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« **How to Reconcile Pandemic Business Interruption Risk With Insurance Coverage?**»

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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 a (re)insurer, exposed to different major risks a firm) 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, business interruption losses, (re)insurance, securitization, corporate risk management.

JEL Classification: G11, Q54, G22.

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1 Introduction

In early 2020 the World Health Organization (WHO) alerted the world to the high probability of being hit in the coming weeks by a new virus, the one now known as COVID-19. Driven by fears of an exponential increase in the number of infected people, as well as the threat that hospitals would no longer have enough resuscitation units to receive sick patients, and the alarmingly high forecasts of deaths if nothing were done, governments moved progressively to announce lockdowns. By the end of March 2020 more than 50 countries had decided on a national quarantine, forcing half of the world's population to stay at home (more than 3.4 billion people).[1] The world economy stopped, the international financial markets collapsed, and on the 12th of March several stock exchanges registered their largest point-loss ever. This was indeed a Black Thursday; but the comparison with the Great Depression stops there. Whereas in 1929 the trigger for the depression was a financial crisis that propagated into the real economy, the 2020 financial crisis came from a health-related event, the pandemic, which affected the real economy by stopping production and sales. Nonetheless, it was not the COVID-19 virus itself that stopped the economy, but rather the administrative decisions taken by different governments to fight it. In this paper, we focus on business interruption risk coverage in the case of a pandemic. We do not consider the different strategies decided upon by countries to fight against the pandemic.[2]

Pandemics, understood as health-related catastrophes, share some features in common with natural catastrophes (henceforth: nat cats): both can produce huge human and economic losses in urbanized areas, both are hard to mutualize because of their systemic characteristics,[3] and, as a direct consequence, both can push insurers to their financial limits. What is more, a pandemic can last for a long time, especially while vaccines are not available, whereas a 'nat cat' event generally unfolds over a single day, or at most several consecutive days.[4] Finally, an important

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[1]The first lockdowns were announced in China, with Wuhan, Huanggang and Ezhou, considered the cradle of the pandemic, being placed in quarantine from the 22nd of January, for a total of more than 20 million people.

[2]Some interesting results concerning the efficiency of more-or-less strict confinement strategies and of confining only specific segments of the population (the elderly, 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).

[3]This is a much bigger issue for pandemic risk since, unlike nat cats, it is not limited to a given geographic area.

[4]We draw the distinction between a 'nat cat' event and the consequences from a nat cat, which can still be observed several months after the event.

issue related to pandemic risk concerns the correlation between the real economy and the financial markets. Indeed, when a nat cat occurs there is no reason to expect a higher likelihood of a financial crisis; but when a pandemic occurs, and governments take decisions that have a major impact on the running of the economy, financial markets are affected. Thus the real economy and the financial markets are hit simultaneously.

When focusing on insurance activity, it can be observed that a specific 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 firm concerned: it is only in those situations that the firm can obtain coverage for its business interruption losses. Hence the mutualization principle at stake for Property and Casualty (P&C) Insurance is still relevant to insure those business interruption risks since the systemic component is excluded from the contracts. Whenever many firms of different sectors suffer simultaneously from business interruptions, such as observed during the COVID-19 pandemic, P&C contracts can no longer cover this risk: mutualization within the pool of impacted firms is no longer possible and the capital needs may be much higher than the insurers' available equity or reserves.

In this paper, we exclusively consider the operational losses borne by firms following administrative decisions taken by countries in order to stop the virus. These are defined as the gross margin lost by firms because of either a slowdown or a stop of their activity compared to a usual (good) sanitary situation. In other words, they correspond to the gross revenue minus variable charges and wages (wages, considered as fixed charges, being processed separately).

We show how the issues evoked above can be partly circumvented in order to transform the pandemic business interruption risk (PBI risk)—today hardly insurable—into a risk that can be reasonably hedged. While we consider existing risk management tools such as self-insurance, portfolio diversification and standard insurance coverage, the two essential properties of an efficient PBI-risk-coverage program that we discuss in this paper are:

i) The necessity for insurers and reinsurers to find new capital by issuing adequate insurance-linked securities on financial markets.

ii) The importance of identifying precisely which actor must intervene to cover what type of loss due to a pandemic, and at what level

For Point ii) we consider separately the fixed costs borne by firms and composed of wages and loans, and other operational losses due to zero sales. Concerning Point i) we set out the characteristics that a newly issued cat bond devoted to the coverage of PBI risks should have in order to be attractive for both (re)insurers and investors. In that respect, we focus on the three layers (or steps) of an integrated risk management process, namely self-insurance, private (re)insurance (comprising standard insurance contracts and securitization), and (inter)national funding. And we highlight the characteristics that each layer must have in a future PBI-risk-management system.

The first layer concerns the initial losses borne by firms at the beginning of the pandemic crisis. We discuss the way firms would 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, Louaas and Picard (2020) suggest that small firms would benefit from facilitated access to financial markets: a strategy of investment in certain specific puts and calls on the financial markets may contribute to the accumulation of 'pandemic' provisions. We discuss both the advantages and the limits of such an investment strategy.

Beyond the upper-limit of self-protection, standard (re)insurance mechanisms should at first be mobilized. For this second layer dedicated to insurance, the first layer acts as a deductible. It permits the firm to save on the administrative costs of insurance and to resolve part of the moral hazard that may appear between the insured firm and its insurer as we explain below. Now, because the mutualization principle can no longer work for the high business interruption pandemic losses of firms of a given sector or a given country, (re)insurers will have to issue pandemic business interruption cat bonds (PBI cat bonds) in order to ensure their solvency. The characteristics of these—not yet existing—corporate PBI cat bonds and their main differences with existing cat bonds for other catastrophes are discussed.

Lastly, the third layer concerns the bodies that act as insurers of last resort, namely states. They act as insurers of last resort by compensating some economic losses out of their reserves and, thus, by complementing private insurance. Governments can also issue public contingent debt, as done for instance by Germany in 2020. More innovatively, they could consider the possibility of issuing some state PBI bonds with the support, if needed, of international bodies such as the World Bank, the International Monetary Fund, and the European Union. Their

involvement concerning the last layer does not exempt states from assuming part of the fixed charges supported by firms before this layer is reached. Our discussion in the paper makes room for this interplay between private and public funding.

Finally, this combination of private and public hedging seems to be reminiscent of what is in place for the coverage of natural catastrophes in countries like France (Vallet, 2004; Barraqué and Moatty, 2020), where nat cat insurance is compulsory, as well as what has been suggested for the nat cat risk more specifically linked to forest vulnerability (Picard et al., 2002; Brunette and Couture, 2013). Public–private funding is also a considerable part of discussions ongoing in different countries about pandemic business interruption risk coverage. The United States adopted the PRIA (Pandemic Risk Insurance Act) in 2020, which is very close to the TRIA (2002) program[5] dedicated to terrorism risks. Germany and the United Kingdom have been working on a public reinsurance fund, while in December 2020 France proposed a public–private insurance mechanism for exceptional risks (pandemic, but also cyber).[6] Unfortunately, in none of these conceptions is securitization explicitly considered: the issue of (new) capital is addressed mainly in the light of risk mutualization within the pool of future insured firms and public funding. We address this gap by arguing that the Insurance Linked Security (ILS) market can play an important role in the issuance of new capital, despite the problem of the correlation between the real economy and the financial markets that emerges when dealing with pandemic business interruption risks.

The paper is organized as follows. In Section 2, we investigate the characteristics of pandemic business interruption risk, discussing them in the light of what we know today about nat cat coverage. In particular, we focus on moral hazard issues, basis risk, correlation with financial markets, and liquidity in the context of pandemic business interruption cat bonds issuance. Section 3 presents the pandemic 3-layered hedging system and focuses, in particular, on the properties that ideal PBI cat bonds should have. Section 4 concludes the paper.

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[5]Terrorism Risk and Insurance Act Program

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

2 Specific features of pandemic risk and the challenge of securitization

The COVID-19 pandemic is a catastrophe (a cat) because of the millions of deaths it has brought about, and also because it has pushed millions of people into poverty, or even extreme poverty, as documented by the World Bank.[7] In this way, such consequences are similar to those observed in the case of a natural catastrophe (nat cat). Nevertheless, while the natural event is directly responsible for the interruption of (local) economic activity, it is not directly the pandemic event itself that stops the economy, but rather government decisions, with each government taking different political decisions in the face of the same virus. Many have announced multiple lockdowns from the very beginning of the pandemic (France, Germany, Italy, Austria, Israel, etc); others sought to reach herd immunity (Sweden, India, etc.); while still others did not take specific decisions. Hence these are human decisions that induce massive economic losses,[8] opening a space for the moral hazard issue that may arise between public decision makers and private actors ((re)insurers in particular). A second important difference with a nat cat is that a pandemic is not limited to a given area or a given country: it is the world economy that is impacted by a pandemic, and this creates the disturbing correlation between the real economies and financial markets. Hence the principle of portfolio diversification seems to be compromised when thinking about pandemic bonds.

In Subsection 2.1, we recall how the ILS market contributes to the coverage of nat cats, and we highlight the differences between those nat cats and PBI risks. Then in Subsection 2.2 we focus on moral hazard issues, explaining how a segmentation of the types of risks covered by the (re)insurers and the governments respectively helps to mitigate agency costs. In Subsection 2.3 we put the issue of correlation into perspective, and we establish the necessary conditions for the emergence of insurance-linked securities adapted to pandemic business interruption loss coverage.

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[7]"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." World Bank, 7 October 2020.

[8]Recall that we focus on immediate business interruption losses, thus leaving aside the big issue of sanitary costs.

2.1 Cat coverage and securitization

A major risk is one that can cause huge financial losses and hurt many people. It can push the affected region into a crisis that interrupts its economic activity and distresses its population. Such a risk cannot be hedged by the insurance market alone, even complemented by standard reinsurance mechanisms: therefore, since the early nineties, capital markets have provided securitized assets, the value of which is defined by the likelihood of the occurrence of a catastrophe. Cat bonds are the best-known contracts. The investor in a cat bond that is designed to cover, for instance, an earthquake risk in San Francisco, lends capital to the issuer, let's say the Californian state. This capital is invested in a special purpose entity, and thus fully collateralized. If no earthquake occurs during the lifetime of the bond, the investor recovers his capital while having received periodic coupons from the issuer during the life of the contract. Whenever an earthquake occurs, the investor loses part of (or all) the capital, which is transferred to the Californian state.[9] Thus, while the state and its citizens are losing money on the physical market because of the earthquake, the state is recovering capital on the financial markets and becomes able to complement the claims paid by the private insurers to the victims: cat bonds thus provide some additional coverage to the victims of the catastrophe.

The market for cat bonds is worth about USD 50 billion in 2021 (15 billion in 1992, the hurricane Andrew year), compared to the world's (standard) reinsurance capacities, which are worth about USD 350 billion (100 billion in 1992).[10] The so-called alternative insurance market has been growing exponentially for several years, as illustrated in Figure 1.[11]

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[9]Such cat bonds have regularly been 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 investors in case of a cat, rather than the debt cancelled. Different types of non-reimbursement clauses exist.

[10]These capacities are hardly commensurate with the world insurance market, which has accumulated more than USD 5,000 billion in 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, thus less frequently than the insurer.

[11]Actually, it is not only nat cats that 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).
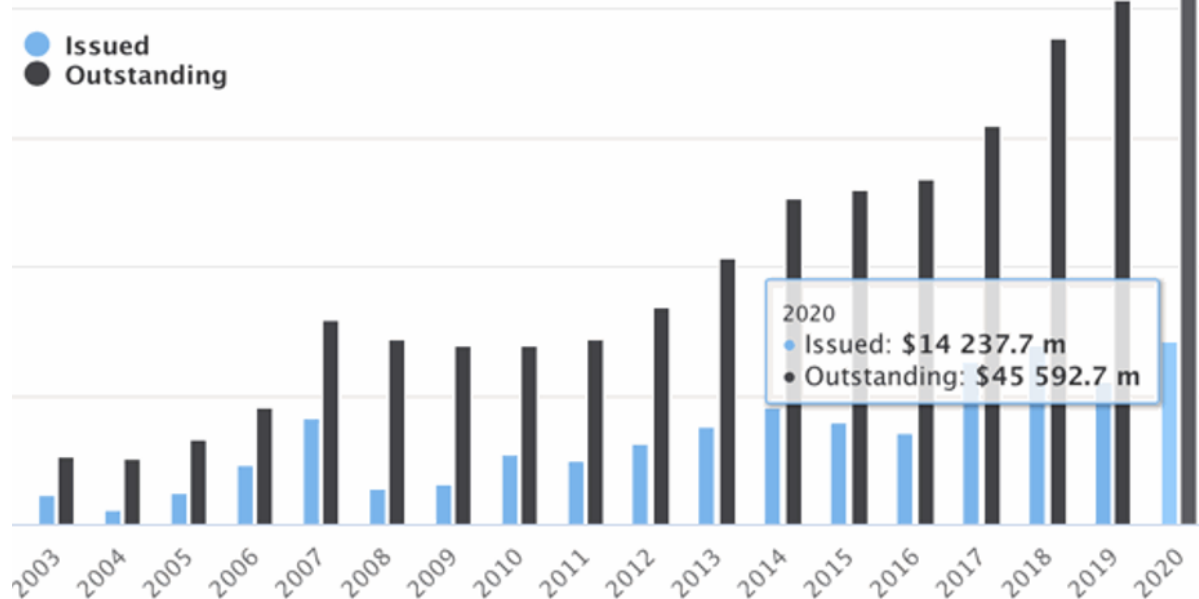
Source: Artemis Deal Directory. Data as of December 31, 2020,
https://www.artemis.bm/dashboard/cat-bond-ils-market-statistics/

Figure 1: Available capital from the issuance of cat bonds

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 would not be 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 notable 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 whose cumulative potential claims exceed K. The reinsurer's solvency is not undermined if there is 'sufficient' independence between the portfolios of these several cedents. The important point to be discussed here is this stastistical 'sufficiency'. Indeed 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

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specific point.[12]

2.2   A cat risk shaped by human decisions

The losses due to the COVID-19 pandemic are both sanitary (primarily health care and protection costs), comprising 10% of the total losses, and economic, comprising 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. Until COVID-19 the word 'pandemic' was mostly associated with diseases, deaths, and health, and 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 within the scope of P&C insurance contracts. This is a first important point. The second one is that the operating losses are not being attached to a specific incident or case of damage, as well defined in the insurance/reinsurance field (a fire, a flood, a sanitary contamination in a restaurant, etc). Instead, they appear because of governmental decisions: lockdowns, closure of firms in specific sectors (restaurants, museums, fitness rooms, etc), or curfews. Hence, the scale of the operational losses is not directly explained by the random event (pandemic or no pandemic), but instead by a political action. And this makes it difficult to mobilize hedging mechanisms that usually rely on random events.

Furthermore, the political decisions taken by a government are influenced by the behaviors of its citizens with regard to the application of all the sanitary protection measures, and thus their efficiency is directly connected to the citizens' incentives to invest time and energy in them.

Finally, 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 on the part of the population. It is rather different, therefore, from a nat cat risk.[13] Hence, one may wonder whether a PBI cat bond would be attractive for investors on the financial markets. In particular, the moral hazard that emerges because of the impact that both government decisions and individual behaviors may have on the severity of the losses can either lead to an unaffordable price for PBI cat bonds or, conversely, to no demand by investors.

Yet securitization should not be abandoned too rapidly. Indeed, choosing triggers of payment

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[12]See Lakdawalla and Zanjani (2012) for a simple and illustrative example of the advantages of partial collateralization in reinsurance mechanisms when risks are independent. Schmitt and Spaeter (2021) mitigate this advantage over securitization by introducing correlation between the firms' business interruption risks.

[13]Note also that people are more inclined to invest in protection measures when the entire profit from their individual measures goes to the benefit of themselves, whereas pandemic risk mitigation calls for individually responsible behaviors in order to obtain a collective benefit.

that do not depend directly on the actions of the issuer of the contract brings about a basis risk, and this basis risk makes it possible to manage the moral hazard between the insured firms and their insurers by imposing no perfect matching between the issuer's claims on the physical market (for instance, the operating losses of a firm or a sector covered by the insurer) and their compensation obtained on the financial market whenever a PBI bond contract is being issued. Hence by partially deconnecting 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.[14]

We probe these points further in Subsection 3.2, where the characteristics of ideal triggers are discussed.

2.3 How to deal with the correlation between the real economy and the financial markets?

Correlation is a major topic for cat bond issuance. Cat bonds for nat cats or technological disasters are almost never correlated with financial assets. Thus, while the investor is losing money on the cat bond market because a cat has occurred and the issuer has exercised the non-reimbursement clause, the global value of his financial portfolio, if well diversified, will hardly be affected.[15] Hence the independence between the cat and the returns of financial assets (stocks, corporate bonds or traditional derivatives) makes cat insurance-linked securities sought-after assets for portfolio diversification. The utility of their property of diversification was much appreciated in view of their stable trading values during the 2007–2009 financial crisis (Cummins and Trainar, 2009; Cummins and Weiss, 2009), and also more recently in 2020, as compared to other assets with similar expected returns. Figure 2 illustrates this stability (Difiore et al., 2021).

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[14]For more on adverse selection costs in the insurer–reinsurer relationship, and their mitigation thanks to cat bond issuance, see for instance Finken and Laux (2009).

[15]This is true for almost all past nat cats. No general and strong decrease of stock market valuation is observed following a cat, although possibly a sector can be momentarily impacted. Recall the explosion of the nuclear plant in Fukushima in 2011 after the Tsunami hit the Asia-Pacific coast. For several weeks, all car manufacturers had difficulty purchasing electronic components, which induced a temporary decrease in their market value: but no financial collapse followed.
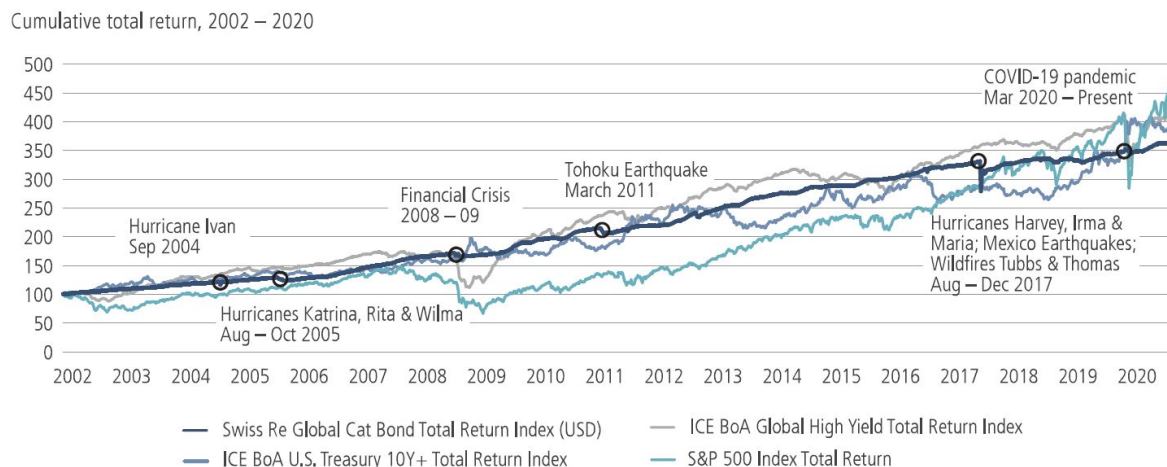
Figure 2: Performance of cat bonds (Source: Difiore, Drui & Ware (2021)

Besides, as yet no cat bondholder has been placed in difficulty following the extinguishment of the debt embedded in the underwritten bonds.[16]

The scenario is very different in the case of a pandemic. The sharp drop in the international stock markets in the middle of March 2020 has shown how heavily a pandemic such as COVID-19 impacts the economic and financial spheres. Hence, portfolio diversification may become much more difficult to attain with PBI cat bonds than with the existing cat bonds. In particular, it will be necessary for investors in PBI cat bonds to build a portfolio strategy based on stocks of sectors that evolve positively during a pandemic crisis (pharmaceutical sector, biotechnology, digital industry). Such a strategy may evolve through each pandemic as winners can become losers and vice versa from one pandemic to another.

In addition, let us note that while financial markets are very sensitive to certain events or announcements, they are also very quick to return to equilibrium: and thus by August 2020 stock markets had recovered their December 2019 value (source: Corporate Performance Analytics, S&P Global). The yield curve was an unambiguous V-curve over this period. Such a pattern plays in favor of PBI cat bonds by mitigating one important concern about them, namely the correlation between the probability of the cat bond triggering (and, thus, the loss of the capital

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[16]For 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 hurricane Katrina in 2005, while the second 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.

for the investor) and the value of the investor's financial portfolio. Nevertheless, not all the correlation can be removed, and this explains why higher coupons will be requested by the investors compared to the coupons of the existing cat bonds. Such a higher price is not such bad news given that traditional bonds pay very low returns for several years and that interest rates shall remain low in the short and mid term. Hence, higher expected coupons that could be paid to investors still improves the attractiveness of future PBI cat bonds.

At this stage it is relevant to note 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 even COVID. Unfortunately, this issuance has been strongly criticised because of its sophisticated and stringent triggering system: the pandemic must have induced at least 250 deaths in the country in which the virus appeared (thus, for COVID-19, China) and at least 20 deaths in another poor country, within a period of twelve weeks from the first report of WHO (released 31 December 2019 for COVID-19). These pandemic bonds were thus finally triggered in April 2020. An equity issue has nevertheless been added to the complexity of the system, the triggers being based on a minimum number for accumulated deaths (Bloomberg, 2020; Raynal, 2020). Our approach in this paper is very different, as explained below.

3   Towards a three-layered PBI risk-management system

A second important difference between a natural, or even technological, catastrophe and a pandemic catastrophe concerns temporality. A nat cat is an event that arises at a given date and whose harms are attached to this event date, although not all need be identified in the immediate aftermath of the cat. Hence, a hurricane will hit a region for a few seconds,[17] an earthquake lasts for several minutes at most, and an explosion in an industrial plant is a momentary event. 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 that the world, a continent, or several countries are suffering from a pandemic. The cat characteristic can still be defined by reference to the level of contagion. However, the economic and financial consequences of the pandemic cat, as we recalled above, are due to several, sequential, and not perfectly foreseeable decisions taken by

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[17]Although a hurricane properly understood will subside after seven to nine days, it only takes a few seconds to devastate a village, a town or an administrative area.

governments or international bodies. Hence, while the population is expecting a return to normal life with the announced reopening of restaurants, museums, fitness rooms, etc., a new variant of the virus could appear and compel the government to take new, drastic decisions that place the economy in difficulty again. 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 capital that was, until then, 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 for 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 must be at work in a pandemic business interruption cat bond, as developed in Subsection 3.2 below.

From the different points set out above, we can see that the coverage system for nat cats cannot merely be duplicated for PBI risk, despite its catastrophic component. Nonetheless, by isolating different states through which a pandemic crisis may pass, it is possible to build an appropriate coverage strategy. This strategy relies on a hybridization of tools, a segmentation of risks being covered by the different actors, and financial innovation. In the course of this section, we sketch the main characteristics of the three layers of coverage at stake.

Each layer is defined by a lower and an upper limit of losses. The probability of facing a more-or-less high level of losses for each actor of each layer closely depends on the time of the crisis at which losses are observed. Typically, operational losses are higher when the crisis lasts for several months or years. Its duration is explained either by sequential, non-anticipated, rebounds of the pandemic, and/or by the fact that governments take too-timid protection measures (for instance no lockdowns, no closure of vulnerable sectors, no major vaccination campaigns). The self-insurance (first) layer can be reached in different ways depending on the size of the firm and the structure of the sector to which it belongs, as we discuss in Subsection 3.1. Insurers and reinsurers can do their job at the second layer of coverage, precisely when potential operational losses become too high for firms to cover by themselves. On this layer, (re)insurance takes place, including securitization. The PBI bonds that have to be issued and subscribed on the ILS market should be designed so as to ensure a sufficient level of liquidity. Besides this, and contrary to natural catastrophes, pandemic risk and financial crisis are correlated. Subsection 3.2 focuses on these two points.

Then, the state intervenes to address losses that exceed the second layer, having issued additional PBI bonds and other forms of debt in order to play its role of insurer of last resort. At this third layer, supranational bodies will also have to intervene in order to provide political, financial, and/or economic support to national governments (Subsection 3.3).

3.1 First layer and self-insurance

In the first half of 2021, the French government was considering fostering the build-up of pandemic provisions by firms in the future by lessening the tax burden on those funds.[18] Therefore, firms would have an incentive to save funds during periods of high activity in order to protect themselves against a decline in their gross profit should a future pandemic justify one or several lockdowns. Self-insurance is here considered 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 losses, meaning those that occur in the first wave of a pandemic.[19]

Self-insurance can be obtained through different means, depending on the size of the firm. Since the early 2000s self-insurance has been common practice in large firms thanks to the success of captives (Porat and Powers, 1999; Picard and Pinquet, 2013). A captive is an insurance entity created by a given firm, or a given sector, in order to insure its own risks. In this way the firm is simultaneously achieving risk retention and risk provision. It transfers insurance premia to its captive such as it would to an external insurer. Captives are used to lessen transaction costs, and to address a specific need for coverage for some risks that are not well covered by private insurers (typically, but not only, for some cat risks).[20]

The greatest benefit of the creation of captives for self-insuring part of the pandemic risk is, in our opinion, the resolution of the agency conflicts that arise between the firm and an external insurer: by being the owner of (at least a part of) a captive, the firm and its 'insurer' belong to the same entity, namely the holding company. Assuming that the holding company has a

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[18]During the period of revision of this paper, a decision to postpone such a proposal was taken by the French government.

[19]The first wave of the pandemic refers to the first weeks after a pandemic has been declared, during which firms may be affected by the first administrative decisions taken by a government to fight against it.

[20]The British Petroleum (BP) company was one of the first firms in the petroleum sector to build a captive in 1985 (named JUPITER Insurance). In the media, it was observed that this decision was motivated by the fact that BP's insurers at that time were more likely to become bankrupt than BP itself following a huge incident that they would have to compensate. This captive has been 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), the latter event resulting in 11 deaths, 17 people injured, and costing the firm about $63 billion (in indemnities and fines).

clear interest in risk mitigation, it is also able to improve its risk management by orienting and monitoring the risk-management strategy of its subsidiaries. In this context, adequate investment decisions in protection and prevention activities may be taken.

Such an internal risk-diversification scheme works well for large firms which have substantial equity and engage in a number of different activities or have many subsidiaries. Firms of intermediary size might have more difficulty sustaining the creation of their own captive, however, even if it is dedicated to major risks such as pandemics, cyber attacks, 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 it for 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 renting a cell of the captive.

Even so, small firms can remain excluded 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) suggest that, under some specific conditions, small firms can also effect some self-protection for pandemic risk by investing in financial markets. The aim is not to issue some insurance-linked securities, but rather to buy put and call options on financial stocks from different sectors of winners and losers of a pandemic crisis. In the case of COVID-19, the sectors of tourism, transportation, and catering are severely affected, while the stocks of the biotech and pharmaceutical industry were very much in demand at the beginning of the crisis, investors anticipating an increase in their stock-market value. In the simulations proposed by Louaas and Picard (2020), 12 years are sufficient to obtain a capital of higher than 11 million Euros when 20,000 Euros are invested each year in the described portfolio. We argue that such a strategy must be part of a global coverage strategy. It cannot solve all the issues. 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 the high costs of full collateralization of the firms' capital. Furthermore, the winners of a pandemic may be the losers of the next one. And during the saving period, no other big crisis should happen.

In sum, self-insurance remains a pillar of a global risk-management strategy, but both its upper bound and the tools used to build up reserves depend on the size of the firm. The

opportunity cost of immobilizing too much capital can increase exponentially and may weaken the firm in its development strategy during stable economic periods.[21]

3.2 (Re)insurance and pandemic business interruption bonds at the second layer

The second layer corresponds to a range of losses that are '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 the holder of the contract exclusively. In such a context, loss of gross profit 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 of the ongoing year. Hence for this first part of the losses, risk mutualization is still at work.

Then, for higher losses, securitization would be mobilized in order to raise new capital that would complement the reserves built up thanks to P&C insurance premia. The purpose is to prompt insurers and reinsurers to issue pandemic bonds, which have yet to be created.[22] In addition, complementing standard insurance with ILS products mitigates the adverse selection issue relative to sectors vulnerable to pandemic loss and, thus, particularly interested by a specific coverage included in their insurance contracts.

From the discussion proposed in Section 2 above, we know that the important point when building relevant PBI cat bonds is to select relevant triggers. First, operational losses may arise without any pandemic event: thus it is necessary to guarantee that the non-reimbursement clause of a PBI cat 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. Schmitt and Spaeter (2021) suggests that a very good candidate would be the release by the WHO of a PHEIC, i.e. a Public Health Emergency of International Concern.[23] At the time of a PHEIC,

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[21]See also Clarke et al. (2017) on the opportunity costs of building up some reserves in the case of cat risks.

[22]The first pandemic bonds were issued in 2003 to cover extreme mortality risk. Their efficacy was regularly called into question (Alloway and Vossos, 2020), with a last and most recent debate concerning the pandemic bonds issued in 2017 by the World Bank, as mentioned earlier in this paper.

[23]On 31 January 2020 the Director-General of the WHO declared that the outbreak of 2019-nCoV constituted

the term 'pandemic' is not yet used. The next step is thus the announcement of a pandemic state as scientifically defined. Hence, we argue that two types of PBI cat bonds could be issued that relate exclusively to the first trigger: some with a PHEIC trigger and others with a 'pandemic state' trigger. This would introduce sequentiality in the triggering of cat bonds linked to a same epidemiological event. Hence, financial markets would be able to build PBI cat bond contracts with different probabilities of triggers and different pricings for a given pandemic.

Note also that all member states of the WHO are involved in the procedure of advising the Director-General of the WHO to announce a PHEIC. In this way, the announcement of a PHEIC is not called into question by any country.

The second trigger of a PBI cat bond would be a threshold of operational losses borne by the economic sector concerned by the coverage. By doing so, the trigger would based on well-known parameters, i.e. the operational losses, as already used by (re)insurers in the existing insurance contracts and reinsurance treaties. Moreover, a fair basis risk is maintained due to the imperfect, but still high, correlation between the losses of the sector and the losses of the firms that belong to it. Besides, such a second trigger based on a level of operational losses also allows for a distinction between countries that decide one or several general lockdowns and those that have adopted the laisser-faire strategy. Indeed, in this last case operational losses would not be so high compared to a given threshold, at least in the first stage of the pandemic. To illustrate this point in the context of the current pandemic, such PBI cat 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 upon (the situation changed during the second semester of 2020). Lastly, the triggers at stake here allow the avoidance of criticisms such as those levelled against the pandemic bond issued by the World Bank in 2017 in order to compensate losses from Ebola virus. Recall that its trigger was defined with respect to a certain number of deaths, and this in particular engendered debates concerning both its ethics and its efficacy. It was considered unethical to bet on deaths in order to win on the financial markets by exercising the non-reimbursement clause. And other observers estimated that such a trigger was even counterproductive since it was annihilating all

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a PHEIC. The 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."

incentives a government might have had to contain the spread of the virus.

Drawing on this, it seems to us that there is also room for the issuance of 'pandemic' bonds by international bodies. This time the capital raised in case of a pandemic would serve to cover both the operational losses and sanitary costs of the pandemic in poor countries. On the economic side, corporate insurance is far less often proposed in such countries than in developed ones. Hence, the issue of operational loss coverage by private insurers is currently not even considered. Besides, on the sanitary front, some poor countries were acquiescing to a laisser-faire situation simply because they were not able to adopt adequate measures, whether financially, politically, or both. In these cases, international bodies such as the World Bank or the International Monetary Fund have a role to play by issuing 'pandemic' bonds with triggers adapted to the coverage of economic losses for some countries and of sanitary losses for others. In particular, a very simple 'pandemic' bond with one trigger based on the WHO declaration could be consistent with the aim of covering sanitary costs. No minimum number of deaths should be required to trigger the non-reimbursement clause. Instead, the international bodies would also be in charge of verifying that the capital raised is used exclusively for sanitary purposes. Hence different kinds of 'pandemic' bonds might coexist and a primary issue would be to build up these bonds on tailored triggers.

Now, because pandemic business interruption risk is correlated with financial risk, it is also important to verify that the buyer of pandemic bonds will be able to diversify his portfolio. In the case of COVID-19, the financial collapse of the stock markets in March 2020 entailed a sharp and deep devaluation, but also a very quick recovery of the financial yields in the following weeks. Hence the most-traded financial indices recovered to pre-COVID levels during the summer of 2020, thanks to positive perspectives about vaccines and to the decision taken by the developed countries to bolster their economies. If, in a next international crisis caused by a pandemic, such national and supra-national support could be associated with adequate available reserves owned by private (re)insurers in order to cover part of the operational losses, the financial markets would recover even more rapidly. We can also imagine that the collapse would not be so hard. These features support PBI and/or pandemic cat bonds and they suggest that a portfolio comprising such financial assets could be diversified, in particular if those cat bonds are held over two or three years.

Lastly, let us recall that the first layer of coverage discussed in Subsection 3.1 acts as a deductible for the second one. And, as is well known in the insurance economics literature, the existence of a deductible lessens the administrative costs of insurance. In the frame of the pandemic risk, such a deductible may also help to identify the types of firms. Indeed, firms that are already facing economic difficulties before a pandemic will also have trouble effecting the precautionary savings of the first layer. Depending on the upper bound of this layer, some firms might go bankrupt before getting in touch with the insurer for the second layer of coverage. Hence, the first layer of the risk management system contributes also to mitigating the adverse selection issue.

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

The third layer of the PBI losses is the hardest one in terms of the crisis. The operational losses of this layer are linked to successive lockdowns and to administrative closures of different sectors, which can last for months. At this stage, public intervention takes over and complements all other layers when they exist.

It is easier for solvent governments than for firms to raise money in the very short term and at acceptable interest rates.[24] While almost all countries are hit by a pandemic, the most solvent ones remain attractive for investors who still have an excess of cash. Institutions like the European Union, the World Bank, or the International Monetary Fund act as guarantors economically and/or politically for the other vulnerable countries. Hence, on the third layer of economic losses, states act as insurers of last resort, with the support of, or in coordination with, the international bodies.

Note that governments do not intervene only in the last stage. An essential condition for the success of an integrated economic risk-management system is the prevalence, in parallel and throughout all the waves of the pandemic, of a continuous sanitary risk management. This means that regional, national, and international public policies must be put in place in order to engage in prevention and protection against the virus (population training and acculturation, continuous investment in R&D).

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[24]The lending conditions of firms and states during the current pandemic crisis benefit from very low interest rates, and this reduces the weight of debt. Nevertheless, such favorable conditions may not hold during a future pandemic crisis.

In addition, it is also important that governments focus on the coverage of fixed charges borne by firms. Public lending should continue to be devoted to this objective. In this way, there is no conflict of interest between private insurers and public funding. Furthermore, this distribution of different types of risks to different actors contributes to the coherence of an integrated risk-management system.

Lastly, a government can spread the reimbursement of the debt either over all citizens of a given generation or of different successive generations. It is also the government that decides whether a lockdown must be announced, or if restaurants, schools, etc. must be closed. Thus in the last layer the same entity simultaneously decides which protection measures to take in order to stop the virus spreading, and compensates for the additional economic consequences.

Figure 3 displays an example $I_{partial}(X)$ of a coverage strategy when partial coverage of economic losses can be, or shall be, provided.
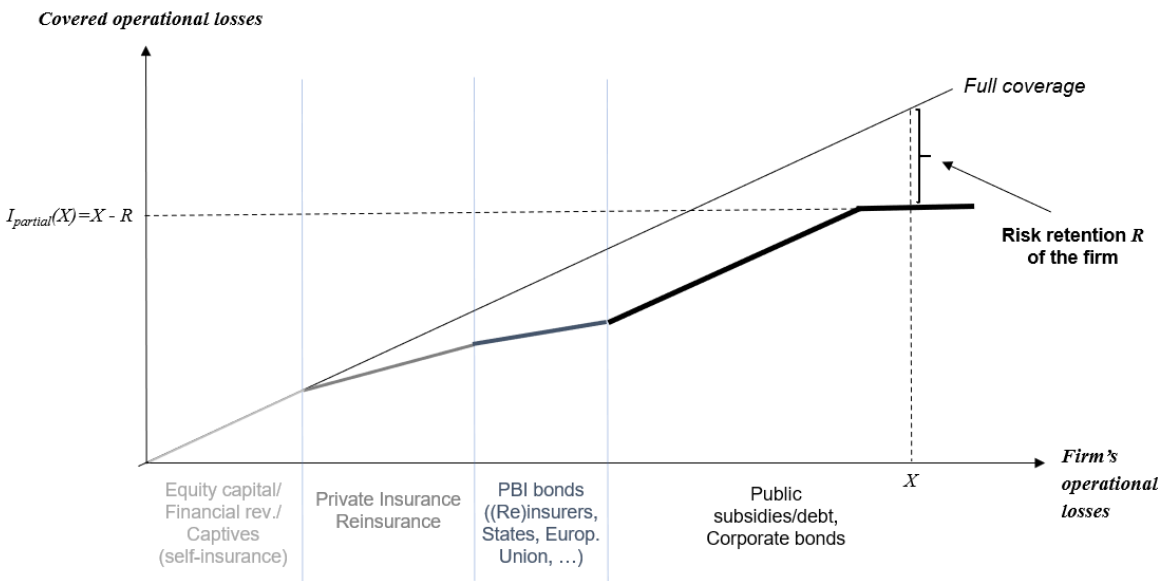

Figure 3: Combined hedging system for PBI Risk: partial coverage

This highlights the different dimensions that must be addressed in order to arbitrate between agency costs, basis risk, transaction costs, and adequate levels of coverage. First, the parameters of the different layers should 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 discussed between the hedging body (the firm itself, the (re)insurer, the state, the international bodies), and the hedged entity (the firm). The level of coinsurance can also be negotiated between two hedging bodies such as the firm and the insurer on the first and second layers, the (re)insurer and the state on the second and third layers, or the state and the economic area it belongs to on the third layer. 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.

A second important point concerns the objective of a government: does it want to reach herd immunity, 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 might justify different lower and upper bonds of the three layers of losses.

Third, the size of the layers in a given country is also impacted by the strategy adopted by its neighbouring countries. A laissez-faire strategy adopted by one country will surely have an impact on the efficiency of the strategy adopted by the other whenever mobility of people is not rapidly constrained. Externalities are also a matter of importance.

Lastly, each preceding layer acts as a deductible for the following one; or, to put it differently, each upper layer intervenes only after the preceding one. Thus the higher the floor of a given layer, the lower the probability it will be mobilized: it will depend on the severity of the pandemic, on the actions taken by the states, and on individual behaviors day-to-day.

To get an idea about how such a system could function, let us consider the 2020 situation for non-financial firms in France. Lockdowns lasted for a total of seven months and six days. The total losses of revenues of firms over this period were estimated at 150 billion Euros (Bureau et al., 2021). Partial unemployment costs of 26.28 billion Euros were borne by both the National Professional Union for Employment in Industry and Trade (UNEDIC) and the State. Let us consider the 2018 mean gross operational margin of 26% of the commercial firms in France (INSEE, 2020). Hence, the operational losses equal 41.6 billion Euros.

Now assume that firms have done some self-protection and are able to retain the first 20% of their operational losses, namely 8.32 billion. On the second layer, let us assume that insurance

markets cover 30% of the operational losses through the P&C contracts (and reinsurance), that is an amount of 12.48 billion. If PBI cat bonds were initially issued by the same (re)insurers with an exhaustion point at 30% upon the 50% already covered (20% plus 30%), the liberalized capital will be equal to 12.48 billion. The remaining 20% of operational losses must be covered at the third layer thanks to (inter)national public funding and contingent debt issuance. This last layer of 20% corresponds to an amount of 8.32 billion Euros. This amount seems rather low compared to what is paid/covered over the first two layers. Actually, and additionally to this 8.32 million, the government also pays for some fixed costs not embedded in the operational losses considered in our risk-management system (wages, loan interests, lease payments). Lastly, all sanitary costs are borne exclusively by the government.

Now, let us put these amounts in perspective by comparing them to the available equity of insurers and also with what was paid by the different actors in France in 2020. Concerning insurance, the French Federation of Insurance reported a total amount of more than 5 billion Euros paid by the insurance sector to their customers. Of this, 2.6 billion was paid directly to customers through reimbursements, subsidies, and commercial gestures. These payments were not linked to the content of insurance contracts. Indeed, only 3% of the P&C contracts had a 'pandemic' option. French insurers agreed to pay an additional 2 billion in order to sustain a solidarity fund dedicated to the small and medium firms impacted by the COVID-19 crisis. Currently, some insurance companies are still involved in judicial procedures, which will cost them an additional hundreds of millions of Euros. In addition, France has about 4 million firms (INSEE, 2020) which, in 2018, were distributed as follows: 269 big firms produced 32% of the added value, 5,700 firms of intermediary size produced 26 % of the added value, 148,100 small and medium firms produced 23% of the added value, while 3.8 million microfirms produced 20% of the added value. Now, when considering the CATEX private–public coverage system that was proposed at the end of December 2020 by the French insurers to the government (but not retained), small firms would pay an annual additional premium of around 4.20 Euros per month. Medium firms would pay between 155 Euros and 7400 euros per month (nothing is said about big firms, for which tailor-made contracts hold). By doing the arithmetic when the mean premium for small and medium firms is put at 2000 Euros per month, the additional capital available from the additional premia would be about 316,378,000 Euros, which is rather low compared to the amounts involved in the pandemic. Nevertheless, these levels of premia do not take into account

the price of PBI cat bonds, since the CATEX system, unfortunately, did not consider them to be a risk-management tool. Lastly, the French governement paid out more than 200 billion Euros in 2020, encompassing zero-interest loans, subsidies, wage compensations, and all sanitary costs.

4   Conclusion

Different tools exist to cover firms' operational losses induced by administrative decisions taken to fight a pandemic, and not all of these have yet been fully mobilized. Each has its advantages and limitations. The aim of this paper was to discuss the opportunity costs of each coverage instrument, their accessibility for small/medium/large firms, and also to evoke the governance that is needed to ensure the coherence and the efficiency of a pandemic business interruption risk management system suited to a crisis such as the one the world has been experiencing 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 build up financial reserves during good economic periods. These reserves would be mobilized to cover their first operational losses whenever a 'pandemic' was 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 some captives or rent-a-captives. Self-insurance is more tricky for small firms, which have limited opportunity to immobilize capital, and on this point, Louaas and Picard (2020) suggest a put and call diversification strategy: firms invest in financial markets and identify 'pandemic' winning and losing sectors in order to buy adequate options on them. To improve the attractiveness of such a strategy, it is necessary that governments reduce the burden of tax on these 'pandemic' provisions. Some governments have recently communicated that they are considering this, but no political decision in this regard has been taken so far.

In a second stage of the crisis, insurance and reinsurance play their role. They cover those economic losses that are too high to be retained by the firms, but still fair for the (re)insurance sector to cover without endangering its solvency. To do so, some specific Insurance Linked Securities can be built for pandemic business interruption risk. We explained how two important impediments to the duplication of a cat bond strategy, namely moral hazard and correlation with the financial markets, can be partially circumvented by creating certain double-triggered

pandemic business interruption (PBI) cat bonds.

On the third layer, the governments play the role of insurer of last resort. They may be supported on the economic and/or political level by international bodies. On this layer of losses, securitization (also accessible to states) should be complemented by a massive issuance of public contingent debt.

Of course, various limitations to our proposition can be remarked upon. Rather than listing them, we select some that ought to be considered by the mixed working groups (private (re)insurers and public bodies) that have been constituted in several countries in order to make progress 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, should be compulsory. On one hand, not all sectors are 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 is an option in an insurance contract, only firms with high risks of being impacted by administrative lockdowns will buy coverage. This would give rise to an important adverse selection issue, and would also limit the amount of funds constituted by insurers. Hence insurance could be compulsory, built partly on a solidarity principle.

A second issue concerns the sanitary costs of the crisis, which in this paper we have virtually not considered. Nevertheless, governments have to combine the financial support to the economy with the financing of the sanitary measures.

Lastly, the technical issue remains to be addressed of building PBI cat bonds by integrating the elements developed in this paper. To our knowledge, the first attempt at undertaking this task can be found in Schmitt and Spaeter (2021).

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