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The Use of Catastrophe Bonds as a Means of Economic Development in Emerging Economies

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Abstract: Catastrophe bonds offer a way for entities located in natural disaster prone regions to safely and efficiently transfer the risk of insuring property to the financial markets and subsequently, create a financially attractive environment for insurers and investors. The opportunity for investors to utilize modeled loss analytical platforms such as those created by AIR, Risk Management Solutions, and EQECAT, could be used to bridge the growing gap in emerging economies between economic losses created by natural disasters and insured losses. Bridging this insurance gap in emerging economies could have positive global implications for the insurance industry, global trade, foreign direct investment, and the average humanitarian aid spent on natural disaster recovery and resistance. Apart from the additional profits that could be generated from increased underwriting in emerging economies, introducing catastrophe and property insurance to emerging economies could create a roadmap for other emerging economies who are struggling to balance economic development with disaster financing. Experience from sovereigns which have experimented with this method of risk transfer, such as Haiti and Mexico offer a basis for understanding the advantages and difficulties associated with developing a country specific modelled loss analytical platform for measuring natural hazard risks.

Contents:

Summary.....	1
Introduction: Global Economic Impacts and the Solution.....	3
• Global insurance penetration to overall losses declining.....	4
• Why catastrophe bonds in emerging economies?.....	5
I. Protecting Global Assets through Localized Help: Disaster Risk Reduction in Emerging Countries Could Mean Widespread Economic Progress.....	6
i. The protection gap: profits to be made.....	6
ii. Individual progress is global progress.....	7
iii. Emerging economies' stake in the global supply chain.....	9
iv. Emerging economies' dependence on foreign aid.....	9
II. Why Catastrophe Bonds?.....	10
i. The development of the catastrophe bond market.....	10
ii. Cat bonds offer higher yields.....	11
iii. Cat bond market offers diversity in perils and triggers.....	11
iv. The structure and types of catastrophe bonds.....	13
v. Basis risk and moral hazard.....	13
vi. Trigger types: indemnity, industry, and parametric catastrophe bonds..	14
III. Indonesia: An Industrial Hub with Acute Vulnerability.....	17
i. The positive economic outlook for Indonesia.....	18
ii. Indonesia's stake in global trade.....	18
iii. Current disaster financing in Indonesia.....	19
iv. The catastrophe insurance market in Indonesia and lessons from MultiCat Mexico.....	20
v. Advancing toward a risk transfer solution.....	21
Conclusion.....	23
References.....	25

Introduction: Global Economic Impacts and the Solutions

The use of catastrophe bonds in emerging economies to efficiently and safely transfer the risk of insuring property in natural disaster prone areas can open a gateway for additional foreign direct investment and a more balanced budget that prioritizes infrastructure development and socioeconomic progress. However it is important to note that catastrophe bonds are just one part of a very complex solution for economic progress in emerging economies. Han et. al (2010) studied the significant impact that insurance has on economic development and found that insurance typically contributes to an economy in the following aspects: (1) Promotes financial stability and reduces anxiety; (2) Can substitute for government security programs; (3) Facilitates trade and commerce; (4) Mobilizes savings; (5) Enables risk to be managed more efficiently; (6) Encourages loss mitigation; (7) Fosters a more efficient capital allocation. However, it is often the case that additional insurance coverage is needed in emerging economies where natural disasters make insurers less inclined to underwrite such high risk properties. Thus, for insurers to take on such an exorbitant amount of risk, there must be an efficient way for insurers (and reinsurers) to transfer this risk to investors; hence, the need for catastrophe bonds. As the world's largest industry, the insurance sector poses a particularly vulnerable position as natural disasters become increasingly erratic in occurrence and unpredictable in severity (Huber and Gullledge 2011). Despite the growing availability and analysis of historical and real-time weather related data, the number of global natural disasters, overall losses, and fatalities has increased over the last thirty years while the percentage of insured losses has declined (Insurance Information Institute, 2016). According to Munich Re, in 2015 more than 1000 natural disasters occurred, the highest number ever to be recorded in a single year. Estimated economic losses totaled \$90 billion USD of which, only \$27 billion was insured (Insurance Information Institute, 2016). Contrary to surmounting evidence that climate change plays an active role in the intensity and frequency of weather related disasters, the historic level of global insurance coverage for these events is sporadic and has even declined in recent years.

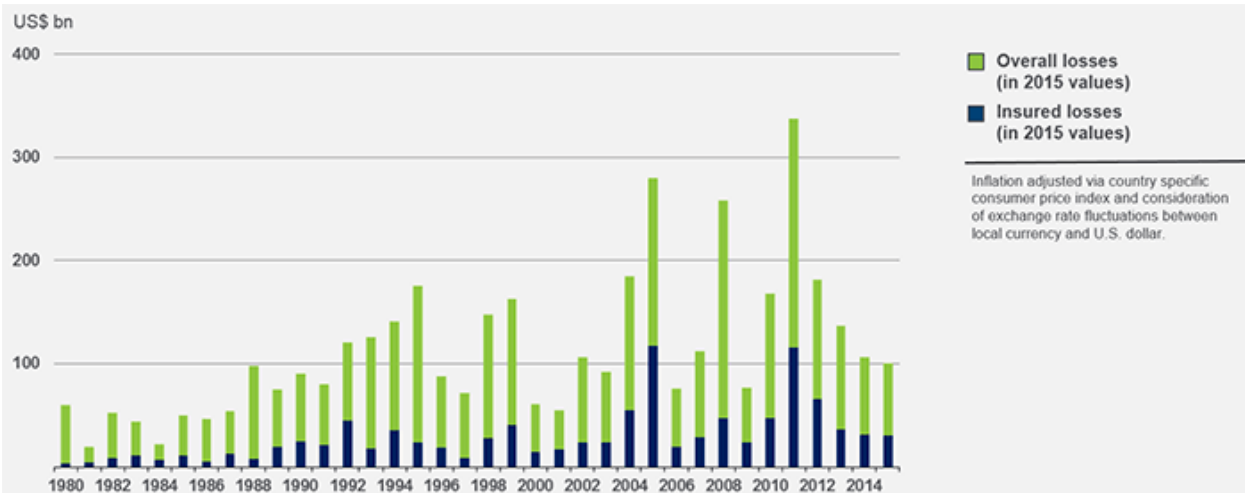


Figure 1. Global overall economic losses compared with insured losses in 2015 from 1980-2015. Values adjusted for inflation via country specific consumer price index and consideration of exchange rate fluctuations. (Munich Re)

- **Global insurance penetration to overall losses ratio declining**

Figure 1, shows that the amount of overall losses, measured by the loss of value for properties and structures, and insured losses is often incompatible. NatCatSERVICE, Munich Re’s comprehensive natural catastrophe loss database derives overall losses by estimating the direct and indirect losses that result from natural disasters. Direct losses, those that are visible, countable, physical and tangible may include the damage or loss of homes and content, the loss of livestock, and damage or loss of vehicles. Indirect losses, those that are intangible, non-physical, and immaterial may include examples such as, higher transportation costs due to damaged infrastructure, supply chain interruptions, and the loss of a family member’s income from death (Beilharz, Rauch, and Wallner, 2013). Although, the level of overall losses shows an upward trend over the past two decades with unusually high peaks in years 2005, 2008, and 2011, in contrast, the level of insured losses has risen, on average, since 1980 but, has declined every year since 2011 (Insurance Information Institute, 2016). A large contributor to this growing difference between insured losses and overall losses is the location and magnitude of losses. As industrialization in emerging countries persists, the concentration of urban dwellings around high risk areas and industrial hubs is ever more common. Duc (2013) reported that when forecasted losses are measured as a percentage of GDP, emerging countries have the greatest risk because they have less sophisticated infrastructure, fewer existing flood and storm defenses, and larger poorer populations. In fact, in the top ten most vulnerable cities, when measured as a percentage of GDP, Duc (2013) noticed that in most of these cities, “the poor are most at risk as

rapid urbanization has pushed them into the most vulnerable neighborhoods, often low-lying areas and along waterways prone to flooding.” An unforeseen effect of this rapid urbanization in low-lying, vulnerable, coastal cities, is that the level of insurance coverage where it is needed most, is declining.

- **Why catastrophe bonds in emerging economies?**

The growing gap between insurance coverage and overall economic losses from natural disasters in high risk high density areas puts a large strain on the sovereigns which struggle to balance economic growth and financial stability. Figure 2 shows the large gap between the insurance coverage in industrialized countries, such as those in North America (64%) and the insurance coverage in emerging countries, such as those in South East Asia (14%) (Neuther and Rauch, 2013).

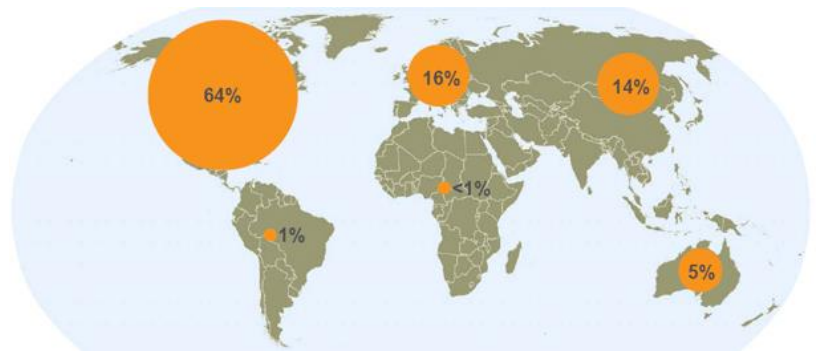


Figure 2. Average level of insurance coverage in industrialized, emerging, and developed countries. (Neuther and Rauch, 2013)

This gap that exists between the level of economic losses generated by catastrophes and the level of insured losses can be addressed using the right financial

tool and data analytic platform to measure the associated risk. Catastrophe bonds, an asset class of the insurance-linked securitization instruments, which are not linked to the activity of the financial markets but rather to the activity of the natural world, are the ideal solution for sovereigns and companies who are invested in property situated in high risk areas for the following three reasons. First, the introduction of an emerging economy into the catastrophe bond market may readily benefit the insurance industry who is well positioned to turn a profit off of climate change by taking a more proactive approach in exploring this untapped section of the market, argues Mills (2007). Second, the outstanding growth of the catastrophe bond market since its inception (see figure 3), makes the opportunity for property owners, sovereigns, and insurers to transfer the risk of economic loss from natural disasters to investors greater than ever before. In the second quarter of 2016, Evans (2014), owner of Guy Carpenter reported that for the first time in the past decade, issuance of catastrophe bonds failed to meet investor demand. Finally, by providing insurance coverage and a mechanism to transfer the financial risk of doing

so, sovereigns in the emerging economies could potentially depend less on foreign aid from developed economies to finance post-disaster recovery which would free up funds for infrastructure, education, and economic development. In doing so, the individual progress made on the forefront of these emerging nations could indirectly boost global economic development over time.

The following sections will address the Protection Gap, a property casualty (PC) insurance coverage phenomenon seen among emerging countries, how this Protection Gap can be managed using the power of the financial markets, and the global implications that this would have. In addition, this paper will describe how a catastrophe bond can result in global and localized benefits by generating revenue where economic loss would otherwise persist. Finally, the structure and trigger types of catastrophe bonds will be discussed and will conclude with a study of Indonesia, a country plagued by natural disaster and poverty which poses the optimal characteristics for the use of catastrophe bonds.

I. Protecting Global Assets through Localized Help: Disaster Risk Reduction in Emerging Countries Could Mean Widespread Economic Progress

- **The protection gap: profits to be made**

The Protection Gap, the difference between actual and insured losses, is largest in emerging countries where insurance of any type is often unaffordable for many. Since 2005, four out of the top ten costliest natural disasters across the globe have occurred in emerging countries as a result of hurricanes or flooding (Insurance Information Institute, 2016). Of the total economic losses resulting from natural disasters in the emerging world, more than 90% of this is uninsured (Beilharz, Rauch, and Wallner, 2013). A study produced by Munich Re on the economic consequences of natural disasters found that many emerging countries do not have the economic resources or regulations needed to fully protect themselves from the economic impact

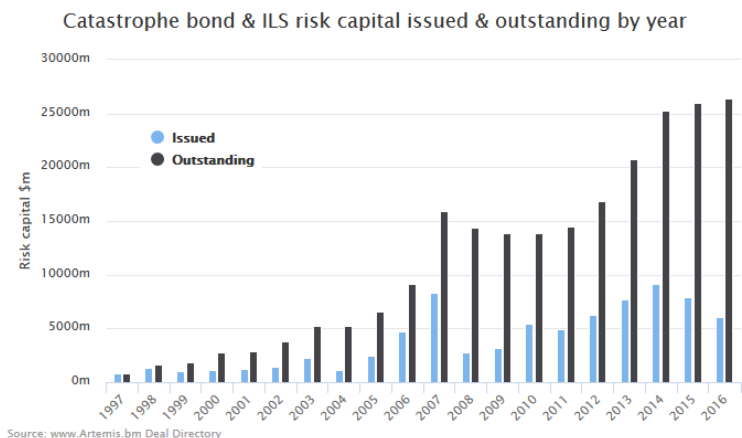


Figure 3. The value of catastrophe bonds issued and outstanding risk capital each year from 1997-2016. Issued bonds translates to the supply of catastrophe bonds while outstanding risk capital translates to investor demand. (Artemis, 2016)

of natural disasters. In addition to a lack of resources and protocol, a major cause for the upward trend seen in overall economic losses stemming from natural disasters is the increased urbanization around coastal cities (Beilharz, Rauch, and Wallner, 2013).

Settlement around fragile coastal cities where there may be an absence of insurance coverage, especially in areas affected by tropical cyclones, like Southeast Asia, has only augmented the economic risk associated with natural disasters (Beilharz, Rauch, and Wallner, 2013). If these untapped markets are sought after by insurance companies, the industry as a whole could see a huge surge in underwriting, as well as, large gains in revenue. However, these untapped markets also pose a large threat to the insurance industry as Allianz, Europe's largest insurer estimates that in a bad year, insurance losses resulting from climate change related events could top \$1 trillion USD (Mills 2007). Yet, Mills (2007) finds that insurers recognize that the real threat to the industry is the lack of action to engage in solutions to combat climate change which, he notes, represents a "duty to shareholders and a boon for economic growth". Even with the availability of insurance in industrialized countries, insurers like Allstate have moved away from insuring coastal properties in the United States that are more vulnerable to tropical storms and flooding. For emerging countries where risks tend to be concentrated in highly urbanized coastal areas, insurers suggest that improved building codes and land use management are key components to generating insurance underwriting where it is needed most. Over time, Mills (2007) believes that innovative technology for reducing infrastructure vulnerability and for improving energy efficiency should evolve to reduce overall inherent risk and make insuring coastal properties in emerging countries more attractive.

- **Individual progress is global progress**

The inability for emerging economies to advance economically and socially at the pace of industrialized economies may be in part a result of their physical and financial inadequacies for dealing with natural disasters. Data derived from the NatCatSERVICE database shows that the average percentage of direct losses per year with respect to GDP resulting from natural disasters is greatest in emerging economies at 2.9%, followed by (1.3%) in developing countries, and (0.8%) in industrialized countries (Beilharz, Rauch, and Wallner, 2013). Not only does the cost of repairing the damage caused by a natural disaster affect a country's GDP but, it also affects the level of per capita debt that a country has. This can have negative global implications for the countries that invest in, trade with, and send aid to those economies which are consistently

dragged down by natural disasters. In their empirical study on the correlation between a country's level of debt and the economic losses suffered from a natural disaster, Melecky and Raddatz (2011) found that on average, natural disasters have a negative impact on the debt of emerging economies. They concluded that on average, per capita government debt increases 30% just after five years following a natural disaster. However, in industrialized countries, data revealed no statistically significant deviation from the general trend for per capita government debt following a natural disaster (Beilharz, Rauch, and Wallner, 2013). By alleviating the costs imposed by natural disasters, emerging countries can free up funds to reduce foreign and domestic debt while requiring less humanitarian assistance for disaster relief and funneling more dollars into disaster preparedness programs. Additionally, Rodrik (2007) argues that historically, "nothing has worked better than economic growth in enabling societies to improve the life chances of their members, including those at the very bottom".

The need for economic growth in individual emerging countries coincides with the agenda for global economic development which stresses the need for improvement in global economic cooperation to fight global poverty and eradicate sources of social stress. Bhattacharya, Oppenheim and Stern (2015) state that all individual agendas aimed at accelerating sustainable development and those aimed at combating climate change are "deeply intertwined". They contest that those agendas which do not succeed at reducing poverty or mitigating climate change will prove to be unsustainable and that any institution which aims to achieve both goals should consider the importance of infrastructure development. Similarly, Munich Re, one of the world's leading reinsurers, believes that political and institutional frameworks in conjunction with general economic conditions strongly determine a country's recovery speed following a natural disaster. A central component to these frameworks is the insurance market's degree of development for which emerging economies can benefit from immensely (Beilharz, Rauch, and Wallner, 2013). The penetration of insurance coverage in emerging economies is essential both to the development of infrastructure and to the economic progress that will benefit both the individual country and the global economy. The indirect benefits to the global economy are made possible through trade liberalization and foreign direct investment but the vulnerability of the infrastructures which support these two realms of the global economy could pose a large threat to the viability of individual economies and the global economy.

- **Emerging economies' stake in the global supply chain**

Industrialized countries have a large stake in emerging countries through global trade, foreign direct investment, humanitarian assistance donations, and through the financial markets. The assets located in emerging economies that are directly or indirectly tied to industrialized and other economies should be efficiently protected by an insurance-linked-security like a catastrophe bond. A large majority of the World Trade Organization members are emerging countries and the increasing volume of exports generated by these countries over the past decade inherently suggests that there is an increasing dependence on these countries (WTO 2016). Industrialization in emerging countries, made possible by lower trade costs and improved communication technology, further exemplifies the interdependence of the global trading system. Between 1995 and 2011, the globe experienced a 35% increase in the share of world traded goods and services that took place within global value chains (Escaith, 2015). For small emerging countries especially, the opportunity to specialize in a particular stage of a good's production, made possible largely by foreign direct investment, has dramatically augmented the share of emerging countries involved in the manufacturing, textile, resource extraction, and pharmaceutical industries (Escaith, 2015). Jackson (2013) states that as of 2013, United States direct investment abroad amounted to about \$368 billion. The direction and magnitude of direct investment flows is largely determined by relative rates of growth between U.S. and foreign economies in addition to expectations about the performance of national economies (Jackson 2013). Catastrophe bonds offer a way for investors who have a stake in industries based in emerging economies to protect their interests essentially securing expectations about future liquidity in the event of a natural disaster. By insuring the infrastructure and facilities that make global trade possible, global deadweight loss is reduced and emerging economies are able to gain more stable ground in the global supply chain.

- **Emerging economies' dependence on foreign aid**

Emerging countries are immensely dependent on foreign aid in the wake of a natural disaster where economic losses often far outweigh their financial capacity. In 2015, \$532 million USD was spent globally on disaster prevention and preparedness through humanitarian assistance aid reflecting a consecutive increase in donations over the past decade. Even so, humanitarian assistance is usually insufficient to cover the total economic losses realized after a natural disaster, amounting on average to just under 10% of disaster losses in recipient countries

(Linnerooth-Bayer, Mechler, and Pflug, 2005). Lattimer and Swithern (2016) state that as the need for humanitarian assistance rises globally for disaster recovery and prevention, the World Humanitarian Summit and other global processes have escalated the search for new types and scales of financing. They suggest that although the volume of humanitarian assistance has grown, it is neither sufficient nor appropriate to address the full spectrum of disaster recovery and prevention needs. Furthermore, they argue that this global issue requires a variety of resources and a diverse financial toolkit ranging from insurance for natural hazards to concessional loans for long-term displaced persons hosting (Lattimer and Swithern 2016). In addition to the benefit of reduced reliance on foreign aid, insurance instruments offer global relief by allowing a government to utilize funds for infrastructure development and fiscal programs while simultaneously attracting foreign direct investment with the promise of less risk absorption on the owner's behalf, should there be a disaster.

In the previous sections I have demonstrated that the ability for a natural catastrophe prone country to reduce its risk associated with creating and maintaining a built environment is intertwined with a country's ability to foster economic growth. The economic growth that could be made possible through increased insurance underwriting, increased foreign direct investment, and improvements in infrastructure development could have trickle down effects for the industrialized or emerging economies that are connected to those who benefit directly from the use of catastrophe bonds. In the following sections I will demonstrate why a catastrophe bond is the optimal financial tool, how a catastrophe bond is structured, and apply the above arguments to an emerging economy that could benefit immensely from the use of catastrophe bonds; Indonesia.

II. Why Catastrophe Bonds?

- **The development of the catastrophe bond market**

Losses created by catastrophic events, those characterized by extreme losses but small probability, have motivated the insurance industry to build up sizable pools of liquidity through securitization mechanics. However, in the event that two catastrophes occur within a short time frame, as was the case in the 1990's when Hurricane Andrew and the Northridge Earthquake occurred within two years of each other, insurance underwriters often do not have the capacity to pay every claim. In essence, catastrophe bonds provide a way for property/casualty insurers and reinsurers to transfer large risks from their books to the capital market investors, and in turn

reducing their overall reinsurance costs while gaining capital to underwrite additional policies (Zhengtang, 2011). Investors are eager to invest in catastrophe bonds because they often offer higher premiums, they are said to be zero-beta instruments because they are not correlated with the financial markets, and they remain a useful diversification tool for an investment portfolio (Skees, 1999).

- **Cat bonds offer higher yields**

As of October 2016, in the nearly 20-year history of catastrophe bonds, only ten transactions have resulted in a loss of principal to investors out of more than 300 transactions that have entered the market (Skees, 1999). In the current low rate environment, investors continue to seek out high yielding instruments in alternative asset classes. For example, a comparison of the historical returns and volatility of the S&P 500, Dow Jones Corporate Bond Index, and the Swiss Re Cat Bond Total Return Index shows that catastrophe bonds, on average, offer much higher returns with lower volatility. Historically, the annual return on the S&P 500 Index is 1.06% with 16.24% volatility. Similarly, the Dow Jones Corporate Bond Index has averaged a 1.19% annual return with 6.70% volatility (FIRA, 2013). However, according to the Financial Industry Regulatory Authority (2013), the historical annual return on the Swiss Re Cat Bond Total Return Index is reported to be 7.98% with just 2.97% volatility. In fact, in Japan, where interest rates are negative, investors are eagerly looking to the cat bond market for positive yields and diversifying assets. Eiji Miua, the managing executive officer of a Tokyo-based firm, stated in an interview with Bloomberg Markets Magazine, “If you look at the industrialized countries, yields are low or negative everywhere at the moment. This cat bond still has 500 to 600 basis point of yields. And it has low or no correlation with equity markets. From the stand point of diversification, that makes sense for our investors,” (Chu and Ito, 2016). Not only do catastrophe bonds offer potentially higher yields with less volatility, the market for catastrophe bonds itself is diversified among perils insured.

- **Cat bond market offers diversity in perils and triggers**

Despite the opportunity for increased diversity among perils, the cat bond market has been dominated by U.S. hurricane risk. This is due to the concentration of urbanization around hurricane prone areas in the United States (Florida and the Gulf region) which has made U.S. Hurricanes a ‘peak peril (Rogowsky and Laney-Cummings, 2009). Two other peak perils, earthquakes in Japan (the dominating peril in 2016) and windstorms in Europe exist in the ILS

market but usually get considerably less concentration. In Q3 of 2016, earthquakes in Japan represent \$700 million or 65% (figure 4) followed by U.S. multi-peril at \$225 (Artemis and GC Securities, 2016). Despite the increasing need for risk financing in emerging countries, the share of market issuance for perils outside of industrialized countries is so small

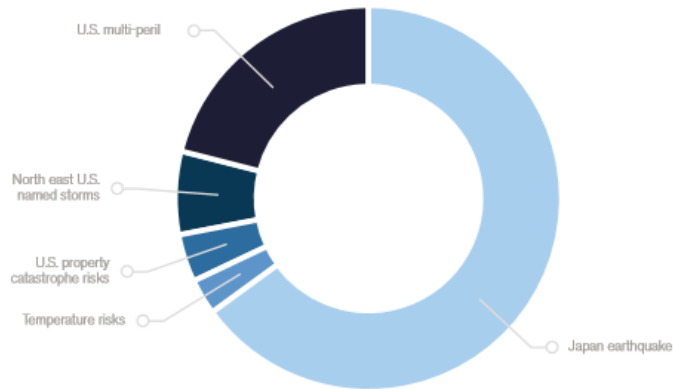


Figure 4. Total issuance of catastrophe bonds by peril for quarter three of 2016. (Guy Carpenter Securities, 2016)

that they represent less than 1% of the total cat bond market share (Artemis and GC Securities, 2016). However, because of the immense risk that the prescribed peak perils offer, investors are eager to take on other types of risk that will provide a diversification benefit to a catastrophe bond portfolio and will have considerably less probability of loss (Bennett, 2014). In this respect, insurers have the potential to increase coverage in emerging and emerging economies where the catastrophe bonds for perils in these countries would offer lower risks and potentially higher rewards.

The World Bank, as part of its disaster-risk management goals, is attempting to make the catastrophe bond market more accessible to its clients, especially in light of the increasing demand for diversifying risks. However, there remains high barriers to entry into the ILS market for any governments. These barriers include: a lack of education about the reinsurance and catastrophe bond market in particular for many government officials in emerging and emerging economies, limited or non-existent data of natural disasters and limited or non-existent modeling of inherent risk exposure to natural disasters in many countries, relatively high transaction costs required for an ILS transaction, and the political conflict associated with purchasing insurance protection when the payout is uncertain (Bennett, 2014). In order to facilitate access for the World Bank member countries to the catastrophe bond market, in 2009 the World Bank Treasury established the MultiCat Program which simplifies the issuance process and allows the World Bank to act as arranger in the issuance of an ILS for a member country (World Bank Treasury, 2009). A beneficiary of this program is Mexico which has successfully issued two parametric index catastrophe bonds through the MultiCat program.

- **The structure and types of catastrophe bonds**

The basic structure of any catastrophe bond involves five elements. First, a sponsoring (ceding) insurance company establishes a special purpose vehicle in a tax efficient jurisdiction. A special purpose vehicle, sometimes referred to as a special purpose entity (SPE/SPV) is created through limited partnerships, trusts, corporations, limited liability corporations or other entities and typically serves the purpose of helping companies securitize assets, create joint ventures, isolate corporate assets or perform other financial transactions (NAIC Capital Markets Bureau, 2016). The use of the SPV in Insurance Linked Securitization (ILS) Markets is to establish a reinsurance agreement with the sponsoring insurance company. The SPV then issues a note to investors which has default provisions that typically mirror the terms of the reinsurance agreement. The proceeds from the sale of this note are managed in a segregated collateral account to generate money market returns (i.e. reinvested in stable assets like treasury bonds). If no trigger events occur during the term of the bond, the SPV returns the principal to the investors with the final coupon payment (Stone et. al., 2012). Although the basic structure of any cat bond is standard, the type of bond trigger and the level of risk vary according to type of peril covered, the location of the insured risk, and the degree of infrastructure vulnerability.

- **Basis risk and moral hazard**

Investors and issuers alike should consider both the basis risk and the moral hazard of any catastrophe bond with regards to how to how the bond will perform in the event of a trigger. Basis risk is the mismatch between contractual expectations and performance in finance. A simple way to consider basis risk is by asking the question, will this contract hedge as expected? In the event that a catastrophe causes low industry loss but high individual loss to the insurer, the basis risk may cause the insurer to default on their debt which could affect the price of the bond. On the other hand, moral hazard is the notion that one party, for example a property owner in southern Florida, takes on more risk because another entity, his insurer, has agreed to bear the costs of those risks (Stone et al, 2012). To protect the interests of all parties involved, the insurance contract should be structured so as to incentivize the policyholder to undergo risk reduction efforts by charging premiums that correlate with the owner's level of risk exposure or by providing discounts for policyholders who protect their property from disaster damage (Hudson et. al., 2014). For example, in Mongolia where the climate is characterized by particularly harsh winters and a very narrow growing season, Mongolian farmers, who typically

secure their livelihoods with grazing animals, can only gain by taking measures to protect their herd against adverse winter weather since insurance claims are based on average livestock loss in designated regions (Linnerooth-Bayer and Mechler, 2009). In emerging countries, such as Mongolia where infrastructure vulnerability may be elevated due to a lack of resources, policy holders may have greater incentives to protect their property from a disaster because of their increased dependence on private dwellings or industrial facilities. In a study that developed a model to measure the impact that default-risk, moral hazard, and basis risk have on the price of catastrophe bonds, Lee and Yu (2002) found that moral hazard drives the price of bonds down substantially. The negative effect of moral hazard was found to be especially true as the catastrophe occurrence, intensity, loss volatility, and interest rate risk of the insurer's assets increases. When basis risk was taken into account, the price of the bond was also driven downward but at a decreasing rate and the magnitude of the basis risk affect increased as catastrophe occurrence, intensity, and loss volatility increases (Lee and Yu, 2002). Thus, for both investors and issuers there is a tradeoff between the basis risk and moral hazard of a catastrophe bond.

- **Trigger types: indemnity, industry, and parametric catastrophe bonds**

The three most commonly defined classes of catastrophe bonds used in the cat bond market are indemnity, industry loss, and parametric. A fourth and newer class, modeled loss, is an expansion of the parametric class and uses a model in place of an index function (Stone et. al., 2012). An indemnity trigger catastrophe bond is defined by an index of the actual loss incurred by the sponsoring insurer followed by the occurrence of a specified catastrophe event, in a specified geographic region, for a specified line of business (Stone et. al., 2012). For example, in 2015 UnipolSai sponsored the first ever indemnity trigger catastrophe bond, Azzurro Re, in agreement with Willis Re of €200 million to protect against earthquake risk and ensuing perils in Italy and neighboring countries for three and a half years (Varcarini, Malloy, and Poillon, 2015). Indemnity trigger bonds are often said to observe very minimal basis risk because the contractual expected loss is based off of the primary insurer's actual loss, thus there is a near perfect hedge. However, indemnity triggers do observe some moral hazard based on whether or not the insurance policy is structured to incentivize the policy holder to take precautions (Artemis, 2016).

Industry loss catastrophe bonds operate differently from indemnity trigger such that, the contract is based on the total insured loss experienced by the industry rather than their own loss from a specified event. Industry loss catastrophe bonds are typically purchased by insurers themselves who have a stake in the property insurance market in a peak peril area (Artemis, 2016). For example, suppose an insurer has exposure to floods in Louisiana. The insurer could issue an industry loss catastrophe bond for flood exposure in the Louisiana region which could be triggered if the total industry loss rose above \$30 million as a result of a disaster in that area. Industry loss catastrophe bonds have sizable basis risk because there is a considerable probability that the losses observed by the insurance industry as a whole do not match up with the losses observed by the individual sponsoring insurer. The level of moral hazard associated with an industry loss catastrophe bond is likely to be reduced because the individual sponsoring insurer is not able to influence industry losses but is able to influence their own losses. The goal of the sponsoring insurer in an industry loss contract is to reduce the probability of a negative hedge, that is, the industry loss being less than the individual loss (Artemis, 2016).

The structure of a parametric index catastrophe bond differs from that of an indemnity trigger and an industry loss bond in that the trigger of the bond is based on the physical characteristics of the catastrophe (Stone et. al., 2012). For example, within the fourth quarter of 2016, Hurricane Matthew struck Haiti and the southeastern coast of the United States causing billions in damage. The damage caused by Hurricane Matthew was so severe that the parametric index catastrophe bond(s) covering Haiti, Barbados, Saint Lucia and St. Vincent was triggered by the excess rainfall clause. The Caribbean Catastrophe Risk Insurance Facility (CCRIF), a parametric disaster insurance facility aimed at transferring the risk of climate related disasters to the financial markets, who sponsored these bonds made payouts to all \$29.2 million in claims within 14 days after Hurricane Matthew's passing (Artemis, 2016). This payout was the largest single payment ever made by the facility but will be the second payment made to Haiti, after the 2010 Earthquake which ushered in a payment from the CCRIF of \$7.7 million (Artemis, 2016). The advantage of a parametric index bond is that it offers the least information bias for the investor and the least risk of an extended bond term because storm data is typically available within days of the event. However, because there is increased basis risk for the sponsoring insurer due to the fact that the bond is structured around event parameters rather than estimated insured losses, these bonds are less popular for the sponsoring agent despite their popularity

among investors (Risk Management Solutions, 2012). Emerging countries are good contenders for parametric index catastrophe bonds because they involve the highest transparency of information, a bonus for uncertain investors, and they offer post-disaster liquidity comparatively fast.

As previously mentioned, modeled loss catastrophe bonds are a subset of the parametric index class of cat bonds. The trigger for a modeled loss cat bond is calculated by computer models that use objective data such as historical weather data, the NOAA database archives, IPCC reports, and satellite data to estimate the sponsor's exposure or expected loss for a specified event (Stone et. al., 2012). The bond is triggered if the sponsor's exposure exceeds a specified dollar amount. In essence, the modeled loss bond uses techniques used to estimate the parametric index bonds as well as the indemnity loss bonds (FINRA, 2016). To date, there have been very few modeled loss cat bond transactions and those that have occurred are virtually impossible to track down. A report generated by the Bermuda Monetary Authority, an institution which regulates Bermuda's financial sector, \$0.4 billion in outstanding issues of a modeled loss catastrophe bond for the Bermuda jurisdiction in Q2 of 2016 (Artemis and Bermuda Monetary Authority, 2016).

Although there is a wide range of catastrophe bonds to choose from, there is no scientific or empirical agreement as to which trigger type is optimal and the amount of issuance for each type varies greatly each year.

The Financial Industry Regulatory Authority (2013) suggests that each year the composition of issuance for trigger types is determined by the stronger market force; investor demand or issuer supply. Roughly \$272 million or 25% of the cat bond market was comprised of an industry loss index trigger in Q3 of 2016 (figure 5), (Risk Management Solutions and GC Securities, 2016). A whopping 72% of total risk capital issued or \$775 million of risk capital was indemnity loss bonds and the remaining 3% or \$31 million of new issues were parametric index cat bonds (figure 5). The composition of the catastrophe bond

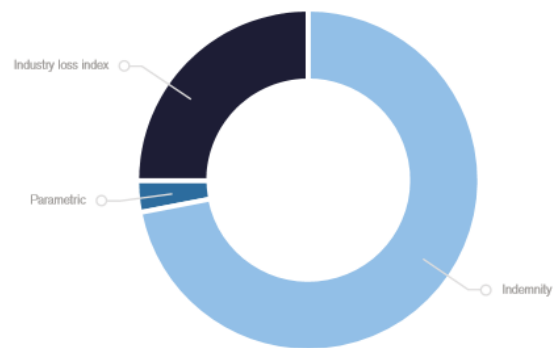


Figure 5. Issuance of catastrophe bonds by trigger type in quarter three of 2016. (Guy Carpenter Securities, 2016)

market by peril and issuance is important to emerging economies because new types of risk help the cat bond market grow which in turn, attracts investors (Artemis and Guy Carpenter, 2016).

IV. Indonesia: An Industrial Hub with Acute Vulnerability

Indonesia, as a rising stronghold in the global economy, presents the favorable characteristics for a country which should use catastrophe bonds as a means to efficiently transfer the risk of insuring property in natural disaster prone areas. Indonesia is home to a variety of natural disasters including volcanoes, earthquakes, storm surges, tsunamis, tropical cyclones, mudslides, and floods (Mahul et. al., 2012). However, Indonesia has managed to strengthen their economy by attracting labor intensive industries over the past few decades and inserting themselves as a crucial participator of the global supply chain. The Government of Indonesia (GoI) has recognized the dire need for a better financial system to deal with the effects of natural disasters in addition to a strong network of disaster recovery and prevention policies. In recent years the GoI has developed and fine-tuned Law 24/2007 which defines a natural disaster and identifies the responsibilities of the central and local governments as well as the duties of the National and Regional Disaster Management Agencies (Mahul et. al., 2012).



Figure 6. Foreign Direct Investment (FDI) Inflows in Indonesia from 1985-2015. (The World Bank)

Aside from 2015, when FDI inflows in Indonesia declined (see figure 6), FDI inflows over the past decade have continued to rise reflecting Indonesia’s positive economic outlook, growing stake in the global supply chain, and interest in securing safe and efficient disaster risk

management policies via newly elected President Joko Widodo (CEIC, 2016). However, the GoI currently finances the insurance of private dwellings through a single government sponsored insurer, PT Maipark. Unfortunately, this leaves no room in Indonesia's budget to finance the insurance of public infrastructure including schools, hospitals, and roadways (Mahul et al, 2012). With all of these factors in mind, the introduction of Indonesia into the catastrophe bond market would not only provide monetary relief for the GoI to focus efforts on economic progress but, it would also increase the insurance coverage in Indonesia, diversify the current supply of catastrophe bonds on the market, and it would supply companies based in Indonesia, as well as, its citizens with certain post-disaster liquidity for reconstruction.

- **The positive economic outlook for Indonesia**

Despite the seemingly constant onslaught of catastrophes, Indonesia ranks 16th among global GDP and in 2014, observed a 5.0% annual GDP growth rate (estimated in constant 2005 USD) compared to other emerging economies like India which experienced 7.3% in 2014, and Mexico which experienced 2.2% (World Statistics Pocketbook, 2016). Indonesia offers strong economic prospects for global financial progress including its favorable demographics (a large and young population), its abundant natural resources, relatively strong international relations, history of overall resilience to global financial crises, relatively low public debt and increasingly strong fiscal policies (Islam, 2016) and (Mahul, 2012). In recent years, Indonesia has seen stagnant economic performance but has become a large recipient of foreign direct investment due to the shift of labor-intensive manufacturing to Indonesia from higher-cost countries (Hwee and Mirza, 2015). The increase in FDI over the past decade (figure 6), has strengthened Indonesia's regional production networks and regional value chains, an attractive aspect for developed economies looking to invest in those positioned with stable economic inflows and less volatile financial markets. Reflecting the stagnant trend in economic progress in spite of the continuous onslaught of catastrophes over the years, Indonesia has managed to lower its debt-to-GDP ratio from 100% in 1999, just after the Asian financial crises, to less than 25% today. Both Moody's and Fitch Group have upgraded Indonesia's credit rating to investment grade as of December 2011 (The World Factbook, 2016).

- **Indonesia's stake in global trade**

In addition to the positive outlook for Indonesia's overall economic profile, the country's economy is comprised of 14% agriculture, 41.3% industry and 44.7% services; making

Indonesia a large contributor to the flow of global trade. Petroleum and natural gas, textiles, automotive, electrical appliances, apparel, footwear, mining, cement, medical instruments and appliances, chemical fertilizers, plywood, rubber, processed food, jewelry, and tourism are among the most crucial industries in Indonesia (Office of the United States Trade Representative, 2016) and (The World Factbook, 2016). The three largest importers of Indonesian made products include Japan (12%), the United States (10.8%), and China (10%), (Office of the United States Trade Representative, 2016). The United States, in particular, has a unique relationship with Indonesia. Under the Trade and Investment Framework Agreement (TIFA) signed in July 1996, the United States imported \$19.6 billion of goods in 2015 and in April of 2016 met with Indonesia to discuss ways to boost trade and investment (Office of the US Trade Rep, 2016). In fact, over the past decade, two-way trade with Indonesia has nearly doubled and U.S. firms have stated their intention to open or reopen plants in Indonesia with a combined investment of over \$450 million. United States FDI in Indonesia has grown 175% from 2008 reaching \$256 million (Hwee and Mirza, 2015). Although trade interests in Indonesia have grown, the country continues to be plagued by a multitude of natural disasters that stunt the economic and infrastructure development of the country which could otherwise be supported by the money spent on post-disaster reconstruction.

- **Current disaster financing in Indonesia**

Indonesia is situated on the Pacific Ring of Fire, a convergence of four tectonic plates, and has been continuously identified in the Center for Research on the Epidemiology of Disasters' Annual Disaster Review as one of the five countries most frequently impacted by catastrophes (Mahul, 2012). The 2004 Indian Ocean Earthquake, which originated off the west coast of Sumatra, caused a tsunami that resulted in an estimated direct losses of \$8 billion USD and affected other major emerging economies including Sri Lanka, Thailand, and India (Chatenoux and Peduzzi, 2006). Because Indonesia is located in one of the most seismically active areas on Earth, the biggest threat to Indonesia's stability comes from earthquakes (Chatenoux and Peduzzi, 2006). AIR's industry exposure database for Indonesia, which catalogs the building inventory including industrial facilities, estimates the value of insurable properties at more than \$3 trillion USD. Furthermore, an estimated 35% of the building inventory is masonry construction which is subject to significant damage in the event of an earthquake (AIR

Worldwide, 2016). The annual average cost of natural disasters in Indonesia is estimated at 0.3% of its GDP or \$1.5 billion USD (Mahul, 2012).

Indonesia finances disaster recovery and prevention through humanitarian assistance and the central budget. In 2015, Indonesia received \$60million USD in humanitarian assistance to help aid disaster recovery and prevention but, this failed to cover even a fraction of a single wildfire that occurred in the same year costing \$1billion USD. As a result, the bulk of disaster recovery and prevention is financed via the central budget of the GoI which requires approval from parliament (Mahul, 2012). There are a number of major deficiencies created by this process of post-disaster funds appropriation. Namely, the timing of assistance often delays recovery by weeks and sometimes several months because budget appropriations for post-disaster recovery are discussed during parliament budget meetings held only in December and July. Second, within Law 24/2007, which defines a natural disaster, the unclear distinction between a major national disaster which falls to the responsibility of the central budget and a minor local disaster which falls under the responsibility of local contingency budgets, creates further delayed recovery action and prolonged suffering. Finally, the undercapitalization of the Rehabilitation and Reconstruction Fund, which acts as the source for national recovery action results in the GoI prioritizing the reconstruction of private dwellings over public infrastructure such as schools, health facilities, and roadways (Mahul et al, 2012). Fortunately, the GoI has begun the arduous process of creating a more efficient risk transfer solution for Indonesia's private and public properties which they believe, can draw it's central theme from a country with similar economic and disaster parameters; Mexico.

- **The catastrophe insurance market in Indonesia and lessons from MultiCat Mexico**

The catastrophe insurance market in Indonesia, as a percentage of GDP, is estimated at 0.6%, a lower penetration rate than that of its neighboring countries, Malaysia (1.6%) and Thailand (1.1%) (Mahul, 2012). In fact, PT Maipark is the only specialized earthquake insurance company in Indonesia which was established jointly in 2004 by the General Insurance Association of Indonesia and the GoI Bureau of Insurance. One of the goals of PT Maipark is to develop a hazard and exposure database for earthquakes (Mahul, 2012). The GoI has drawn on the examples set by the Government of Mexico to develop a national disaster risk reduction framework. In the past, the Government of Mexico developed a catastrophe risk model called R-

FONDEN which offered catastrophe risk analysis for four major perils (earthquake, floods, tropical cyclones, and storm surge) at the national level, state level, and sub-state level. R-FONDEN was instrumental in the development of Multicat Mexico 2009 and Multicat Mexico 2012, two very successful earthquake catastrophe bonds issued by the Government of Mexico (Hardle and Cabrera, 2007). Multicat Mexico 2009, a \$290 million parametric catastrophe bond that provided coverage against earthquakes and hurricanes, was oversubscribed when it hit the catastrophe bond market. Similarly, MultiCat Mexico 2012 is a \$315 million parametric catastrophe bond that offers coverage against earthquake risk in five geographic regions and hurricane risk in three regions within Mexico and above a 7.50% coupon on all tranches (Artemis, 2016). Entrance into the catastrophe bond market has since allowed the Government of Mexico to transfer a pool of disaster risk to the financial markets, secure multi-year protection for the covered risks at a fixed price, and reduce potential pressure on public budgets in years to come (World Bank Treasury, 2009). The GoI is eager to explore the use of parametric catastrophe bonds which would offer relatively transparent risk exposure to insurers and investors and would allow for fast claims settlement in the event of a disaster (Mahul, 2012). Not only would the GoI and foreign firms that have direct investments in Indonesia have the security of insured assets, but the GoI would augment its disaster recovery reserves and direct funds toward infrastructure and economic development.

- **Advancing toward a solution for efficient risk transfer**

Indonesia has taken the first step in devising disaster risk financing solutions by assessing the financial and fiscal risk associated with the natural disasters that have affected the country. This assessment procedure has been made possible through historic loss data and modeled losses from catastrophe risk models based on the methodology created by the Economic Commission for Latin America and the Caribbean (ECLAC) (Mahul, 2012). Physical damage alone, is not sufficient for modelling hazard risks in Indonesia, where earthquakes are often relatively unpredictable. Understanding the nature of the Pacific Ring of Fire (the convergence of the Pacific, Eurasian, Australian, and Philippine Sea plates), is an essential component of modeling seismic risk in Indonesia. The AIR Earthquake Models for Southeast Asia incorporate the latest historical seismic data, active fault and paleoseismological data (data collected from geologic sediments and rocks for signs of ancient earthquakes), kinematic modeling of GPS data on crustal deformation, geotechnical data on soil, and damage survey data from recent earthquakes

(AIR Worldwide, 2016). A cohesive hazard map, see figure 7, which shows the degree of exposure to tsunami and storm surges, floods, tropical storms, volcanic eruptions, and earthquakes has been developed by the United Nations Cartographic Section in coordination with the Global Discovery, Indonesian National Statistical Office, Smithsonian Institute, Pacific Disaster Center, UNISYS, and Munich Reinsurance Group This comprehensive hazard map is just one of many in a combined effort to boost Indonesia's potential to earn a spot in the catastrophe bond market.

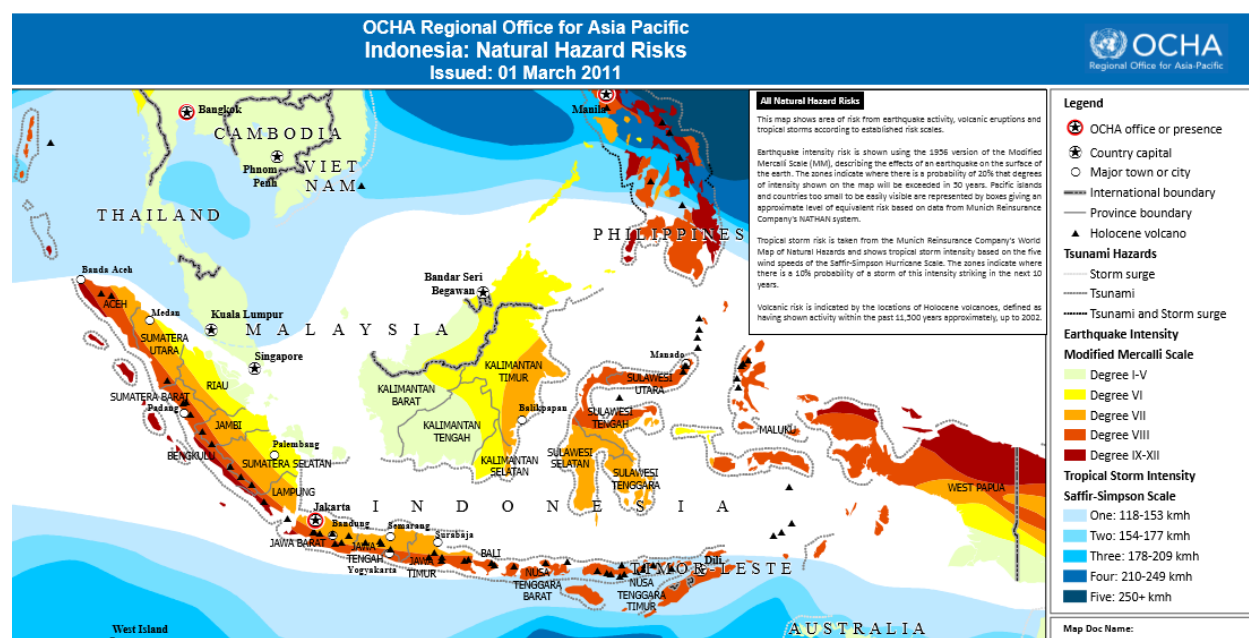


Figure 7. A cohesive hazard map of Indonesia's natural disaster risks by degree of intensity and probability. Natural disasters measured include: storm surge, tsunami, tsunami and storm surge combined, earthquake, volcano, and tropical storms. (OCHA Regional Office for Asia Pacific)

A team of researchers from The World Bank and the Global Facility for Disaster Risk Reduction and Recovery (GFDRR) have identified a three-tier risk layering strategy that the GoI can undertake in order to help increase the immediate financial response capacity against natural disasters (Mahul, 2012). Figure 8 shows the associated disaster risks and appropriate disaster risk financing instruments ranked by the frequency and severity of the disaster. Note that the GoI intends to use catastrophe bonds, if at all possible, for low frequency high severity natural disasters. As previously mentioned, a parametric catastrophe bond would be optimal for these types of scenarios where damage could be well beyond what the GoI could handle. The use of hazard maps created by PT Maipark coupled with the use of Indonesia's risk assessment

database and AIR’s Southeast Asian Earthquake modelling, provide an optimal context for the GoI and the insurance industry to efficiently issue parametric catastrophe bonds in Indonesia where information bias would be reduced strengthening the positing for investors. Not only is the data available for modelling a catastrophe bond but Indonesia is a prime contender for investors looking to diversify their portfolio with higher risk and higher reward bonds. Additionally, the increasing influx of FDI in Indonesia, positive economic outlook, and the country’s increasing presence in world trade presents a multitude of risks worth protecting.

Figure 1. Indicative disaster risk financing strategy for Indonesia

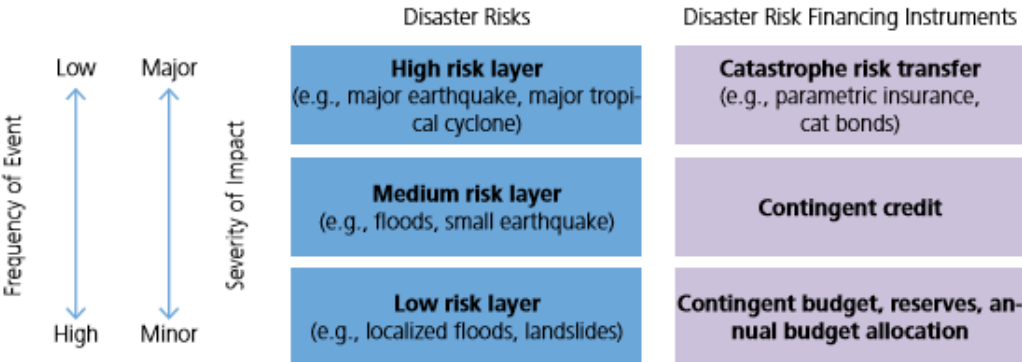


Figure 8. Disaster risk financing strategies organized by the Gol and the Ministry of Finance. Financing solutions are organized by the frequency and severity of an event couple with the type of event. (Mahul et al, 2012)

Conclusion

This paper has attempted to argue that the vulnerability to natural disasters faced by emerging economies, where urbanization is often concentrated in high risk areas, can be partially offset by transferring the risk to the financial markets through the use of catastrophe bonds. Emerging economies present a unique case for catastrophe bonds because as technology improves communication and mobilization, these countries are an increasing market force in global trade, foreign direct investment flows, and the direction of humanitarian assistance. Many studies have shown that the availability of insurance plays an important role in the economic and social development of a nation. Thus, addressing these growing vulnerabilities must be a key component in the framework of any global climate change policy. Going forward, public policy should draw on the efforts and experiences of established risk reduction organizations such as the Caribbean Catastrophe Risk Insurance Facility (CCRIF) and MultiCat Mexico. The MultiCat Mexico Earthquake catastrophe bonds of 2009 and 2012 demonstrate that the use of catastrophe

bonds to finance disaster risk reduction and recovery result in the reduced financial burden on government and the assurance of safe investments. The CCRIF is one of many recently developed organizations which pools the risk of many countries and uses insurance linked securities to provide liquidity in the aftermath of a natural disaster (Das, 2016). The parametric policies designed by the CCRIF demonstrates how the integration of a successfully operating and globally unique risk transfer solution can become part of a country's more efficient risk management framework. The facility's success in finding a solution for efficient risk transfer and relief for disasters in emerging countries has been identified by the Parties to the United Nations framework convention for climate change at the Conference of Parties in both Copenhagen and Paris (Sagicor Insurance Managers, 2016). Emerging countries like Indonesia, stand to benefit immensely from use of catastrophe bonds to efficiently transfer the risk of exposure to natural hazards. The potential economic benefits include decreased expenditures on natural disasters within the affected country, decreased dependence on foreign aid, increased economic development and infrastructure development within the affected country, and global economic progress as poverty is alleviated and foreign direct investment in emerging countries is increased. Aside from the additional profits that can be generated from increased insurance coverage in emerging countries, catastrophe and property insurance offer a larger diversified risk pool in the catastrophe bond and may very well improve market intelligence over time as modelled loss platforms are improved for emerging economies. As catastrophe bonds become a more attractive asset both to investors and sovereigns, it is important to consider the significance of country specific modelled loss platforms. The rise of big data analytics has made it possible for reduce information bias, an advantage for all parties involved in a catastrophe bond transaction. Looking forward, emerging economies can seize the opportunity to use the data generated by natural disasters to develop an analytical tool, similar to those developed by AIR, which could tell them more about what storm parameters, trigger types, and pricing strategies would be optimal.

References

- AIR Worldwide. 2016. *AIR Earthquake Models for Southeast Asia*. Verisk Analytics.
- Artemis. 2016. *Haiti in Line for \$20m after CCRIF Parametric Trigger hit by Matthew*. Steve Evans Ltd. Retrieved October 2016 (<http://www.artemis.bm/blog/2016/10/07/haiti-in-line-for-20m-after-ccrif-parametric-trigger-hit-by-matthew/>).
- Artemis and Guy Carpenter Securities. 2016. Q2 2016 Catastrophe Bond & ILS Market Report. Artemis.
- Beilharz, Hans-Jorg, B. Rauch, and C. Wallner. 2013. *Economic Consequences of Natural Catastrophes: Emerging and Developing Economies Particularly Affected- Insurance Cover is Essential*. Munich Re Economic Research. Retrieved September 2016 (<http://www.iii.org/fact-statistic/catastrophes-global>).
- Bennett, Michael. *Greening the Global Economy: Opening the Catastrophe Bond Market to Developing Countries*. Green Economy Report 2015.05 Green Finance. Retrieved October 2016 (http://treasury.worldbank.org/cmd/pdf/Opening_the_Catastrophe_Bond_Market_to_Developing_Countries.pdf).
- Bermuda Monetary Authority. 2016. *Bermuda Insurance-Linked Securities (ILS) Market Report*. Bermuda Monetary Authority Q2-2016 4(2). Retrieved November 2016 (<http://www.ilsbermuda.com/wp-content/uploads/2016/10/Q2-2016-Bermuda-ILS-Market-Report.pdf>).
- CEIC. 2016. Indonesia Foreign Direct Investment FDI Data. CEIC: A Euromoney Institutional Investor Company. Retrieved December 2016 (<https://www.ceicdata.com/en/statistics/Indonesia/Foreign-Direct-Investment-FDI>).
- Chatenoux, B. and P. Peduzzi. 2006. Impacts from the 2004 Indian Ocean Tsunami: Analyzing the Potential Protecting Role of Environmental Features. *Natural Hazards* (2007) 40:289.
- Chu, Kathleen and Komaki Ito. 2016. "More Japanese Investors Are Piling Into Catastrophe Bonds". Bloomberg Markets, August 18, 2016. Retrieved December 2016 (<https://www.bloomberg.com/news/articles/2016-08-18/hurricanes-worth-the-risk-as-yields-vanish-for-japan-s-investors>).
- Committee on Assessing the Costs of Natural Disasters et. al. 1999. *The Impacts of Natural Disasters: A Framework for Loss Estimation*. Washington, D.C., National Academy Press. Retrieved November 2016 (<https://www.nap.edu/catalog/6425/the-impacts-of-natural-disasters-a-framework-for-loss-estimation>).
- Das, Anupreeta and Leslie, Scism. October 6, 2016. *Hurricane Matthew to Test Catastrophe-Bond Market*. The Wall Street Journal, October 6, 2016. Retrieved from: <http://www.wsj.com/articles/hurricane-matthew-to-test-catastrophe-bond-market-1475791599> on October 10, 2016.
- Duc, Tran Viet. 2013. Which Coastal Cities Are at Highest Risk of Damaging Floods? New Study Crunches the Numbers. The World Bank: Feature Story. Retrieved December 2016 (<http://www.worldbank.org/en/news/feature/2013/08/19/coastal-cities-at-highest-risk-floods>).
- Escaith, Hubert. 2015. *International Trade Statistics 2015*. Geneva, World Trade Organization.
- Financial Industry Regulatory Authority. 2013. *Investor Alerts: Catastrophe Bonds and Other Event-Linked Securities*. Financial Industry Regulatory Authority. Retrieved September 2016 (<http://www.finra.org/investors/alerts/catastrophe-bonds-and-other-event-linked-securities>).
- Grossi, Patricia and H. Kunreuther. 2005. *Catastrophe Modeling: A New Approach to Managing Risk*. Springer Science + Business Media, Inc. New York, NY. 2005.
- Han, Liyan, D. Li, F. Moshirian, and Y. Tian. 2010. Insurance Development and Economic Growth. *The Geneva Papers on Risk and Insurance: Issues and Practice* 35(2) 183-199.
- Hardle, Wolfgang Karl, and Brenda Lopez Cabrera. 2007. *Calibrating CAT Bonds for Mexican Earthquakes*. Center for Applied Statistics and Economics, Humboldt-University of Berlin.

- Huber, Daniel and J. Gullede. 2011. *Extreme Weather and Climate Change*. Center for Climate and Energy Solutions. Retrieved October 2016 (<http://www.c2es.org/publications/extreme-weather-and-climate-change>).
- Hudson, Paul, W.J.W. Botzen, J. Czajkowski, and H. Kreibich. 2014. *Risk Selection and Moral Hazard in Natural Disaster Insurance Markets: Empirical Evidence from Germany and the United States*. The Wharton School, University of Pennsylvania. Retrieved October 2016 (<http://opim.wharton.upenn.edu/risk/library/WP201407-Risk-Selection-in-Natural-Disaster-Insurance-Markets.pdf>).
- Hwee, Wee Kee and H. Mirza. 2015. *ASEAN Investment Report 2015: Infrastructure Investment and Connectivity*. ASEAN Secretariat and United Nations Conference on Trade and Development. Retrieved November 26, 2016 (http://unctad.org/en/PublicationsLibrary/unctad_asean_air2015d1.pdf).
- Insurance Information Institute. 2016. *Catastrophes: Insurance Issues*. Insurance Information Institute, Inc. Retrieved October 2016 (<http://www.iii.org/issue-update/catastrophes-insurance-issues>).
- Insurance Information Institute. 2016. *Global Insured Disaster Losses in May: \$7 Billion and Counting*. Insurance Information Institute. Retrieved November 2016 (<http://www.iii.org/insuranceindustryblog/?p=4482>).
- Islam, Mahamoud. 2016. *Country Report: Indonesia*. Euler Hermes Economic Research. Retrieved November 27, 2016 (<http://www.eulerhermes.com/economic-research/blog/EconomicPublications/indonesia-country-report-sep16.pdf>).
- Jackson, James K. 2013. *U.S. Direct Investment Abroad: Trends and Current Issues*. Congressional Research Service Report 7-5700.
- Jain, Ashish. 2016. *From Lava to Water to Shake: Indonesia Has it All*. In Focus: Risk, Modeling, and Industry Buzz (AIR Worldwide), June 2016.
- Lattimer, Charlotte and Sophia Swithern. 2016. *Global Humanitarian Assistance Report 2016*. Global Humanitarian Assistance.
- Lee, Jin-Ping and Min-The Yu. 2002. Pricing Default-Risky CAT Bonds with Moral Hazard and Basis Risk. *The Journal of Risk and Insurance* **69**(1):25-44.
- Linnerooth-Bayer, Joanne, R. Mechler, and G. Pflug. Refocusing Disaster Aid. *Science* **309**(5737):1044-1046.
- Mahul, Oliver, et. al. 2012. *Indonesia: Advancing a National Disaster Risk Financing Strategy- Options for Consideration*. Disaster Risk Financing and Insurance Program, GFDRR and FCMNB. October 2011. Retrieved November 2016 (https://www.gfdr.org/sites/gfdr/files/publication/Indonesia_DRFI_Report_FINALOct11.pdf).
- Mills, Evan. August 2005. *Insurance in a Climate of Change*. Science Magazine **309**(5737): 1040-1044.
- Mills, Evan. 2007. "Responding to Climate Change — The Insurance Industry Perspective." In *Climate Action*, Sustainable Development International (in partnership with the United Nations Environment Program), December, pp. 100-103.
- Neuthor, Laila and Ernst Rauch. April 2013. *Emerging Countries Affected By Insurance Gaps*. Topics Online: The Magazine for Insurers (Munich Re), April 8, 2013. Retrieved November 2016 (<https://www.munichre.com/en/reinsurance/magazine/topics-online/2013/02/risikomanagement/index.html>).
- Office of the United States Trade Representative. 2014. *Indonesia*. Washington: Executive Office of the President. Retrieved November 27, 2016 (<https://ustr.gov/countries-regions/southeast-asia-pacific/indonesia>).
- Office of the United States Trade Representative. 2016. *United States and Indonesia Explore Initiatives to Increase Trade and Investment*. Washington, DC: Press Office. Retrieved November 22, 2016 (<https://ustr.gov/about-us/policy-offices/press-office/press-releases/2016/april/united-states-and-indonesia-explore>).
- Riebeek, Holli. 2005. *The Rising Cost of Natural Hazards*. NASA Earth Observatory. Retrieved October 2016 (<http://earthobservatory.nasa.gov/Features/RisingCost/printall.php>).

- Rodrik, Dani. 2007. *One Economics-Many Recipes: Globalization, Institutions, and Economic Growth*. Princeton, NJ, Princeton University Press.
- Rogowsky Robert A. and K. Laney-Cummings. 2009. *Property and Casualty Insurance Services: Competitive Conditions in Foreign Markets*. Washington, DC: U.S. International Trade Commission.
- Sagicor Insurance Managers. 2016. *The CCRIF Model- An Essential Component of a Climate Change Adaptation Strategy*. The Caribbean Catastrophe Risk Insurance Facility. Retrieved October 2016(<http://www.ccrif.org/content/ccrif-model-essential-component-climate-change-adaptation-strategy>).
- Skees, Jerry R. 1999. Opportunities for Improved Efficiency in Risk Sharing Using Capital Markets. *American Journal of Agricultural Economics* **81**(5):1228-1233.
- Stone, Robert, M. Abramska, P. Nakada, and J. Stoughair. 2012. *Cat Bonds Demystified: RMS Guide to the Asset Class*. Risk Management Solutions.
- Swiss Reinsurance. 2007. *Swiss Re Launches the First Catastrophe Bond Indices*. Swiss Re. Retrieved October 2016 (http://www.swissre.com/media/news_releases/swiss_re_launches_the_first_catastrophe_bond_indices.html).
- The World Bank Treasury. 2012. *Mexico Launches Second Catastrophe Bond to Provide Coverage Against Earthquakes and Hurricanes*. The World Bank. Retrieved November 2016 (http://treasury.worldbank.org/bdm/html/Financing_Noteworthy/Mexico_Launches_Second_Catrophe_Bond_Oct2012.html).
- The World Factbook. 2016. *East & Southeast Asia: Mongolia*. Central Intelligence Agency. Retrieved October 2016 (<https://www.cia.gov/library/publications/the-world-factbook/geos/mg.html>).
- The World Trade Organization. 2016. *Millennium Development Goals: Trade and Development*. The World Trade Organization. Retrieved November 2016 (https://www.wto.org/english/thewto_e/coher_e/mdg_e/development_e.htm).
- United States Department of State. 2011. *U.S. - Indonesia Trade and Investment Relationship*. Washington, DC: Office of the Spokesperson. Retrieved November 22, 2016 (<http://www.state.gov/r/pa/prs/ps/2011/11/177383.htm>).
- World Statistics Pocketbook. 2016. Indonesia Country Profile. The United Nations Statistics Division. Retrieved December 2016 (<http://data.un.org/CountryProfile.aspx?crName=indonesia#Summary>).
- World Statistics Pocketbook. 2016. Mexico Country Profile. The United Nations Statistics Division. Retrieved December 2016 (<http://data.un.org/CountryProfile.aspx?crName=mexico#Summary>).
- World Statistics Pocketbook. 2016. India Country Profile. The United Nations Statistics Division. Retrieved December 2016 (<http://data.un.org/CountryProfile.aspx?crName=india#Summary>).
- Vacarini, Fernando, L. Molloy, and P. Poillon. 2015. *UnipolSai and Willis Confirm Completion of Industry-first Catastrophe Bond, Azzurro Re*. Willis Re. Retrieved October 2016 (<http://investors.willis.com/phoenix.zhtml?c=129857&p=irol-newsArticle&ID=2079481>).
- NAIC Capital Markets Bureau. 2016. *Insurance Linked Securities: Catastrophe Bonds, Sidecars, and Life Insurance Securitization*. Retrieved October 2016 (http://www.naic.org/cipr_topics/topic_insurance_linked_securities.htm).
- Zhengtang, Zhao. 2011. Natural Catastrophe Risk, Insurance and Economic Development. *Energy Procedia* **5**(2011):2340-2345.