insurance. We discuss the way firms will be able to accumulate financial pandemic reserves with respect to their size. In particular, while captives and rent-a-captives may be self-insurance solutions for large firms or medium ones with well-structured risk management systems, small firms will benefit from a facilitated access to financial markets. As [Louaas and Picard \(2020\)](#) suggest it, and if no economic or sanitary event hurts the financial markets during the period, a strategy of investment in some specific puts and calls on the financial markets may contribute to the accumulation of pandemic provisions. The strategy is built on stocks of winners and losers of the pandemic on the markets. We discuss both the advantages and the limits of such an investment strategy.

In terms of investment capacity, the smaller the firm, the smaller the upper-limit of self-insurance. Beyond this upper-limit and for a second layer, standard (re)insurance mechanisms shall be at stake. Hence the first layer acts as a deductible for insurance. It permits to save administrative costs of insurance and to solve part of the moral hazard issue as we explain it below. On the second layer, because the mutualization principle can no longer work for business interruption pandemic losses of firms of a given sector or a given country, (re)insurers will have to issue some pandemic business interruption bonds (PBI bonds in the course of the paper) in order to ensure their solvency. The characteristics of these corporate PBI bonds and their main differences with the existing cat bonds for other catastrophes are discussed. In particular, we touch on the design of a double triggered pandemic bond as proposed by [Schmitt and Spaeter \(2021\)](#). Lastly, the third layer shall be supported by the body that acts as an insurer of last resort, namely the states. Public contingent debt and state PBI bonds might be issued with the support, if needed, of international bodies such as the World Bank, the International Monetary Fund, the European Union. This involvement on the last layer does not exempt states from

assuming part of the fixed charges supported by firms before this layer is reached. Indeed, we are dealing with variable economic losses explained by the slowdown, even the stop, of economic activities following governmental administrative decisions. Wages, for instance, are fixed costs. They are not embedded in the claims concerned by the three layers coverage, as they are currently excluded from the eligible claims of the P&C existing contracts. Instead, public subsidy can take place in complement of all the coverage layers that are described in this paper.

Finally, this combination of private and public hedging seems to be reminiscent of what is in place for the coverage of natural catastrophes in some countries, like France (Vallet, 2004; Barraqué and Moatty, 2020), and what was also suggested for the cat risk more specifically linked to forest vulnerability (Picard et al., 2002; Brunette and Couture, 2013). Nevertheless, eventhough reinsurers have sufficient financial strength and legal expertise to be able to issue some cat bonds for their own coverage, no specific securitization is at stake in these private/public coverage systems. The government acts as an insurer of last resort by paying out of its reserves and by complementing private standard insurance, sometimes accumulated thanks to a private fund (like CCR in France for nat cats).

The paper is organized as follows. In the second section of the paper, we recall how nat cats are covered today thanks to the issuance of cat bonds on financial markets. The specificities of the pandemic business interruption risk are then investigated in the third section, in the light of what will have been developed in Section 2. Section 4 presents the pandemic 3-layers hedging system. Section 5 concludes the paper.

2 What do we know about cat coverage?

A major risk causes huge financial losses and hurts many people. It pushes the damaged region into a crisis that interrupts its economic activity and dismays its affected population. Such a risk cannot be hedged by the insurance market alone, even complemented by standard reinsurance mechanisms. Since the early nineties, capital markets provide securitized assets which value is defined over the occurrence of a catastrophe. Cat bonds are the best-known contracts. The underwriter of a cat bond (the investor), based for instance on an earthquake risk in San Francisco, lends a capital to the issuer, let's say the Californian state. This capital is invested in a special purpose entity (or special purpose vehicle), and thus fully collateralized. If no earthquake occurs during the lifetime of the bond, the underwriter recovers his capital while

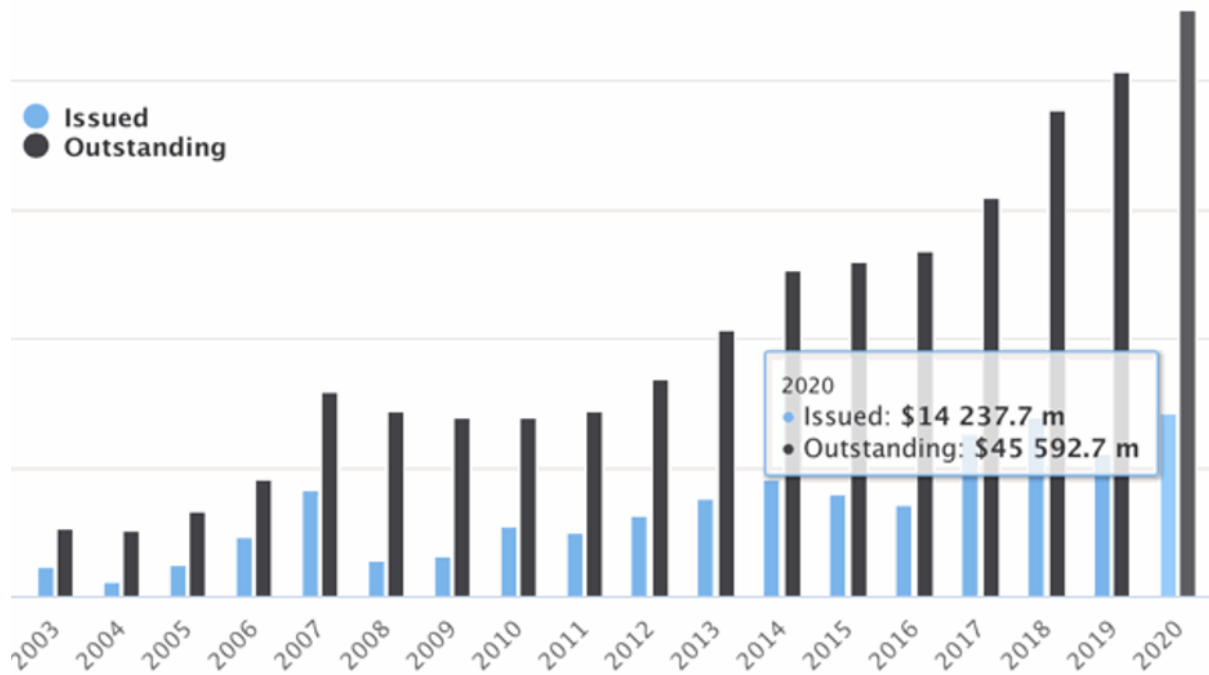
having received periodic coupons during the life of the contract. Whenever an earthquake occurs, the underwriter loses part of, or all, the capital, which becomes the property of the Californian state.⁷ Thus, while the state and its citizens are losing money on the physical market, the state recovers capital on the financial markets and becomes able to complement the claims paid by the private insurers to the victims: cat bonds provide some additional coverage to the victims of the catastrophe.

The market of cat bonds is worth in 2021 about 50 billion of dollars (15 billion in 1992, the Andrew's year), while the world (standard) reinsurance capacities are worth about USD 350 billion (100 billion in 1992).⁸ The so-called alternative insurance market has been growing exponentially for several years, as illustrated on Figure 1.⁹

⁷Such cat bonds are regularly issued by the Californian State since the end of the nineties. For some of them, the non reimbursement clause can stipulate that coupons will no longer be paid to the underwriter in case of a cat, rather than the debt cancelled. Different types of non reimbursement clauses exist.

⁸These capacities are not in line with the world insurance market which accumulates more than USD 5000 billion of reserves. But recall that private insurance is the first layer of coverage for insured risks, while a reinsurer intervenes only for risks that insurers have transferred to him and only as a second layer, such less frequently than the insurer.

⁹Actually, not only nat cats are covered through the issuance of cat bonds. Reinsurers also issue many cat bonds on property cat, mortality or mortgage risk. Much can be found about cat bonds issuance on the website of the alternative risk transfer media ARTEMIS (www.artemis.bm)



Source: Artemis Deal Directory. Data as of December 31, 2020,
<https://www.artemis.bm/dashboard/cat-bond-ils-market-statistics/>

Figure 1: Available capital from the issuance of cat bonds

In what follows, we put in light the advantages of issuing cat bonds when the trigger is a natural catastrophe (nat cat). In Section 3, it will be time to put into perspective the specificities of nat cats and those relative to a pandemic business interruption (PBI) risk. While both are catastrophes, inducing high economic losses and deaths, we will show that it is unwise to consider the creative financial markets as a savior when dealing with PBI risk coverage.

2.1 No default risk from the cat bond’s investor

Full collateralization is a property of this kind of securitization that is not effective for standard reinsurance. Indeed, when a cat bond (it works also for other Insurance Linked Securities) is issued, the whole debt is put aside (in the special purpose entity) by the holder of this cat bond. As a direct consequence, there is no risk that the bondholder fails to deliver this capital to the issuer in case of a cat. This absence of default risk is particularly valuable in the context of cat coverage. Indeed, with full collateralization, there is no risk that the contract be not honored in a

state of nature (the cat state) in which the issuer is already incurring financial hardship because of losses due to the cat. In the meantime, it is interesting to notice that this full collateralization is sometimes also viewed as a disadvantage. The immobilization of the whole capital of a cat bond induces a high opportunity cost for the investor. On this point, standard reinsurance can do better since no full collateralization is needed. Its coverage mechanism relies on the mutualization principle: a same capital K can be mobilized in order to insure the portfolio of risks of several ceding companies, which cumulative potential claims exceed K . The reinsurer's solvency is not undermined if there is 'sufficient' independence between the portfolios of these several cedants.¹⁰ The important point to be discussed here is this statistical 'sufficiency'. Actually, we are dealing with catastrophes, which are systemic risks, and not with highly diversifiable risk portfolios. Hence, partial collateralization by reinsurers cannot be too weak when dealing with correlated risks, thus reducing the apparent advantage of standard reinsurance over securitization on this specific point.

2.2 Cat bonds issuance as a way to lessen agency costs

One important topic in economics which borrows many illustrations from insurance economics is agency theory. When the insurer does not know, or cannot verify, what effort is done by a fully insured client to mitigate her individual risk, no or few effort is actually made. This so-called moral hazard issue exists also in the relationship between an insurer and her reinsurer.¹¹ The agency costs due to asymmetrical information may arise because the insurer transfers to the reinsurer part of a portfolio of fully insured risks. In another realistic context, too high degrees of coverage provided by a reinsurer to his cedent can lessen the incentives of the latter to operate an efficient monitoring of his reinsured portfolios of risks. Cat bonds can be built on the basis of triggers that do not solely depend on the issuer's losses. A trigger can be the level of harms caused by the cat to a region, to a sector rather than to a specific firm of this sector. It can also be a physical measure such as the severity of an earthquake on the Richter scale, the wind speed for hurricanes. By partially disconnecting the trigger of the non reimbursement clause in the cat bond contract from the effective losses of the issuer, incentives to mitigate risk can be preserved. The so-called basis risk that appears (the difference between the claims of the

¹⁰See [Lakdawalla and Zanjani \(2012\)](#) for a simple and illustrative example of the advantages of partial collateralization in reinsurance mechanisms.

¹¹Costs of moral hazard are considered as the highest transaction costs in insurance and reinsurance ([Doherty, 2000](#); [Doherty and Richter, 2002](#); [Doherty and Smetters, 2005](#)).

issuer and the amount covered by the cat bond) produces finally the same effects as a deductible in individual P&C insurance contracts: it maintains incentives to invest in prevention and/or protection measures at a reasonable level.

Consider now the other important information asymmetry that prevails in agency theory, namely adverse selection. Reinsurers have private information about the characteristics of the ceding companies with whom they contract in a long-run business relationship. Thus when a cedent wants to quit her historical reinsurer, a negative signal is sent to the market: the probability of being a high risk and having to cope with increasing reinsurance premia that she does no longer accept is high. Whatever her type, low or high risk, this signal makes negotiations that she will have with a potential new reinsurer even harder, thus rendering the ceding company captive from her historical reinsurer. Such considerations can be easily overcome with securitization, by choosing a trigger that is not linked to the issuer's private characteristics.¹²

2.3 (Almost) no causal relationship between nat cat and financial collapse

Up to now, we focused on the advantages of issuing cat bonds: while losing money on the physical market because of having to compensate victims and to rebuild collective infrastructures after a nat cat, a cat bond permits the issuer to simultaneously raise capital from the financial markets. At this time, the investor is losing the immobilized capital, the remaining coupons or even both. Thus one may ask what an investor is looking for when subscribing a cat bond: actually, he is looking for some additional financial return and for portfolio diversification.

A nat cat does not cause the collapse of the capital markets.¹³ Symmetrically, the likelihood of a nat cat is not higher in a poor macroeconomic situation than in a more prosperous one. Hence the independence between the cat and the returns of financial assets (stocks, corporate bonds or traditional derivatives) make cat insurance linked securities (ILS) sought-after assets for portfolio diversification. Their appreciated stable trading values during the 2007-2009 financial crisis (Cummins and Trainar, 2009; Cummins and Weiss, 2009) and also much more recently in 2020 compared to other assets with similar expected returns reinforces their diversification

¹²Furthermore, Finken and Laux (2009) explain how the introduction of cat bonds in the cat global coverage system lessens the adverse selection costs.

¹³This is true for almost all past nat cats. No general and strong decrease of the stock markets' valuation is observed following a cat, possibly a sector can be momentarily impacted. Recall the explosion of the nuclear plant in Fukushima in 2011 after that a tsunami hit the Asian-Pacific coasts. During several weeks, all car manufacturers had some trouble to purchase electronic components, which induced a temporary decrease of their market value. But no financial collapse has followed.

property. Figure 2 hereafter illustrates this stability (Difiore et al., 2021).

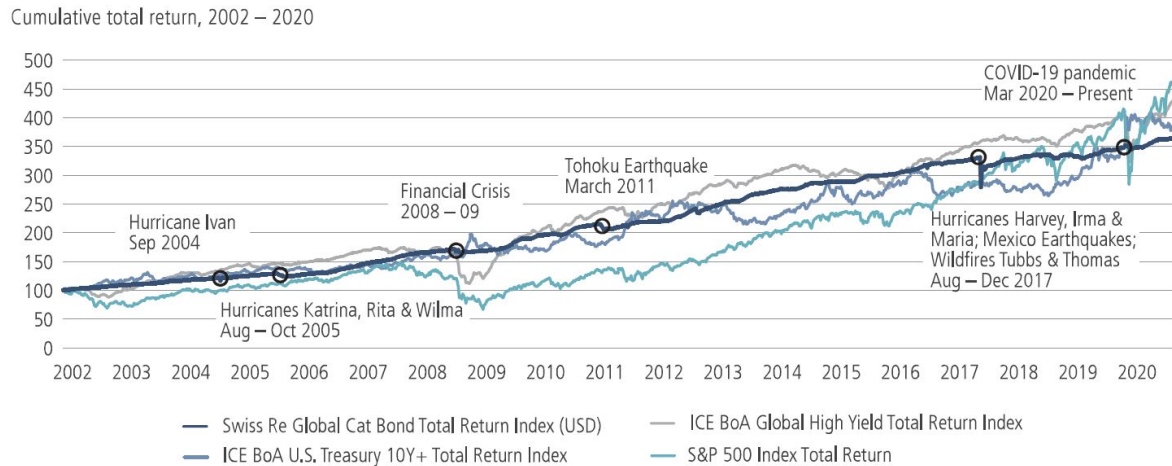


Figure 2: Performance of cat bonds (Source: Difiore, Drui & Ware (2021))

The currently very low interest rates on standard bonds that are observed on the capital markets is another argument in favor of the subscription of cat bonds by investors. Indeed, the reimbursement clause embedded in the cat bond justifies a higher rate for the coupon to be paid to the investor. To illustrate this point, consider that the non reimbursement clause is triggered with probability 2% (that means that the probability of a cat is 0.02 in this example). Then, the coupon rate of the cat bond writes

$$r_{cat} = r_{libor} + 0,02.m, \tag{1}$$

with m being a risk multiplier that encompasses the investor’s risk aversion and also the risk of error embedded in the cat prevision models. Let us notice that this risk multiplier was higher than 6 in the early days of the cat bonds market in the nineties. Since then, the attractiveness of this market has grown significantly, which is explaining a continuing decline of m .

Now, let us turn to the pandemic business interruption risk. It is also presented as a catastrophe risk. Thus, following the different points we have developed above, the use of Insurance Linked Securities should permit to usefully complement the insurance/reinsurance capacities. Nevertheless some specific, and somewhat annoying, characteristics of the pandemic risk are

not observed with nat cats. In the following section, we explain why these differences curb the potential efficiency of pandemic risk securitization.

3 Specificities of a pandemic risk and challenge of its securitization

The COVID-19 pandemic is a catastrophe (a cat) because of the millions of deaths registered in the world, also because it pushes millions of people into poverty, or even extreme poverty, as well documented by the World Bank.¹⁴ At this stage, it is interesting to notice that pandemic bonds were issued by the World Bank in 2017 in order to provide financial help to poor countries that would be hurt by a pandemic, such as Ebola or ... Covid-19. And this happened. Unfortunately, his issuance has been strongly criticised because of its sophisticate triggering system: the pandemic shall have induced at least 250 deaths in the country in which the virus appeared (China for Covid-19) and at least 20 deaths in another poor country, with a period of 12 weeks from the first report of WHO (released the 31th December 2019 for Covid-19). These pandemic bonds were finally triggered in April 2020. Despite this, an equity issue has still been added to the complexity of the system, the triggers being built over a need of a minimum number of deaths (Bloomberg, 2020; Raynal, 2020). Our approach in this paper is strongly different, as explained below. To understand it, we need to point out the differences between a pandemic cat and a nat cat.

Contrary to a nat cat, it is not the event "pandemic" that stops the economy, but governmental decisions. And each government is taking different political decisions, while they face the same virus. Many of them have already decided several lockdowns since the beginning of the pandemic (France, Germany, Italy, Austria, Israel, ...). Others were seeking to reach a herd immunity (Sweden, India, ...) while still others did not take specific decisions. Hence these are human decisions that induce billions of financial losses due to the shutdown of the activities of many firms. A second important difference with a nat cat, or a technological one, is that a

¹⁴One can read on the 7th October 2020 press release of the World Bank: "The COVID-19 pandemic is estimated to push an additional 88 million to 115 million people into extreme poverty this year, with the total rising to as many as 150 million by 2021, depending on the severity of the economic contraction. Extreme poverty, defined as living on less than \$1.90 a day, is likely to affect between 9.1% and 9.4% of the world's population in 2020, according to the biennial Poverty and Shared Prosperity Report. This would represent a regression to the rate of 9.2% in 2017. Had the pandemic not convulsed the globe, the poverty rate was expected to drop to 7.9% in 2020."

pandemic is not defined by a given event at a given date. It consists of different stages, with successive waves of contamination.

Besides, a pandemic does have an incidence on financial markets, because it cannot be contained to a given area or a given country (otherwise, it would not be called a pandemic by the World Health Organisation). Pandemic risk is also correlated with other risks such as those linked to biotech innovations or cyberattacks. Hence portfolio diversification seems to be compromised when thinking about pandemic bonds. Nevertheless, all these three points can be put into perspective. We discuss them in the next subsections.

3.1 A cat risk shaped by human decisions

The COVID-19 pandemic concerns sanitary losses (health care and protection costs mostly) for 10% and economic losses for the other 90%. These economic losses result from the stop and go strategy adopted by many governments during 2020 and also in the first semester of 2021. Up to Covid-19, the word 'pandemic' was mostly associated with diseases, deaths, health insurance, thus attached to the health insurance line, and not so much to P&C coverage. However, the economic losses are largely composed of business interruption losses, which fall in the scope of P&C insurance contracts. This is the first point that was not anticipated. The second one is that the operating losses are not being attached to an incident or a damage, as well defined in the insurance/reinsurance scope (a fire, a flood, a sanitary contamination in a restaurant, etc). Instead, they appear because of governmental decisions: lockdowns, closure of firms of specific sectors (restaurants, museums, fitness rooms, etc) or curfews. Hence, the operating losses are not directly explained by a random event, but instead by a political action. And this makes it difficult to mobilize hedging mechanisms that strongly rely on random events.

Furthermore, the political decisions taken by a government are influenced by the behaviors of citizens with regard to the application of all the sanitary barrier measures. This is directly connected to their incentives to invest time and energy in protection measures.¹⁵ Hence, the amount of losses due to a pandemic is highly dependent on how a government decides to fight against it, and also on the social acceptability and degree of application of the protection measures by the population. It is rather different from a natural cat risk. First, people are more inclined

¹⁵Protection measures concern efforts done to reduce the severity of a loss or a disease whenever the risk is already realized (here the pandemic risk). In the meantime, prevention permits it to reduce the probability of observing the emergence of a contagious virus. In that case, protection can be considered as *ex post* risk management, while prevention contributes to *ex ante* risk management.

to invest in protection measures when the entire profit of their individual measures benefit to themselves. Pandemic risk mitigation calls for some individual responsible behaviors in order to obtain a collective benefit. Second, investment in protection for nat cats takes place before the catastrophe (people reinforce their house structures or leave the concerned region), while protection against a pandemic can only be put in place when the pandemic is already present in the population (it is useless to wear masks for protection purpose otherwise). In such a context, one may wonder how to price an insurance/reinsurance contract, how to price an insurance linked security on the financial markets. Indeed neither (re)insurers nor financial investors do like the high level of moral hazard that can be embedded in a pandemic risk hedging strategy if it is not, at least partially, shared with different other actors.

Yet, securitization should not be abandoned too rapidly. Recall that choosing triggers of payment that do not depend directly on the actions of the issuer of the contract makes emerge a basis risk. This basis risk permits it to manage moral hazard by imposing no perfect correlation between the issuer's claims on the physical market (for instance, the operating losses of a firm or a sector) and his compensation obtained on the financial market whenever a pandemic bond contract were being issued. In the same spirit, firms' P&C insurance contracts that can be, tomorrow, one layer of a more global compensation system could rely on the mean losses of the sector¹⁶. We come back to this point in Section 4.

3.2 The difficulty to define relevant triggers

A second important difference between a catastrophe as we usually conceive it (natural, technological, sanitary-other than pandemic) and a pandemic catastrophe deals with temporality. A nat cat is an event that arises at a given date and whose harms are attached to this event date, although being not all identified in the immediate aftermath of the cat. Hence a hurricane hits a region during a few seconds¹⁷, an earthquake is lasting for at most several minutes, an explosion in an industrial plant is ... an explosion. Even a flood can be registered at a precise date, although water may take several days to leave the flooded areas. A pandemic cat can also be defined with regard to a date: the date at which the World Health Organization announces

¹⁶This principle was retained by the french insurers in their first attempt to build a public-private compensation system of exceptional catastrophes at the end of 2020 (named CATEX system). To date, this system is not at work, additional insurance premia for firms already in difficulty having been considered as inappropriate in these times of crisis.

¹⁷Actually, an hurricane dies after seven to nine days but it only takes a few seconds to devastate a village, a town or an administrative area.

that the world, a continent or several countries are suffering from a pandemic for instance. The cat characteristic can still be defined by a level of contagion that would be attained. However, the economic and financial consequences of the pandemic cat, as we recalled it above, are due to several, sequential and not perfectly foreseeable decisions taken by governments or international bodies. Hence, while the population is anticipating a return to normal life with the announced reopening of restaurants, museums, fitness rooms, etc, a new variant of the virus can appear and compel the government to take some new, drastic decisions that place again the economy into difficulty. In such a frame, it is particularly difficult to decide which parameter should be chosen in a contract to trigger the payment of claims or the release of a capital that was, until there, tied up in a special purpose vehicle.

In particular, it seems clear that a unique trigger will be insufficient. Indeed, a net decline of operating losses of a firm or a sector can be explained by events that took place before the pandemic crisis. They can also be registered without any virus in circulation. Hence, at least two triggers shall be at work in a pandemic business interruption bond as developed by [Schmitt and Spaeter \(2021\)](#) and evoked in Section 4 below.

3.3 Correlation is at stake

Correlation is a big topic for the pandemic bonds issuing. As we explained it below, cat bonds relative to nat cats or technological disasters are almost never correlated with financial markets. Thus, while the investor is losing money on the cat bond because a cat occurred and the issuer has exercised the non reimbursement clause, the global value of his financial portfolio, if well diversified, will not be hardly affected. Up to now, no cat bondholder (in particular reinsurers) were put into trouble following the extinguishment of the debt embedded in the underwritten cat bonds.¹⁸ The scenario is strongly different in the case of a pandemic. The sharp drop in the international stock markets in the mid of March 2020 has shown how a pandemic such as the Covid-19 heavily impacts the economic and financial spheres. Hence, portfolio diversification may become much more difficult to reach with some pandemic business interruption bonds than with the existing cat bonds. In particular, it will be necessary for pandemic bonds' investors to

¹⁸For more details about this point, the website Artemis lists all the cat bonds defaulted, triggered or at risk since 2000: www.artemis.bm/cat-bond-losses/

Among them, are the 'Kamp Re 2005 Ltd' issued by Zurich Financial and the Cat bond 'Muteki 2008' issued by Munich Re. The first cat bond covered part of the losses due to the hurricane Katrina in 2005, while the second one covered part of the losses induced by the nuclear explosion in Fukushima in 2011. For both cat bonds, all the capital was lost by the reinsurers and retained by the claimants.

build a portfolio strategy based on stocks of sectors that evolve positively during a pandemic crisis (pharmaceutical sector, biotechnology, digital industry). And from one pandemic to another one, winners can become losers and symmetrically.

4 Toward a three-layers PBI risk management system

From the different points developed above, we understand that the coverage system of nat cats cannot be duplicated to PBI risk, despite its catastrophic component. Nonetheless, by isolating different states through which comes a pandemic crisis, it is possible to build an integrated coverage strategy. The driving force of this strategy might be hybridization of tools and also cooperation of different levels of structures of governance.

An efficient coverage system shall be composed of three distinct layers, each being defined by a lower and an upper limit of losses. For sure, the probability to face a more or less high layer of losses deeply depends on the time of the crisis at which losses are observed. Typically, operational losses are higher when the crisis lasts for several months. And its duration is explained either by sequential, non anticipated, rebounds of the pandemic, or by the fact that governments take too timid protection measures (for instance no lockdowns, no closure of vulnerable sectors), or even both. The first layer of a suitable coverage system shall be the layer of self-insurance by firms. This self-insurance can be reached by different ways depending on the size of the firm and the structure of the sector she belongs to. Insurers and reinsurers can do their job on a second layer of coverage, precisely when potential operational losses become too high for firms to be covered by themselves. On this layer, (re)insurance takes place, complemented by securitization. The PBI bonds shall be designed in order to ensure a sufficient level of liquidity on the cat bond market. In particular, as we discuss it further below and following [Schmitt and Spaeter \(2021\)](#), some specific triggers must be chosen in order to, simultaneously, offer an acceptable basis risk to the issuer and a possibility of diversification on the financial markets for the investor. Recall that our initial hypothesis is that, contrary to natural catastrophes, pandemic risk and financial crisis are correlated.

At last but not at least, governments shall intervene for losses that exceed the second layer, by having issued additional pandemic bonds and by issuing other forms of debt in order to play its role of insurer of last resort. On this third layer, supranational bodies such as the European

Union, the International Monetary Fund or the World Bank, will also have to intervene in order to provide political, financial and/or economic support to the national governments.

The functioning of each layer is explained in the following subsections. We also provide arguments to justify the order of the layers that we propose. It determines the time of the crisis at which the different actors intervene and, as a direct consequence, the probability of having to intervene for each of them.

4.1 First layer and self-insurance

Recently, the French government announced that it could foster the build-up of pandemic provisions by firms in the future by lessening the tax burden on those funds. Therefore firms would have incentives to save during high activity periods in order to protect themselves against a decline in their gross profit should a future pandemic justify one or several lockdowns. Self-insurance is considered here as precautionary saving (Briys and Schlesinger, 1990; Leland, 1968; Menegatti, 2007; Sandmo, 1970). We argue that such a strategy can be put in place to cover the first operational losses, that means those borne in the first wave of a pandemic.¹⁹ Self-insurance can be obtained through different ways. We discuss them below with regard to the size of the firm.

Self-insurance is common practice in large firms since the early 2000s with the success of captives (Schmitt and Spaeter, 2013). A captive is an insurance company created by a firm in order to insure its own risks. In this way, the firm is making simultaneously risk retention and risk provision. It transfers insurance premia to its captive such as it would do it to an external insurer. Captives are used to lessen transaction costs, and to address a specific need of coverage for some risks that are not well covered by private insurers (typically, but not only, for some cat risks).²⁰

The highest benefit of the creation of captives to self-insure part of the pandemic risk is, in our opinion, the resolution of the agency conflicts between the insured firm and its insurer: both

¹⁹The first wave of the pandemic refers to the first weeks after a pandemic has been declared that are concerned by administrative decisions taken by a government to fight against it.

²⁰The British Petroleum (BP) company was one of the first firm in the petroleum sector to build a captive in 1985 (named JUPITER Insurance). In the media, this decision was motivated by the fact that BP's insurers at that time had more chance to be bankrupt following a huge incident that they would have to compensate than BP itself. This captive was mobilized several times since its creation, in particular for the Texas city refinery explosion (killing 15 workers, injuring 180 others) and for the offshore Deepwater Horizon drilling rig explosion in the Gulf of Mexico (Louisiana). This last event resulted in 11 deaths, 17 injureds and cost about \$63 billion to the firm (indemnities and fines).

depend on the same entity, namely the holding company. Since the holding company has a clear interest in risk mitigation, it is able to significantly improve its risk management by orienting and monitoring the risk management strategy of its subsidiaries. In this context, adequate investment decisions in the protection and the prevention activities may be taken.

Actually, such an internal risk diversification scheme is running well for large firms, which have substantial equity, and different activities or subsidiaries. Firms of intermediary size might have more difficulties to sustain the creation of their own captive, even if it could be dedicated to several major risks, such as pandemic, cyber attack, civil liability or e-reputation. An alternative is to rent a piece of captive that belongs to an insurer or a reinsurer. By doing so, the firm is benefiting from the (re)insurer's infrastructure, which charges to it the operational costs. The advantages of such a "rent-a-captive" are its flexibility (renting can be stopped at each contract anniversary date) and the mutualization of the operational costs with other firms having rent a cell of the captive.

Even so, small firms can remain far away from this self-insurance coverage system, which requires a minimum of funds and also well-structured risk management strategies. Instead of creating special subsidiaries for covering the pandemic risk, [Louaas and Picard \(2020\)](#) show that, under some specific conditions, small firms can also save for pandemic risk by investing on financial markets. The aim is not to issue some insurance linked securities but rather to buy put and call options on financial stocks. Indeed the authors observe that there are winners and losers on the markets during a pandemic crisis. Typically, for the Covid-19 the sectors of tourism, of transportation, or of catering are being severely affected. In the meantime, stocks of the biotech and pharmaceutical industry where very much demanded at the beginning of the crisis, investors anticipating an increase in their stock-market value. Hence, a firm can build up a capital by buying call options on the winner stocks and put options on the losers. In the simulations they propose, 12 years are sufficient to obtain a capital of higher than 11 million of euros when 20 000 Euros are invested each year in the described portfolio. We argue that such a strategy must be (shall be) part of a global coverage strategy. It cannot solve all the issue. Indeed, investing 20 000 Euros each year for a small firm is not innocuous. The capital is immobilized and this brings us to the issue of full collateralization of the capital by investors already considered in the previous section when dealing with securitization. Furthermore, the winners of a pandemic may be the losers for another one. And during the saving period, no other big crisis shall arrive.

Finally, self-insurance must be considered as one pillar of a global risk management strategy. Precisely, it shall be considered within a first layer of coverage, the upper bound of which depending on the size of the firm. The opportunity cost of immobilizing too much capital, regard its size, can exponentially increase and it may weaken the firm in its development strategy during stable economic periods.²¹

4.2 (Re)insurance and pandemic business interruption bonds on the second layer

The second layer corresponds to a range of losses 'sufficiently' high for the firm to transfer them to an external party, and sufficiently fair for the (re)insurers to be able to play their full role. For a first part of losses on this layer, existing P&C corporate contracts might provide coverage of gross profit with a threshold that would correspond to what the insurer is able to cover for all its corporate customers without threatening its solvency. Many existing corporate P&C insurance contracts cover the business interruption cost of an incident or an administrative decision that concerns exclusively the holder of the contract. In such a context, loss of gross profit, including variable costs but excluding fixed costs such as wages for instance, is compensated on a given period (for instance up to 3 months). The operational losses are estimated by experts on the basis of the activity on the ongoing year. Then, for higher losses, securitization can be useful. The purpose is to lead insurers and reinsurers to issue some pandemic bonds, which have still to be created, in order to complement the coverage of their customers.²² Insurance Linked Securities are of great interest for PBI risk because risk mutualization by insurers is complicate to achieve in the case of a pandemic and also because essentially the potential vulnerable sectors shall be interested into PBI insurance. Thus an adverse selection issue appears, which further weakens risk mutualization by the insurers.

Thanks to the elements developed in Subsection 3.2 above, we know that the important point to build relevant pandemic bonds is to select relevant triggers. Moreover, because pandemic business interruption risk is correlated with financial risk (see Subsection 3.3), it is also important to ensure to the buyer of pandemic bonds that he will be able to diversify his portfolio. In this

²¹See also [Clarke et al. \(2017\)](#) on opportunity costs of building up some reserves for a state facing cat risks.

²²Actually, the first pandemic bonds have been issued in 2003 to cover extreme mortality risk. Their efficiency were regularly put in doubt ([Alloway and Vossos, 2020](#)), with a last and recent debate on the pandemic bonds issued in 2017 by the World Bank as mentioned at the beginning of Section 3. More details related to their triggers are given below.

spirit, [Schmitt and Spaeter \(2021\)](#) build a pandemic business interruption bond with two triggers.

First, it is important to have in mind that operational losses may also arise without any pandemic. Thus, it is necessary to guarantee that the non reimbursement clause of a PBI bond cannot be exercised outside a pandemic period. The first trigger must do this job. It must be simple to understand and to operate, and also accepted by all parties. Following [Schmitt and Spaeter \(2021\)](#), a very good candidate is the release by WHO of a PHEIC, i.e. a Public Health Emergency of International Concern.²³ The 31th of January 2020, The Director-General of WHO declared that the outbreak of 2019-nCoV was constituting a PHEIC. At this time, the term 'pandemic' was not used yet. All countries members of WHO are involved in the procedure of advising, or not, the Director-General of WHO to announce a PHEIC. In this way, the announcement of a PHEIC is widely accepted by all the countries in the world. Then it can also be a well accepted candidate for being an official first trigger of PBI bonds.

The second trigger corresponds to a level of operational losses of the sector of the firm concerned by the coverage. By doing so, the trigger is based on some well-known parameters, the operational losses, already used by (re)insurers in the existing insurance contracts and reinsurance treaties. Besides, a fair basis risk is maintained due to the high, but not perfect, correlation between the losses of the sector and the losses of the firms that belong to it. Such a trigger permits it also to avoid critics such as those done to the pandemic bond issued by the World Bank in 2017 in order to compensate losses from Ebola virus. Recall that its trigger was defined over a number of deaths. In particular, an ethical and an efficiency debate came rapidly at stake. Some were estimating that it was not ethical to bet on deaths in order to win on the financial markets by exercising the non reimbursement clause, while others estimated that such a trigger was even counterproductive since it was annihilating all incentives a government might have had to contain the spread of the virus. Lastly, such a second trigger based on a level of operational losses which would be compared to a threshold embedded in the bond contract permit also to make the difference between countries that decided one or several general lockdowns and those who have adopted the *laissez-faire* strategy. Indeed, in this last case operational losses shall not be so high compared to a given threshold. Hence, considering the current pandemic, such

²³The term PHEIC is defined in the International Health Regulations (2005) as “an extraordinary event which is determined, as provided in these Regulations:

- to constitute a public health risk to other States through the international spread of disease; and
- to potentially require a coordinated international response”. One can also read on the WHO website that "This definition implies a situation that: is serious, unusual or unexpected; carries implications for public health beyond the affected State's national border; and may require immediate international action."

PBI bonds would not have been operated in the first semester of 2020 in countries such as the United States or India because no severe lockdowns were decided (the situation changed during the second semester of 2020). Drawing on this, it seems to us that there is also big room for the issuance of other types of pandemic bonds by international bodies in order, this time, to cover sanitary costs of the pandemic in poor countries. Indeed, some poor countries (not the United States..), rather than adopting a *laisser-faire* strategy, leave a *laisser-faire* situation taking root because they were not able to adopt adequate measures, financially, politically or both. In these cases, international bodies, the World Bank, have a role to play by issuing pandemic bonds with triggers adapted to the coverage of, this time, sanitary losses. We do not develop this point in this paper. We just want to mention that different kinds of pandemic bonds might coexist. Contrary to what was written in different financial newspapers about the World' Bank 2017 issuance of pandemic bonds, it is not the usefulness of such an insurance linked security that must be put in doubt, but its triggers.

For further details on those PBI bonds, the reader is invited to read [Schmitt and Spaeter \(2021\)](#). They show how such a double trigger PBI bond permits to complement efficiently a strategy of (re)insurance, how it contributes to the need of market liquidity and how they solve the ethical issue.

Finally, the first layer of coverage acts as a deductible for the second one. And, as it is well known in the insurance economics literature, the existence of a deductible lessens the administrative costs of insurance. Indeed without any external coverage on small operational losses, insurance administrative costs on it are saved. In the frame of the pandemic risk we are dealing with, such a deductible may also help at identify the types of the firms. Indeed, firms that are already facing some operational difficulties before a pandemic will still have some trouble to constitute the precautionary saving of the first layer. Depending on the upper bound of this layer, some firms might be bankrupt before getting in touch with the insurer for the second layer of coverage.

4.3 Governments as insurers of last resort, supported by supranational bodies

The third layer corresponds to the hardest one in terms of crisis. Operational losses of this layer may be linked to several successive lockdowns and to administrative closings of differ-

ent sectors that are lasting for months. At this stage, public intervention must take over and complement all other layers.

It is easier for solvent governments than for firms or sectors to raise money in the very short time and at acceptable interest rates. Whenever almost all countries are hit by the pandemic, the less insolvent ones become attractive for investors having an excess of cash. Moreover, institutions like the European Union, the World Bank or the International Monetary Fund shall act as guarantors, in particular for developing countries and others that are economically vulnerable. A complement to public debt is that these institutions issue some pandemic bonds for the account of the states. In such a way, the international body acts either as an intermediary (a facilitator) between a given country and an investor, or as an administrative body that issues pandemic bonds to protect itself against the non reimbursement by states of loans that it would have distributed during the crisis. One simple trigger of the bonds could be an aggregate level of 'pandemic debt' of the member states. This international issuance of bonds would complement those issued by the firms and/or their insurers to cover the second layer. Hence on this third layer, states act as insurers of last resort with the support of, or in coordination with, the international bodies. Furthermore, a government is the sole decision making entity in a country that can spread the reimbursement of the debt either on all citizens of a given generation or of different successive generations. It is also the administrative body that decides whether a lockdown shall be decided, or if restaurants, schools, shall be closed. Thus in the last layer, the same entity simultaneously decides which protection measures to be taken in order to stop the virus spreading and compensates for the additional economic consequences.

Finally, the combined hedging system can be illustrated by the claims indemnity function $I_{full}(X)$ on Figure 3 when full insurance is requested.

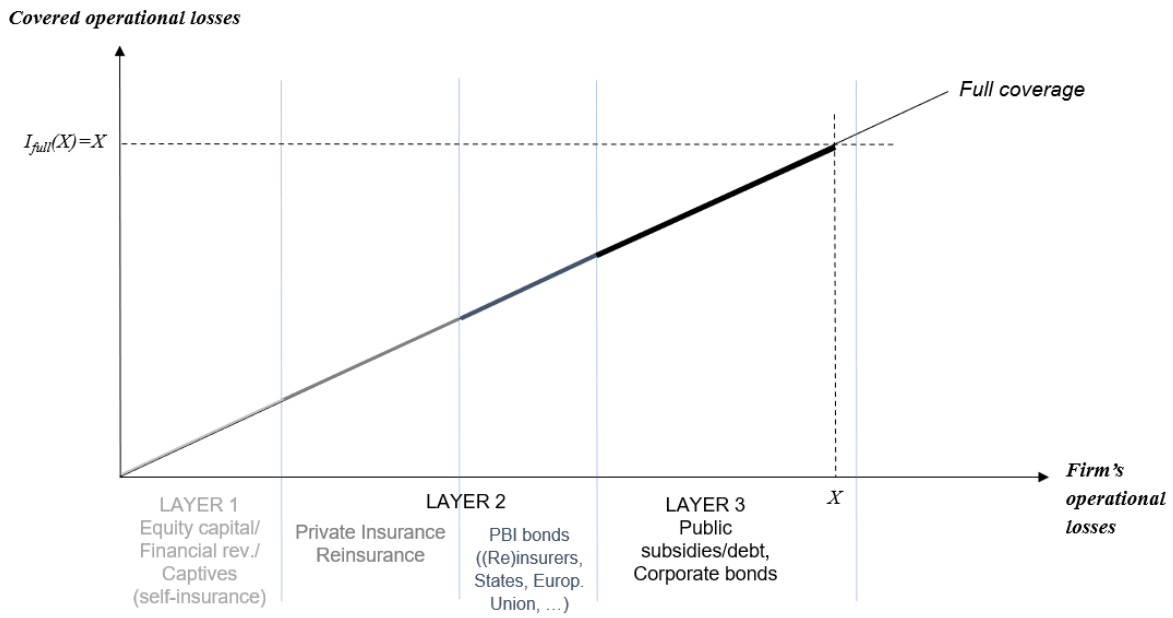


Figure 3: Combined hedging system for PBI Risk: full coverage

Figure 4 displays an example $I_{partial}(X)$ of coverage strategy when only partial insurance can be, or shall be, provided.

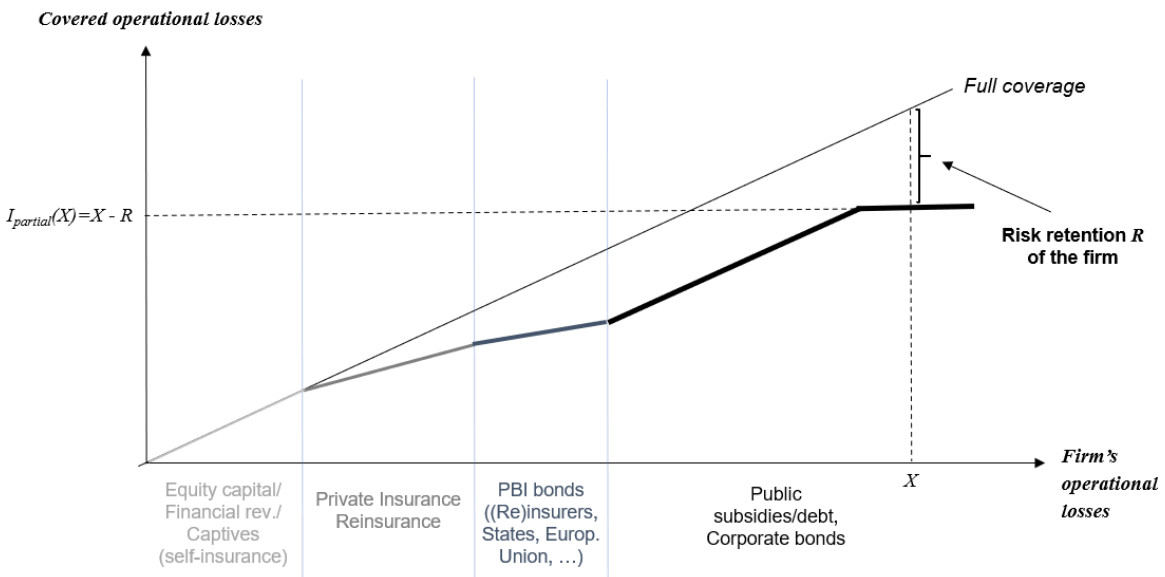


Figure 4: Combined hedging system for PBI Risk: partial coverage

This second figure highlights the different dimensions that can be addressed in order to

arbitrate between agency costs, basis risk, transaction costs and adequate levels of coverage. First, the length of the different layers can be adapted to the financial capacities of each actor, to the availability of Insurance Linked Securities able to cover PBI risk, and to the liquidity of the cat bond market. Then, on each layer the percentage of coinsurance can be manipulated between, first, the hedging body (the firm itself, the (re)insurer, the state, the international bodies) and the hedged entity (the firm) and, second, between two hedging bodies such as the firm and the insurer, the (re)insurer and the state, or the state and the economic area it belongs to. This level of coinsurance is represented by the slope of the indemnity function: the lower this slope, the higher the risk retention by the firm. At the limit, a zero slope signifies that an upper-limit of coverage holds, such as on the third layer on Figure 4. Lastly, even though no explicit deductible seems to appear on both figures, there exists one for each layer. Indeed, each preceding layer acts as a deductible for the following one. Or said differently, each upper layer intervenes only after the preceding one. Thus the higher the layer, the lower the probability it will be mobilized. It will depend on the severity of the pandemic and, thus, on the actions taken by the states and on individual behaviors day-to-day.

5 Conclusion

Different tools exist today to cover the firms' operational losses induced by administrative decisions taken to fight a pandemic. Each of them have advantages and limits. The aim of this paper was to discuss the opportunity costs of each coverage instrument, their accessibility for small/medium/large firms and also the type of (hybrid) governance that is needed to ensure coherence and efficiency of a pandemic business interruption risk management system suited to a crisis such as the one the world is suffering from since the end of 2019.

To do so, we split the scale of losses into three layers. On the first one, we discussed the relevance of giving firms incentives to adopt self-insurance techniques in order to constitute financial reserves during good economic periods. These reserves will be mobilized to cover their first operational losses whenever a 'pandemic' were announced, followed by some first restrictions imposed by the government. Large firms may use their captives for this 'pandemic' self-insurance. Medium ones, with a well structured risk management process, may also have access to captives, at least to rent-a-captives. Self-insurance is more delicate for small firms, having limited capital to be immobilized for (self) insurance. On this point, we follow [Louaas and Picard \(2020\)](#)'s

put and call diversification strategy: firms invest on financial markets and identify 'pandemic' winning and losing sectors in order to buy adequate options on them. To ensure the desirability of such a strategy, it is necessary that governments reduce the burden of tax on what we call 'pandemic' provisions. Some governments have recently communicated in that sense but no political decision in this regard has been made so far.

In a second stage of the crisis, insurance and reinsurance shall play their role. They shall cover the economic losses that are too high to be retained by the firms, but still fair for the (re)insurance sector to be covered without endangering its solvency. And, contrary to what was argued until there, Insurance Linked Securities, securitization to make short, for the pandemic business interruption risk can be built. Indeed, we explain how both most important impediments to the duplication of a (nat) cat bond strategy, namely moral hazard (and, to a lesser extend, adverse selection) and correlation with the financial markets, can be circumvented by creating some double triggered 'pandemic cat' bonds. For details on such assets' specificities, the reader is invited to read [Schmitt and Spaeter \(2021\)](#).

On the third layer, the governments play the role of insurer of last resort. They may be supported by international bodies, economically and/or politically. On this layer of losses, securitization (also accessible to states) shall be complemented by a massive issuing of public contingent debt. Actually, we are not saying that governments intervene only of last resort. An essential condition to the success of an integrated (economic) risk management system is the prevalence, in parallel and on all waves of the pandemic, of an integrated sanitary risk management process. This means that regional, national and international public policies must be put in place in order to do prevention AND protection (population's training and acculturation, continuous investment in R&D). Such a supra integrated risk management calls for a strong and continuous international cooperation. Although this is not the point of the paper, it must be put in mind when considering the three layers hedging system that we are presenting.

Of course, many limits to our proposition can be drawn. Rather than listing them (it would be too long!), we select some that shall be considered by the mixed working groups (private (re)insurers and public bodies) that have been constituted in several countries in order to go further on the issue of the business interruption losses coverage.

The first important question to ask is whether insurance for pandemic business interruption risk, if embedded tomorrow in the P&C contracts, must be compulsory. On one hand, all sectors

are not negatively impacted by this risk and, consequently, such a line of insurance will not be economically relevant for them. On the other hand and as a direct consequence of the first point, if pandemic insurance (to be short) is an option in an insurance contract, only firms with high risks of being impacted by administrative lockdowns will buy coverage. And this will make appear an important adverse selection issue. Hence insurance could be compulsory, built partly on a solidarity principle. This principle will have to be understood and socially accepted by all the economic sectors in order to provide more collective benefit than it could costs to Society whenever a political and/or social conflict were to occur.

The second important point deals with the objective of a government : does it want to reach an herd immunity or, on the contrary, to protect the highest possible percentage of the population whatever its age composition or, to give priority to the most vulnerable citizens? Each strategy calls for different administrative decisions and thus, each strategy induces different lower and upper bonds of the three layers of losses defined in our pandemic business interruption coverage system. Together with an ethical concern, the question of the least worth strategy to be adopted relies on the well-known issue of paternalism addressed by the welfare economics.

Lastly, the size of the layers for the economic sectors of a given country are also impacted by the strategy adopted by its neighbour countries. Indeed, a laissez-faire strategy adopted by one will surely have an impact on the efficiency of the strategy adopted by the other one whenever mobility of people is not rapidly constrained. Thus the tools of public economics shall also be mobilized in order to take into account the externalities that appear between the countries, and also between the individuals. Non vaccinated people will benefit from positive externalities coming from vaccinated people. This is not a conjecture, but a medical fact.

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