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Are catastrophe bonds effective financial instruments in the transport and infrastructure industries? Evidence and review from international financial markets

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Abstract: We analyse the effectiveness of catastrophe bonds for the financial management of catastrophic risk in the transport and infrastructure industries. We illustrate how these financial instruments are becoming a valuable tool for non-financial firms in the risk management of catastrophic events, supplementing the traditional insurance/reinsurance channel, especially during times of constraints in the insurance industry. We also review cat bond issues sponsored by infrastructure and transport companies, highlighting the usefulness of these structured financial instruments in the management of the catastrophe exposure in these industries. Policy indications are finally given.

JEL Classifications: G32, R42, R53, H54

Keywords: Catastrophe bonds, risk management, investment analysis, public investment, infrastructures, transportation

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1. Introduction

Some observers have noted that the frequency of natural and man-made disasters appears to have increased over the past few decades, especially given the dramatic climatic and environmental changes that nowadays the world is experiencing and the spreading of geopolitical friction (World Meteorological Organization, 2013). The rapid growth in the population and in the worthiness of many areas of the world has increased the potential for human and financial losses in the case of a disaster occurring (World Bank, 2012). Therefore, the risk of (human and financial) losses caused by natural or man-made catastrophes cannot be neglected and needs to be managed carefully (Komljenovic, Gaha, & Abdul-No, 2016). Failure in this task can lead to enormous damage and losses if the event occurs as well as dramatic difficulties in restoring the pre-catastrophe economic, infrastructural, and societal status in the aftermath of the event. The latter challenge calls for public and private risk managers to find solutions to finance the reconstruction and recovery of the usual business and societal operations rapidly and effectively. Traditionally, insurance contracts are concluded to this end. Nevertheless, the exceptionality of the losses related to some catastrophic events (Hurricane Andrew in 1992, the 11/9 terroristic attacks, the earthquake and tsunami in the sea off Sumatra in 2004, Hurricane Katrina in 2005, and Hurricane Sandy in 2012, to cite only a few) and the dramatic growth of the value at risk in the case of catastrophes have driven insurance and reinsurance companies not to insure/reinsure against some catastrophic events and/or to pose significant deductibles or limitations on the compensation and/or to raise the insurance premium consistently, thus making the traditional insurance channel difficult, more expensive, and less effective (on the limitation of the classical insurance channel for the hedging of cat risk, see (Froot, 2001). (Cummins, Doherty, & Lo, 2002) conducted a theoretical and empirical analysis of the capacity of the US property-liability insurance industry to finance major catastrophic property losses. They concluded that industry has more than adequate capacity to pay for catastrophes of moderate size. They also outlined that major events would cause insolvencies and severely destabilize insurance markets.

The need for alternative and effective solutions for the financial risk management of catastrophic events led in the last decade of the previous century to the development of innovative financial instruments that allowed the cat risk to be shared and diversified directly in the financial market (Loubergé, Kellezi, & Gilli, 1999).

In this paper we concentrate on catastrophe bonds, which are nowadays the most used solution to hedge the risk of catastrophes through the capital markets. Largely employed by insurance and reinsurance companies, cat bonds are not a financial instrument that is commonly utilized by non-financial companies. Nevertheless, they can be an effective solution to manage the risk of catastrophes (see among the others (Croson & Kunreuther, 2000) (Lee & Yu, 2007), especially for companies operating in the transport or infrastructure industry, the revenues and assets of which can suffer massively from business interruptions or damage caused by hurricanes, storms, earthquakes, and so on. We analyse the effectiveness of cat bonds for the financial management of catastrophic risk in the transport and infrastructure industries. We also illustrate how these instruments are becoming a valuable financial instrument for non-financial firms, supplementing the traditional insurance/reinsurance channel in the management of the potential losses related to catastrophic events. Moreover, we review the most significant experiences of cat-bond issued by non-financial firms operating in the transport and in the infrastructure industry. Policy indications for public and private risk managers are also given. To the best of our knowledge, this is the very first paper to deal with the employment of cat bonds by non-financial firms operating in the transport and infrastructure industries, thus filling a not negligible gap in the existent literature and contributing to the risk management analysis of the catastrophe risk.

The rest of the paper is structured as follows. The next section introduces the catastrophe risk and the challenges that it poses for the risk management process of a company. Section 3 describes catastrophe bonds and deals with their usefulness in the risk management process of insurance as well as non-financial companies. Section 4 examines and comments on some cat bond issues faced by non-financial companies operating in the transport and infrastructure industry. Section 5 concludes.

2. Catastrophe risk

Many natural (geophysical, meteorological, atmospheric, etc.) or man-made events can produce catastrophic human and/or environmental and/or financial losses or damage (earthquakes, hurricanes, flooding, landslides, volcanic eruptions, meteorite impacts, terrorist attacks, industrial contamination, etc.). The uncertainty surrounding the occurrence and extent of such potential events is the catastrophe risk.[1] Differently from other forms of risk, catastrophe risk is characterized by low frequency of occurrence but high severity of possible losses (Posner, 2004). Moreover, it is a pure risk given that the best outcome from the uncertainty surrounding the risk of catastrophe is that the catastrophe does not occur. From a risk management perspective, the low frequency of occurrence means that it can be very difficult to estimate the occurrence and magnitude with a high degree of accuracy and that the estimation models usually employed for usual financial and operating risks (like mortality rates, automotive accidents, accidents at work, probability of default, etc.) are not functional. (Cossette, Duchesne, & Marceau, 2003) formally demonstrated that catastrophe risk cannot be diversified effectively through premium collection alone, as is the case with other types of risks, even for an arbitrary large portfolio.

In this study the term peril refers to any catastrophic event and the term hazard to any situation that can lead to a peril or to the intensification of its outcomes (for instance an earthquake is a peril, and being on a fault line is a hazard that increases the probability of an earthquake happening or intensifies its damage).

Catastrophes are generally assessed by physical, social, and economic severity measures to provide an estimate of the potential and actual damage (e.g. the Richter scale for earthquakes, Saffir-Simpson scale for hurricanes, and so on). In other cases the metrics are far less clear (e.g., a land mass movement or bomb explosion). Other than direct losses (devastation, deaths, injuries, damage to capital assets), a catastrophe can produce significant indirect costs (like business interruptions, increased private debt, unemployment, public sector deficit, and so on) in the long term.

A complex problem related to the management of cat risks is the estimate of the vulnerability, that is, the potential for losses. A catastrophe can occur without losses (think of a flood in a desolated area). In such a case, no vulnerability exists and there is no need for risk management. The estimate of the vulnerability is a crucial task, since it depends on the severity of the catastrophe (an earthquake of 8.5 magnitude causes much more damage than one of 4 Richter degrees in the same area). Moreover, vulnerability is a dynamic concept, since the demographic and economic conditions of an area can change dramatically in a relatively short period of time. An underestimation of the vulnerability can lead to greater than expected losses and render recovery programmes inadequate.[2] Thus, as for other financial and operative risks, modelling catastrophe risk is the primary step in setting up an effective risk management framework (for a primer on catastrophe risk modelling see (Foote, Hillier, Mitchell-Wallace, & Jones, 2017). Obviously, a catastrophe model cannot predict when or where a peril will occur, its severity, or the actual damage. Nevertheless, if properly built, it should estimate at least the probability of occurrence, the maximum severity, and the level of losses for a given level of severity. Differently from high-frequency/low-severity events, catastrophe risk models have to be

[1] A catastrophe is traditionally viewed as a single massive event. Actually, even a long series of small events must be considered as a catastrophe if the events are related and have the potential to produce very large human and/or financial losses (for example a long series of not severe earthquakes or the phenomenon of erosion). Note that a catastrophe is the event itself and not its damage or losses. Catastrophes can be non-repetitive (they can never be repeated in the same location), irregular (they can be repeated in the same location but without any degree of statistical regularity), regular (they repeat with some regularity, like eruptions from an active volcano), and seasonal (they occur regularly in a certain area in a certain period of the year, for instance tropical cyclones).

[2] It is frequently reported (see for instance (Banks, 2005) that the 1992 Hurricane Andrew in Florida generated a total of $26 billion of damage. At that time the highest estimate for catastrophes of the same level was only $7 billion. It is not surprising that many insurers and reinsurers experienced serious financial distress.

highly customized for any peril/hazard/location given their unique natural and economic features. Moreover, since catastrophes are low-frequency events, they have to deal with the scarcity of historical data, meaning that the construction of the loss distribution is not an easy task, especially for the measurement of its tails (which in the most cases is needed more), and generally it needs to be updated constantly to take into account possible new data and changes in environmental, demographic, natural, environmental, and economic conditions. In the end modelling cat risk is a challenging process that relies heavily on subjective and qualitative inputs.

Catastrophes cannot be eliminated. However, a proper risk management programme can help: a) in reducing the damage of the event (such as efficient building standards, timely hurricane or tsunami alert systems, and so on) and b) in dealing with the actual financial and economic losses. With regard to the latter, insurance and reinsurance are the most important instruments to manage actively the financial losses of a catastrophe, but they cannot always be an effective solution.[1] In many cases other capital market instruments are an alternative or more effective parallel answer.

3. Catastrophe bonds

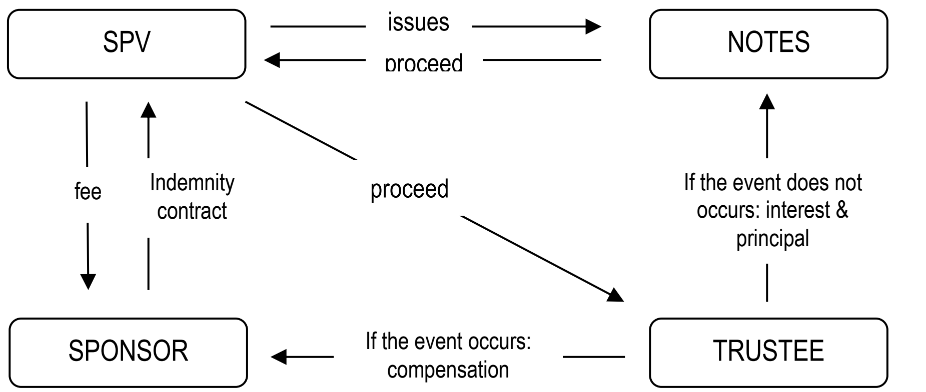
The capital market is the main channel in modern economies for mobilizing capital, providing information, dealing with incentive problems, and managing risks. Financial innovation permits capital markets to deal actively with the dynamism of the financial system and of operators' needs. Moreover, the availability of concurrent financial instruments to deal with the same financial need reduces the volatility of the prices and increases the information and transparency of the market. In this regard, in the last two decades, different financial instruments have been developed to enable more effective management of the catastrophe risk and to overcome some of the limitations of the traditional insurance/reinsurance framework outlined in the previous section. Among these financial instruments, catastrophe bonds (cat bonds hereafter) have gained a predominant position (on the suitability of cat bonds as an alternative to reinsurance for the purpose of transferring natural catastrophe risk, see (Gibson, Habib, & Ziegler, 2014).[2]

[1] Insurance is largely based on the Law of Large Numbers and on the Central Limit Theorem, which allow an insurer to diversify and price a portfolio of risks properly. Nevertheless, the low frequency of catastrophes severely restricts their applicability in the insurance of catastrophe risk. This generally leads to some catastrophes being considered by private insurers and reinsurers as uninsurable or partially insurable. Indeed, in many circumstances companies have encountered great difficulties in insuring against terrorism, flood, and nuclear risk.

[2] Contingent capital and catastrophe derivatives are the other financial instruments usually employed nowadays to manage catastrophe risk actively. Contingent capital is an agreement that permits a financial operator to have access to financing in predetermined conditions (maximum amount, interest rate, maturity, etc.) in the case that a predefined catastrophic event occurs. If the event does not occur, the facility cannot be claimed. The facility is not an indemnification for the damage of the event but funding that has to be repaid at the due maturity. Its aim is to allow the operator to have the certainty of the financing in predefined conditions in the aftermath of the catastrophe to deal with its outcomes. Contingent capital can be structured as contingent debt (funds are provided as refundable debt) or contingent equity (funds are provided by underwriting newly issued common or preferred equity). In return for the commitment, the operator pays the contingent capital supplier a periodic non-refundable commitment fee as well as an underwriting fee if the event occurs and the financing is activated. The operator bears the risk that the contingent capital provider does not fulfill its obligation. It is not obliged to activate the financing if the catastrophe occurs (i.e. the operator can have its own finance to deal with the consequences of the event or be able to fund in more favorable conditions). Cat derivatives are financial derivatives (futures, options, swaps) that are generally based on a catastrophe index (like the Property Claim Service Catastrophe Loss Index). Their use is very limited as yet, and all the attempts of some derivative exchanges (like the Chicago Board of Trade and the Bermuda Commodities Exchange) to introduce exchange-traded cat derivatives have failed. To the best of our knowledge, nowadays only over-the-counter cat derivatives are traded, generally in

A catastrophe bond is a structured financial instrument. In its basic form, a Special Purpose Vehicle (SPV) issues notes in the capital market and concludes an indemnity contract with the sponsor company. Notes are generally placed with institutional investors through private placements. The proceeds of the issuing are in general transferred to a trustee for reinvestment. The sponsor company pays a fee to the SPV in exchange for the indemnity contract. The net return from the reinvestment, the invested proceeds, and the premium paid by the sponsor are employed to pay the interest and repay the principal to the investors. If a predefined catastrophic event occurs and the SPV has to indemnify the sponsor as a result of the indemnity contract, the trustee delays or permanently withholds interest and/or principal payments, employing the capital reinvested to indemnify the sponsor. The investor will receive further interest and principal within the limit of the funds that remain in the trustee's availability, if any, after having indemnified the sponsor. Generally, the maturity of the notes does not exceed three or four years. Retail investors generally have indirect access to these financial products through pension or mutual funds. Secondary market negotiations are generally based on over-the-counter private trades. This increases the difficulties of pricing cat bonds correctly.

FIGURE 1. CATASTROPHE BONDS, BASIC WORKFLOW



The SPV is an independent, bankruptcy-remote entity. Generally, more than one tranche of the notes is issued, each tranche with its own risk–return profile to offer to potential investors a quasi-tailored financial instrument in which to invest. The highest risk/highest nominal return tranche (most junior tranche) suffers before the others from the interest/principal withdrawal in the case that the catastrophic event occurs. At the other end, the lowest risk/lowest nominal return (senior tranche) is repaid before the others, if

the form of swaps. Nevertheless, in our opinion they have considerable potential for managing catastrophe exposures, since, compared with the other instruments examined, they provide several key advantages, like zero counterpart risk (if they are traded in a regulated stock exchange) and limited transaction costs. Swaps also allow the exchange of uncorrelated catastrophe exposures (for example earthquakes in the USA with earthquakes in southern Australia or hurricanes in Florida and volcanic eruptions in Japan). Notice that in general cat bonds, contingent capital, and cat derivatives are designed to work in concert with, rather than as replacements for, traditional catastrophe insurance/reinsurance contracts.

the funds are in the availability of the trustee. An official rating is generally assigned to each tranche by at least one credit agency.

Catastrophe bonds can be structured with indemnity triggers (cat bonds cover the actual losses suffered by the sponsor if the catastrophe happens¸ payouts thus being a function of the losses suffered by the sponsor, like a traditional insurance agreement), parametric triggers (reparations are due if one or more predefined physical parameters are met, like a certain magnitude of an earthquake with its epicentre in a certain area or a hurricane of a predefined intensity in a certain zone), or index triggers (reparations are due if a predefined catastrophe index, generally specifically developed and released for the needs of the issue, reaches certain levels). Most cat bonds are structured with caps (that is, a maximum limit to the reparation at the expense of cat bond holders) and deductibles (that is, the provision that the reparation will be effective provided that the losses are higher than a predefined level; this implies that the first losses are to the sponsor's account). Indemnity trigger cat bonds permit the sponsor to match its desired hedging level adequately, but they raise evident moral hazard problems given that: a) investors face considerable difficulties in appraising the actual sponsor's portfolios of risk and b) the sponsor can be impelled not to take any onerous action to reduce the possible losses deriving from the event given the cat bond coverage. On the other hand, parametric and index trigger cat bonds lead the sponsor to bear a basic risk (that is, since the sponsor's exposure and the parameter or the index are not perfectly matched, the reparation is expected to be higher or lower than the actual losses). Conversely, they reduce moral hazard problems. Moreover, parameter and index triggers are measured immediately, meaning that the compensation for the sponsor is quicker than that of indemnity-based cat bonds, which require losses to be assessed (Doherty, 1997) was among the first to point out that, compared with insurance contracts, catastrophe bonds can be designed in ways that reduce moral hazard and credit risk but at the cost of taking on some basic risk).

The first catastrophe bond was structured by USAA Residential Re (a mutually owned insurance company) in 1997 in the aftermath of Hurricane Andrew to reduce its risk concentration on hurricane reparation.[1] According to the Artemis database,[2] since then more than 450 issues with a total value of more than $82 billion have been placed, with rapid growth in the number as well as in the size of the deals, in the last few years. Most cat bonds cover earthquakes, tropical cyclones, and windstorm events. Recently terrorism-related bonds have been issued.[3]

There are several advantages of a cat bond issue, both for the sponsor and for the investor. First of all, the sponsor has an alternative to the classical insurance/reinsurance framework to deal with its catastrophe risk exposure, which can be cheaper (on the effectiveness of cat bonds in hedging catastrophe risk, see among others (Hagendorff, Hagendorff, Keasey, & Gonzalez, 2014). Moreover, it no longer has to be concerned about the insurer/reinsurer solvency in the case that the event occurs, given that the

[1] The bond was intended to provide USAA coverage on 80% of the losses above $1 b that would have resulted from single hurricanes of class 3 or above. Three tranches of bonds were issued. The entire issue was placed, mostly given its attractive price.

[2] www.artemis.bn. It is the most recognized source of information and data on catastrophe bonds and related issues.

[3] In 2003 the Federation International de Football Association (FIFA) issued $262 m notes structured to cover losses that could derive from the cancellation of the Germany 2006 World Cup due to different catastrophic events, including terrorism. In the event of cancellation, investors would have lost up to 75% of the principal. As a result of the 11/9 attacks, there were enormous difficulties in finding insurers willing to cover the cancellation risk, as done for previous championships; thus, FIFA preferred a cat bond issue to deal with the risk. This was the first cat bond covering terrorism risk as well as the first to cover catastrophe risk related to a sports event.

structure of the cat bond ensures that the funds are available to finance the sponsor whenever the catastrophe happens (on this point see among others (Lakdawalla & Zanjani, 2012). Of the utmost importance for the sponsor can also be the circumstance that, having transferred part of its cat exposure to the market, it has additional risk capacity and has released capital at risk, which can be relevant especially for insurance/reinsurance companies that are subject to strict capital requirements. In this context, (Harrington & Niehaus, 2003) argued that the high levels of equity needed to supply catastrophe risk insurance/reinsurance translate into a relatively high tax disadvantage and have a substantial effect on the cost to US insurers of supplying catastrophe insurance/reinsurance. They also concluded that catastrophe bonds can be effective means by which insurers can reduce tax costs associated with equity financing and simultaneously avoid the financial distress costs of subordinated debt financing. On the other hand, investors have the opportunity to invest in financial assets that have no (or minimal) correlation with the other financial assets in their portfolios, permitting them to achieve more effective diversification of risk (on the benefits of including cat bonds in the portfolio selection process, see among others (Zhang, 2004) (Carayannopoulos & Perez, 2015) (Mariani & Amoruso, 2016). Moreover, in general cat bonds have higher nominal returns than similarly rated corporate bonds (although it has to be admitted that this spread can mostly be the result of the illiquidity of the secondary market and of the greater difficulties in correctly analysing the riskiness and the pricing of the cat bonds; see (Gürtler, Hibbeln, & Winkelvos, 2014). The main disadvantage of cat bonds is related to the higher cost of structuring the issue (incorporating the SPV, preparing the documentation, paying the issuing and subscription fees, paying the trustee and the rating agency, etc.), which implies that the deal has to be large to be economically suitable (cat bond issues are rarely of less than $75 m). Another relevant shortcoming is that it is very difficult to price the notes given the complexities involved in modelling the catastrophe's probability distribution and the illiquidity of the secondary market. In practice the pricing of these products must deal with incomplete markets and non-traded underlying (different papers deal with the development of pricing models for cat bonds, among others (Vaugirard, 2003), (Ma & Ma, 2013), (Lai, Parcollet, & Lamond, 2014). Finally, concerns have been raised relating to contract documentation and the collateral structure of the bonds. The adoption of international and national regulations that address these shortcomings would facilitate greater use of cat bonds (Smack, 2016) argued that regulatory change should also include industry-wide accounting and tax reforms).

4. Infrastructures, catastrophe risk, and catastrophe bonds. A review of the most significant experiences

Many non-financial (public and private) companies have a large part of their business exposed to considerable losses if some kind of catastrophic event occurs. This is especially true for companies operating in transport and in the infrastructure industry (Garg, Naswa, & Shukla, 2015). Earthquakes, hurricanes, flooding, terroristic attacks, and landslides can destroy or cause not negligible damage to bridges, dams, power plants, railways, highways, harbours, and so on and cause a dramatic reduction in the revenues if the business is interrupted as a consequence of the event. Cat bonds have been introduced and developed with the aim of offering insurers and reinsurers a supplementary way to deal with their catastrophe risk exposure (Niehaus, 2002). Nevertheless, their financial and legal structure is well suited to permitting non-financial companies to deal with their catastrophe exposure as well as an alternative or supplement to classical insurance contracts. The advantages for non-financial companies are the same as those described above. Cat bonds can be a more effective way of managing catastrophe risk exposure for these companies. That said, non-financial companies operating in transport and in the infrastructure industry started to structure cat bond issues in the new millennium. We here review some of these experiences with the aim of highlighting the benefits for transportation and infrastructure private and public companies of adopting a cat bond covering for their catastrophe risk exposure.

In 2003 Electricité de France (EDF) arranged an issue of €190 m to cover damage to its French power transmission and distribution operations caused by windstorms. A parametric trigger, based on the recorded wind speed provided by the French meteorological office, regulated the compensation. The parameter was weighted to reflect EDF's vulnerability to wind-related damage in France. Two tranches, A and B, of cat bonds were issued, both with 5 years' maturity, the first of €120 m and the second of €70 m. The first time the parameter exceeded the trigger value, tranche A's investors would lose (in part or in total) their capital according to a sliding scale depending on the severity of the storms. This tranche was rated BB+ by Standard & Poor's (S&P hereafter). The principal of the B tranche should be undermined only if the first tranche has already been triggered, its capital exhausted, and other events occur. This tranche was rated BBB+ by S&P. The recourse to a parametric trigger meant that EDF did not exactly hedge its windstorm exposure, thus bearing the residual risk of suffering losses higher than the compensation received from the cat bond or collecting reimbursement higher than the actual losses. In August 2011 EDF arranged a similar issue of a total value of €150 m (€85 m class A rated B- and €65 m class B rated B+) with maturity of 2016. Class A provided protection in the case that the level of the parameter measured more than 420 up to a value of 777. Class B was for values of the parameters higher than 777 up to an index value of 1,050. In the case that class A notes suffer a total loss, the Class B trigger value is reduced to 420 to ensure that there is no gap in the hedging. Class A was issued with a spread over Libor of 900 basis points (that is, the annual coupon was 9% plus Libor), while class B notes recorded a 550 basis points spread at the issuance. Both the classes were oversubscribed. The trigger levels should have been adjusted annually according to EDF's changes in the windstorm exposure. EDF also had an early redemption clause for both the classes of notes in the case that the adjusted trigger level was at least 25% lower or higher than the initial value. In 2015 EDF eventually exercised the early redemption option. The length of both the deals, longer than usual cat bonds, was very attractive for EDF, permitting long-horizon hedging of its windstorm exposure.

Similarly to EDF, Dominion Resources, a US power and energy company that supplies energy in several states on the US Atlantic coast, sponsored a cat bond emission worth $50 m in 2006. The deal was intended to cover possible losses from named hurricanes in the Gulf of Mexico, where Dominion had platforms and installations. A parametric trigger centred on the class of the hurricane regulated the restorations to the sponsor.

The New York Metropolitan Transportation Authority (MTA), through its wholly owned subsidiary First Mutual Transportation Assurance Co. (FMTAC, a pure captive insurance company established to insure and reinsure MTA's risks), issued a single tranche of 3-year cat bonds in 2013 to cover storm surges. Preliminarily sized $125 m, the issue was subsequently increased to $200 m, and a BB- rating was assigned by S&P. The issue collateralized a reinsurance agreement between MTA and FMTAC and was placed with a coupon of 4.5% plus Libor, lower than initially expected. The notes featured a parametric trigger based on actual recorded storm surge heights in named points of two zones around

New York City (A and B). The notes will experience 100% losses of the outstanding capital if the parameter equals or exceeds 8.5 feet for Area A or 15.5 feet for Area B. With this issue MTA intended to expand and diversify its sources of catastrophic event protection. Indeed, in the aftermath of the 2012 deadliest hurricane, Hurricane Sandy, MTA as well as other companies experienced serious problems in finding insurance coverage for their properties (MTA suffered $5 billion losses as a consequence of Hurricane Sandy, especially due to flooded transit tunnels and subways). The parametric trigger, whilst ensuring a quicker payout than indemnity coverage, led MTA to bear a not negligible basic risk.

TABLE 1. CAT BONDS ISSUES, INFRASTRUCTURE COMPANIES

YEAR	SPONSOR	EVENT	SIZE	MATURITY	RATING	COUPON
1999	Disneyland Tokyo	Earthquakes	200 US$ m	5 years		
2002	Vivendi	Earthquakes	175 US$ m	42 months		
2003	Electricité de France	Windstorms	190 US$ m	5 years	Class A: BB+ Class B: BBB+	
2006	Dominion Resources	Hurricanes	50 US$ m			
2011	Electricité de France	Windstorms	150 US$ m	5 years	Class A: B- Class B: B+	Class A: Libor + 900 bp Class B: Libor + 550 bp
2013	New York MTA	Storm surges	200 US$ m	3 years	BB-	Libor + 450 bp
2015	Amtrak	Storms, wind, and earthquakes	275 US$ m	3 years	BB-	Libor + 450 bp

Two years later Amtrak followed MTA's experience. Amtrak, the US National Railroad Passenger Corporation, is a passenger railroad service that provides medium- and long-distance services across the United States and three Canadian provinces. Amtrak largely operates and has the highest concentration of assets and infrastructures in the states of the north-eastern coast of the US, an area that is often hit by heavy natural disasters. Historically, Amtrak covered possible natural event damage to its operations, assets, and infrastructures through insurance contracts. Following the example of MTA, in 2015 it sponsored, through Passenger Railroad Insurance (PRI), an insurance company of the Amtrak Group, a $275 m cat bond issue to cover losses from storms, wind, and earthquakes in some named states of the north-eastern coast of the US. A single class of notes of three-year maturity was issued by a Bermudian SPV, the proceeds of which were employed to collateralize a reinsurance agreement with PRI that in turn provided protection to Amtrak. Parametric triggers regulated the compensation for all three perils. Compensation will occur if the intensity measurements of the physical parameters for each respective peril, captured at specified measurement locations, breach certain predefined levels. The payout mechanisms are designed to provide a sliding scale of payment for all three perils, with increasing payouts for increasingly severe events. The major contribution to the expected loss of the notes came from storm surges, suggesting that Amtrak particularly fears the impact on its infrastructure and revenues of severe storms. As for EDF, the parametric framework leads to Amtrak bearing a residual risk. The sliding payout mechanism limits the residual risk, ensuing larger compensation for more intensive events (which are supposed to be more detrimental to Amtrak's operations). The notes were placed with a coupon of 450 basis points over Libor. They were rated BB- by S&P. The deal enabled Amtrak to cover part of its natural event catastrophe risk in a cost-effective way. The issue was oversubscribed.

Disneyland Tokyo and Vivendi were two other non-insurance companies that looked at the cat bond market to cover their exposure to catastrophic risk. The first issued $200 m 5-year cat bonds in 1999 to cover losses from earthquakes in the Tokyo area. Two tranches were issued, the first to cover losses from business interruption and the second to finance post-earthquake reconstruction. A parametric trigger linked to the magnitude, location, and depth of the earthquake regulated the restorations to Oriental Land (the owner of Tokyo Disneyland). In 2002 Vivendi sponsored a $175 m cat bond issue to cover possible losses to its properties in Southern California from earthquakes. A parametric index based on the physical intensity of the earthquakes regulated the restorations. Two tranches of bonds were issued with a maturity of 42 months.

5. Conclusions

Catastrophe bonds are securities that allow the transfer to the financial market of the uncertainty surrounding the damage and losses of potential catastrophic events. Initially thought to deal with the need of insurance/reinsurance companies to reduce and manage their catastrophe exposure effectively, they have been successfully employed by non-financial companies operating in the transport and in the infrastructure industry as a supplemental and concurrent instrument to traditional insurance contracts.

We analysed the effectiveness of cat bonds in the transport and infrastructure industries pointing out major advantages in supplementing the traditional insurance/reinsurance channel in the management of the potential losses related to catastrophic events.

We argued that cat-bonds are becoming a valuable financial instrument for non-financial firms and reviewed the most significant issues by non financial firms operating in the transport and in the infrastructure industry. These experiences witnessed the usefulness of these structured financial instruments for the management of the catastrophe exposure of non-financial firms, especially during times of constraints in the insurance industry. They permitted the sponsors to have a potentially cheaper alternative to the classical insurance/reinsurance framework to deal with their catastrophe risk exposure and to eliminate the risk of default of the insurer, which is not negligible given the massive direct and indirect damages that catastrophe events can bring about. Also, they were extremely well received by the market, demonstrating that an adequate demand exists for these securities, allowing the sponsor company to achieve a more effective catastrophe risk coverage.

Cat bonds also revealed themselves to be a powerful instrument for institutional investors to achieve more effective risk/return profiles given their very low correlation with other securities' returns.

International and national regulations aimed at coding the transparency of the information to be disclosed to the investors and at regulating tax regime for sponsor, issuer and investor will incentivize their level of diffusion.

Difficulties in properly pricing the notes also call for further efforts in this field of financial studies.

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