The Financialization of Environmental Risks through Catastrophe Bonds: A Spatial-Temporal Evaluation

by

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Authors Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

As natural disaster risks continue to increase as a result of climate change, insurance companies and other institutions struggle to find ways to deal with these risks. There is a propensity for these risks to be financialized and distributed through the market. Catastrophe bonds are indicative of this trend for environmental problems to be represented through financial and market instruments. This thesis expands upon the critical literature surrounding catastrophe bonds through an analysis of the bonds themselves, acting as an exposé of their nature and processes. It explores how environmental risks are being financialized while exposing the separation of the temporal and spatial aspects of natural catastrophes that manifest through this process. This research consists of an in-depth deconstruction and analysis of catastrophe bonds in addition to qualitative interviews with three catastrophe bond experts. It makes use of relational economic geography to map the processes, actors, and infrastructure of catastrophe bonds to offer a critique of their development and function. It analyzes these bonds from creation to distribution through three mechanisms of financialization: ownership, commensuration and mobilization.

This thesis demonstrates how catastrophe bonds are a form of financialization and argues that transforming environmental risks into exchange values is a form of time-space compression. The separation of the spatial and temporal aspects of natural disaster risk from their exchange value can lead to distortion and undervaluation of these risks. Through this analysis of catastrophe bonds and the process of the financialization of environmental risk, this research aims to analyze these bonds as a mechanism for dealing with climate change risk. This research can be extended to other forms of financialization and offer a critique for the inclination to attempt to address environmental risks through market mechanisms.

Key Words: catastrophe bonds, financialization, relational economic geography, exchange value, time-space compression

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Table of Contents

List of Figures

List of Tables

1. Introduction

The increasing risks of natural disasters associated with climate change increase the frequency and severity of financial losses (Van Aalst, 2006; López Vega et al., 2015; Phalkey & Louis, 2016). These financial losses are of direct concern to the insurance industry as they are often responsible for providing financial coverage for damages incurred from these natural disasters. The potential financial losses that the insurance industry could face in the event of large or even simultaneous natural disasters could outweigh their financial capacity (Loubergé et al., 1999; Edesess, 2015). Typically, insurance companies turn to reinsurance to take on some of their financial risks, however, as climate change induced natural disasters continue to threaten the financial stability of the insurance industry, the need for reinsurance coverage has surpassed what the reinsurance industry is able to cover (Cummins & Weiss, 2009). Catastrophe bonds are a way to transfer insurance risks to the capital market. This thesis examines catastrophe bonds and their transformation of environmental risks into financial figures. It explores the financialization of environmental risks and the separation of the temporal and spatial aspects of natural catastrophes that manifest through the catastrophe bond market.

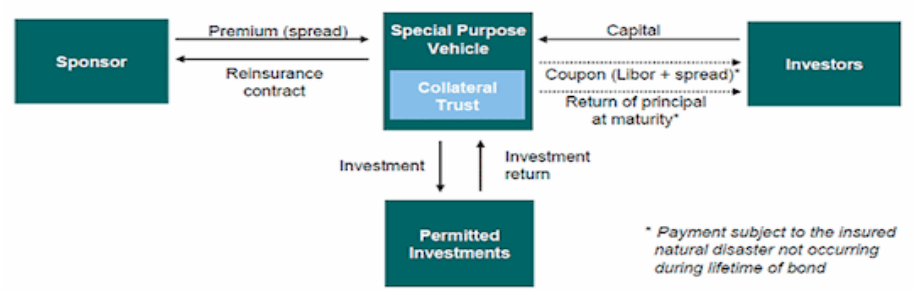
1.1 Catastrophe Bond Developments and Structure

In 1992, Hurricane Andrew hit Southern Florida and became the most costly hurricane in U.S history (Rappaport, 1994; Edesess, 2015), causing 17 billion USD of industry losses in Florida alone (Swiss Re, 2011). The losses from this hurricane superseded what insurance risk managers had expected, ultimately forcing several insurance companies to file for bankruptcy (Swiss Re, 2011; Edesess, 2015). As a result of this shock to the insurance industry, many insurers refused to offer similar coverage in

the future and began to seek new ways to manage their risk (Edesess, 2015). Insurers wanted to make sure that in the case of future natural disasters they would not become bankrupted by damages. Based on these worries and the need for new innovative mechanisms to deal with insurance risk, the use of alternative risk transfer (ART) became common. Insurance-linked securities (ILS), and specifically catastrophe (cat) bonds, emerged on the market and began to see increasing growth for insurers looking for alternative ways to transfer their risks.

Cat bonds offer a way for insurance companies to find reinsurance coverage from outside investors, thus reducing their risk for bankruptcy. These bonds are a type of ILS in that their values are linked to insurance loss events. Cat bonds represent coverage for a specific natural disaster risk. The bonds transfer the natural disaster risk from an insurance company to investors. The investors take on the risks of a specific catastrophe for a fixed period of time. If the disaster does not occur, the investors will gain a positive return on their investment through interest rates on their investments and insurer coverage payments. However, if the disaster does occur, the investor will lose the principal they invested and the insurance company will receive that money to cover the losses of the disaster. Figure 1 below illustrates the typical structure of a catastrophe bond.

Figure 1: Catastrophe Bond Structure



(GAM, 2012)

There are various actors involved in cat bond transactions. The bond begins with a sponsor or issuer, which is usually an insurance company, identifying natural catastrophe risk that they want coverage for. This sponsor then hires a risk modeller to analyze the risk and potential losses. These risk modellers typically use catastrophe modelling and stochastic risk analysis to estimate the range of potential catastrophes as well as the estimated losses from the hypothetical catastrophe (Van Leer, 2015). The natural disaster risk coverage that the sponsor is looking for is then translated into a dollar amount, which becomes the amount of investment the cat bond requires.

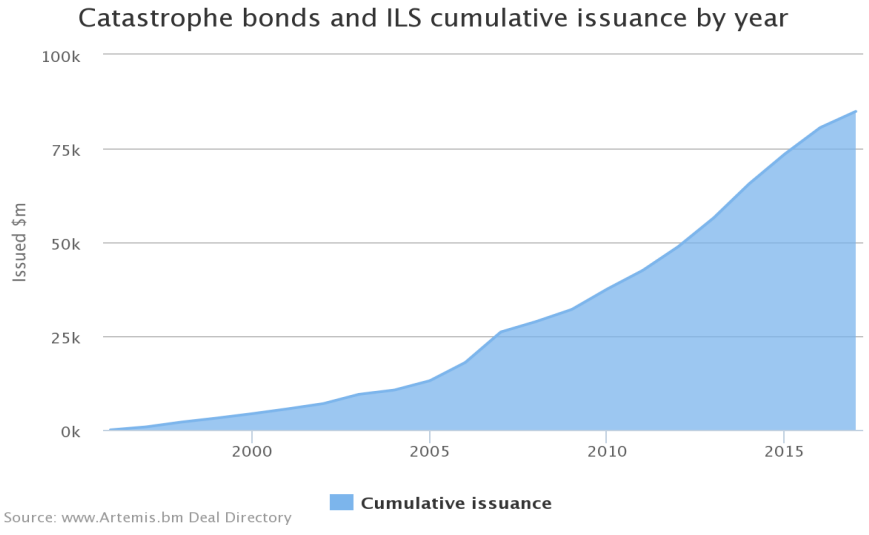
After risk modelling, the trigger type for the proposed cat bond is established. The trigger type refers to the terms that have to be met in order for the cat bond to be paid out to the sponsor. Common triggers for cat bonds are indemnity, industry loss, modelled, and parametric index triggers (Artemis, 2017b). After the price and trigger type have been decided on, the sponsor enters into an agreement with a special purpose vehicle (SPV) for the particular risk coverage. The sponsor pays the SPV premiums for this coverage. The SPV then sells the bond through securities to investors. The funds generated by the purchase of the bonds become the collateral, which will cover the sponsor's risk in case the qualifying event occurs. The collateral is put into an account to collect interest. In return for offering the collateral, the investors receive part of the premiums the sponsor is paying for the risk coverage, as well as interest from the collateral account. If the qualifying event occurs, the collateral account will be liquidated in order to reimburse the sponsor based on the cat bond agreement and investors will lose

their money. If the qualifying event does not occur, the collateral account is liquidated and investors are repaid their initial investment (Artemis, 2017b).

1.2 Catastrophe Bond Market

The cat bond market has seen considerable growth in the past decade with the market totalling $26.82 billion by the end of 2016 (Artemis, 2016a). Figure 2 shows the cumulative volume of risk capital that has been issued since the inception of the cat bond market. Cat bonds are attractive to investors for diversification purposes as they allow them to spread their investment risk across the market and enhance their portfolios (Bantwal & Kunreuther, 2010). Cat bond returns are uncorrelated to the broader financial market (Edesess, 2015; Cummins, 2008; Litzenberger et al., 1996) and offer high returns with annual growth rates of approximately 8 or 9 percent (Swiss Re, 2011). Since 2002, cat bonds have yet to incur a twelve-month period with a negative return (Swiss Re, 2011).

Figure 2: Catastrophe Bond Market by Issuance



(Artemis, 2017a)

The cat bond market is predicted to continue to see increased growth (Phillips, 2014; Johnson, 2015; Edesess, 2015) with some scholars predicting the bonds may eventually be issued in the public market, rather than solely privately (Cummins, 2008). As mounting evidence continues to emerge indicating that climate change will result in an increase in natural disasters (Van Aalst, 2006; López Vega et al., 2015; Phalkey & Louis, 2016), the issuance of cat bonds continues to grow in response (Cummins, 2008).

1.3 Problem Statement

As the cat bond industry becomes a more prominent way of dealing with natural disaster risks, there is a need for a closer examination of this tool and its ability to adequately address environmental catastrophe risks. There is a propensity for environmental risks or problems to be represented through financial figures and addressed through the marketplace. Cat bonds are indicative of this trend as they transform environmental risks into financial figures and trade these risks through the market. Cat bonds are a form of environmental financialization in that they convert environmental risks grounded in space and time to an exchange value, which is separated from spatial and temporal realities. This thesis will refer primarily to Knox-Hayes' (2013) definition of financialization as "the process of reducing value that is exchanged into financial instruments or derivatives of financial instruments" (p. 120).

Catastrophe bonds divorce financial value from the material context they seek to represent. This process of converting environmental risk into exchange value creates distortions in the representation of climate change risk and value and could lead to undervaluation and mismanagement of environmental risks. The separation of exchange

value from the spatial and temporal realities of environmental problems creates distortions of value and fails to address the underlying problem (Knox-Hayes, 2013). Knox-Hayes (2013) refers to this process as time-space compression, defining it as "a process of privileging or converting physical space and time into social space and time. For valuation, time-space compression leads to the conversion of use values into exchange values" (p. 120). While finance literature and cat bond practitioners widely believe that cat bonds are useful risk management tools, the financialization of environmental risks can oversimplify material aspects of time and space. The financialization of environmental risks through catastrophe bonds can lead to the compression of temporal and spatial realities, resulting in mismanagement or undervaluation of risks.

1.4 Significance and Contribution

As discussed in the background section of this paper, cat bonds are seeing considerable growth and represent a significant portion of insurance risk management strategies. As the market continues to grow and cat bond investment becomes more common, there is a risk for investors to lose their money based on inadequate risk modelling and an undervaluation of the problem. Catastrophe bond critics have posed similarities between the risks of these bonds and the systemic financial risk that led to the sub-prime mortgages crisis (Phillips, 2015; Harrington, 2009). The European Insurance and Occupational Pensions Authority (EIOPA) expressed concern in the growth of the catastrophe bond market in their 2013 December financial stability report. They noted that fixed-income investors searching for yield may "not necessarily have the modelling capabilities and experience to fully analyse the underlying risks and complexity of the

insurance market", which without adequate supervision "could cause systemic risk" (EIOPA, 2013, p. 16).

With catastrophe bonds, there is also a risk for less climate change mitigation attempts if climate risk is considered a financial value that can simply be sold off. If insurance companies deem that by selling their risk to outside investors, they have accounted for it, there is an overt disconnect from the objective spatial and temporal aspects of natural catastrophes and their perceived value. The process of financialization creates this disconnect by transferring use value into exchange value. Climate change may become a more significant driver of the losses that cause cat bonds to trigger, which could lead to the source of a financial bubble.

Cat bonds are representative of the broader inclination for environmental problems to be addressed through market mechanisms and financialization. By exposing the process of turning environmental risks into financial values, the limits of financialization as a method of addressing environmental problems can be revealed. Therefore, this research can be representative and informative of other forms of financialization of environmental problems such as carbon permit trading or weather derivatives. The overall contribution of this research will be to reveal the process of developing cat bonds in order to expose them as a form of financialization, while also discussing some of the broader issues of transforming material problems into market values.

1.5 Research Question and Objectives

This thesis is guided by the following research objectives:

- To map the infrastructure and networks of catastrophe bonds to evaluate their function (as a form of financialization)
- To assess catastrophe bonds as a form of financialization through their decoupling of the spatial and temporal aspects of natural catastrophes
- To contribute to critical literature on catastrophe bonds by examining financialization as a tool for addressing environmental risks

How do catastrophe bonds represent a form of financialization that enables time-space compression?

2. Literature Review

2.1 Introduction

This chapter provides a review of the existing literature surrounding catastrophe bonds and insurance risk management through the lens of financialization. In order to comprehend the existing literature on catastrophe bonds, it is important to examine alternative insurance risk management techniques as well. This literature review will look at existing literature on reinsurance and risk management in the insurance sector in addition to catastrophe bonds.

First, a review of insurance risk management literature will be conducted in order to offer preliminary background knowledge on the purpose and state of the industry. The focus of this section of the literature review will be on typical insurance strategies such as reinsurance for managing risk in the industry. The implications of climate change on the insurance sector and risk management in the industry will then be discussed. To conclude this section, the convergence between insurance risk management and financial markets as it has been discussed in existing literature will also be reviewed.

Following the analysis of risk management literature, existing literature on catastrophe bonds will be explored. Cat bonds will be compared to reinsurance as an alternative form of risk transfer for the industry. The purpose, development, and financial benefits of cat bonds will also be discussed in this section.

After context has been provided through the previous sections, this chapter will then analyze the concept of financialization and time-space compression as the theoretical basis for this thesis. The concept of financialization and its societal effects will be described through existing literature. Then, the theory of time-space compression

through financialization will be analyzed and described through existing literature. This section of the literature review will offer the theoretical basis for a critique of catastrophe bonds. It will also describe the framework that will be used for the purpose of this thesis.

Finally, a review of the critical literature surrounding catastrophe bonds and the broader financialization of environmental problems will conclude this chapter.

2.2 Risk Management in the Insurance Industry

2.2.1 Risk Management and Reinsurance

Risk management is an essential element of almost any business model and operation (Dorfman, 1998; Banks, 2004). Individuals, families, and businesses all face potential losses from natural disasters or accidents which could affect homes, places of business, or finances. Dorfman (1998) defines risk management as "the art and science of anticipating the potential losses and developing an efficient plan to survive them" (p. 2). Insurance arrangements are the primary source of risk financing (Dorfman, 1998; Banks, 2004). Banks (2004) notes that "traditional forms of risk management- loss control, loss financing and risk reduction, arranged through insurance mechanisms- have been actively used by companies for many decades, and are an essential element of most corporate strategies" (p. 3). As risk management is an integral part of the operations of any corporation, it is central to the security and success of the insurance industry itself that it develops its own risk management strategies (Carter, 1999; Banks, 2004).

One of the central risk management strategies of the insurance sector has been reinsurance (Kramer, 1980; Carter, 1999; Patrik, 2006; Holland, 2009). Reinsurance is "legally an insurance contract; the reinsurer agrees to indemnify the ceding insurance

company, or cedant, for a specified share or specified types of insurance claims paid by the cedant for a single insurance policy or for a specified set of policies" (Patrik, 2006, p.1). Carter (1999) defines reinsurance as, "the insurance of contractual liabilities to pay claims incurred under contracts of direct insurance or reinsurance" (p. 5). More directly, reinsurance is indeed, insuring insurers (Kiln, 1981).

Reinsurance has been practiced for centuries (Kramer, 1980; Holland, 2009). In 1799, James Allen Park wrote, "Re-assurance, as understood by the law of England, may be said to be a contract, which the first insurer enters into, in order to relieve himself from those risks which he has incautiously undertaken, by throwing them upon other underwriters, who are called re-assurers" (p. 276). The modern global reinsurance industry developed in the 18th and 19th centuries (US Federal Insurance Office, 2014), with the first professional reinsurance company, Cologne Re, opening in 1846 (Holland, 2009). Reinsurance is a key aspect of insurance risk management strategies to this day. For example, in 2011, more than half of $116 billion of insured catastrophe losses were assumed by reinsurers (Swiss Re, 2013).

Reinsurance reduces the financial costs and risks of insurance companies and offers them a safety net (Patrik, 2006). By purchasing reinsurance, insurers limit their loss experience, increase their underwriting capacity, and are able to allocate their resources more efficiently (US Federal Insurance Office, 2014). In their 2012 report, the International Association of Insurance Supervisors identify the core business of reinsurers as "the reinsurance of peak risks originally assumed by primary insurers- i.e., risks with low probabilities of occurrence, but high severities" (p. 19). Purchasing reinsurance reduces the risk of bankruptcy for insurers by limiting their liability on particular risks,

protecting against catastrophes, stabilizing losses, and increasing capacity (Cummins, et al., 2008). Carter (1999) argues that reinsurance is not solely used to control retained claims costs, but is increasingly being used as a tool for financial management of insurers to manage their solvency margins, investment risks and tax liabilities.

Despite all of the noted benefits that reinsurance provides for the insurance industry, the reinsurance market is limited in its ability to cover all insurance risks as a result of their volatile prices and limited capacity (Cummins & Weiss, 2009). The reinsurance underwriting cycle poses difficulties for insurers in predicting future costs and managing risks. Cummins and Weiss (2009) describe this troubling underwriting cycle as, "alternating periods of soft markets, when prices are relatively low and coverage is readily available, and hard markets, when prices are high and coverage supply is restricted" (p. 494). In hard markets, reinsurers' capacity is reduced and the reinsurance prices rise, meanwhile, hard markets are generally when insurers have the greatest need for reinsurance (Cummins, et al., 2008). This transition to a hard market can aggravate insurers' crisis and result in further susceptibility to risks (Berger, et al., 1992). During soft markets, some insurers view reinsurance as risk-free profit and take advantage of cheap reinsurance prices and overriding insurance commissions (Carter, 1999). Under these conditions, insurers are acting as "a broker under another guise" (Carter, 1999, p. 11), as they are misrepresenting their coverage and leaving their policyholders reliant upon reinsurers, in addition to moral hazard issues (Carter, 1999). Moral hazard is defined as the "impact of insurance on the incentives to reduce risk" (Winter, 2000, p. 155), or similarly the "lack of incentive to take care is called moral hazard" (Varian, 2010, p. 724). Doherty and Smetters (2002) note that moral hazard risk increases in

intensity the greater the level of reinsurance. Based on these pricing, capacity, and moral hazard issues, reinsurance can be limited and pose problems for the insurance industry in their risk management strategies.

2.2.2 Climate Change and its Impacts on Insurance Risk Management

As climate change becomes an increasing threat, insurance companies have begun to reanalyze their risk management strategies (Leggett, 1993). In 1993, Leggett noted that the insurance industry was beginning to wake up to the threats that climate change posed for the profitability of their industry. The paper hypothesized three possible options for risk management in the insurance industry. First, it can hope that climate change will be a passing fad and ignore it. Second, it can begin to drastically increase insurance prices and reappraise arrangements with reinsurers to find more realistic ratings for increasing threats. Or third, it can begin to look at strategic protection for the insurance market by lobbying for greenhouse gas emission cuts (Leggett, 1993).

Most scholars would agree that the insurance industry has primarily chosen the second approach, by raising fees and considering alternative reinsurance agreements (Mills, 2007; Herweijer et al., 2009; Thistlethwaite & Wood, 2016). Mills (2005) argues, "insurers use traditional methods to reduce their exposures: increased premiums and deductibles, lowered limits, nonrenewals, and new exclusions" (p. 1042) and warns that treating climate change through these traditional measures will result in reduced willingness to pay and a shift away from the use of insurance. Herweijer et al., (2009) argue that the insurance industry's response to climate change has not focused on incentivizing risk reduction or adaptation strategies. Aside from a few cases, the insurance industry has not yet developed meaningful relationships with policy makers in

order to promote adaptation strategies or deter housing or business developments in geographically exposed areas (Herweijer et al., 2009). Herweijer at al., determine that insurers have primarily turned to investment opportunities and underwriting in addressing climate change risks, rather than playing a role in adaptation. Mills (2005) notes that fewer than one in a hundred insurers appear to have seriously examined the business implications of climate change. Mills argues that, "disjointed modeling traditions and inconclusive attribution analyses hamper the industry's ability to assess weather-related risks and regulators' ability to safeguard both insurers and consumers" (p. 1043). Thistlethwaite and Wood (2016) found that despite the incentives for the insurance industry to meaningfully incorporate climate change into projections and decision-making, there is insufficient evidence of any organizational change in the industry to address this.

Leggett (1993) warned that the problem with addressing climate change through traditional methods, such as increasing premiums and reappraising reinsurance arrangements, was that pricing climate change risks would be problematic and near impossible. This is primarily because the past no longer provides a glimpse into the future of risks because of the rapidness of climate change (Leggett, 1993). Scholars confirm this prediction, demonstrating that the insurance sector continues to underprice risk and base it on past historical records of natural disasters and weather hazards (Herweijer et al., 2009; Thistlethwaite & Wood, 2016).

Herweijer et al., (2009) argue that climate change poses a direct threat to the insurance industry as it undermines their financial stability. They maintain that the insurance industry's traditional view of risk based on historical records of hazards can

lead to significant near-term threats as new climate threats may differ from those of the past. Thistlethwaite and Wood (2016) give light to this argument, demonstrating that the insurance sector has indeed failed to meaningfully integrate climate change risk into its underwriting and investment practices and corporate governance. They argue that climate change could lead to non-linear changes in the frequency and severity of insurance claims as the models insurers use to assess risk mostly focus on present risk rather than anticipating climate trends in the future. Mills (2007) argues that most insurers are behind the curve when it comes to developing new products or services in response to climate change, with most focusing on financial risk management.

Many studies have been conducted which forward the business case for an incorporation of climate change adaptation and mitigation strategies into insurance practices. Herweijer et al., (2009) argue that adaptation to climate change is in the best interest of the commercial success of the insurance industry. They warn that if the industry does not incorporate climate change adaptation into its practices, the availability and affordability of private insurance will be threatened based on the insurability of risks. Kunreuther et al., (2013) further this warning through their analysis of the increased concentration of property and economic activity in hazard-prone areas, arguing that this concentration coupled with changes in climate patterns will restrict the affordability of insurance. In addition, increases in climate change disasters can lead to the risk of correlated losses, which could potentially bankrupt some insurance companies. Activities such as risk-based pricing, incentivized risk mitigation discounts and forming relationships with policy-makers offer reputational rewards and commercial success,

while also protecting the sustainability of the industry (Herweijer et al., 2009; Kunreuther et al., 2013).

Mills (2007) argues that climate change poses a direct threat to the profitability of the insurance industry, noting, "the combined effect of increased losses, pressure on reserves, inflation of construction costs following natural disasters, and rising costs of risk capital result in a gradual increase in the number of years in which the industry is not profitable" (p. 1042). The insurance industry would benefit economically by reversing its destructive industry practice of underpricing future risks (Mills, 2007). Botzen and Van den Bergh (2008) argue that climate change poses severe economic issues for the viability of the insurance industry, while demonstrating how social welfare could improve through the insurance industry's acknowledgement and action toward adapting to the risks posed by climate change.

While there appears to be a clear business case for the insurance industry to incorporate adaptive strategies into its practices, there are other scholars who note that the insurance industry operates under a contradiction, arguing that while the industry does suffer from natural catastrophe losses, these losses also keep their business thriving and pose financial benefits (Sturm & Oh, 2010; Grove, 2012; Johnson, 2015; Lehtonen, 2017). This argument will be further discussed in section 2.5.2 as an implication of financialization.

As the reinsurance industry has limited capacity, the insurance industry required new strategies for managing extreme risks such as climate change. These needs were addressed through the capital market and a convergence of insurance risk management and the financial market. The following section discusses this convergence in more detail.

2.2.3 Convergence of Insurance Risk Management and Financial Markets

Palley (2007) notes that the principal impacts of financialization are, "to (1) elevate the significance of the financial sector relative to the real sector, (2) transfer income from the real sector to the financial sector, and (3) contribute to increased income inequality and wage stagnation" (p. 3). Insurance and reinsurance can be prime examples for this transferring of income from the real sector to the financial sector through their consolidation with capital markets (Amel et al., 2004; Cummins & Weiss, 2009) and their role as intermediaries between the public and the financial sector (Greenwood & Jovanovic, 1990).

Over the past quarter century, there has been a convergence of the financial services industry and (re)insurance sectors, particularly in the property-liability insurance field (Cummins & Weiss, 2009). This convergence was driven by a number of factors, particularly, the growth in property values in areas prone to catastrophic risk, the volatile reinsurance underwriting cycle, and advances in communications and computing technologies, allowing for more accessible risk modelling and enhanced market transparency of risks (Cummins & Weiss, 2009). This convergence has led to the creation of hybrid insurance/financial instruments that combine financial contracts with reinsurance (Cummins & Weiss, 2009). While the primary method of risk transfer for insurers has been reinsurance (Kramer, 1980; Carter, 1999; Patrik, 2006; Holland, 2009), huge risks posed by natural catastrophes created a need for further risk coverage (Edesess, 2015; Cummins & Weiss, 2009).

Inefficiencies in the reinsurance market are arguably the primary driver for the development of alternative risk transfer (ART) and the integration of capital market instruments (Nell & Richter, 2004; Cummins & Weiss, 2009). ART refers to contracts,

solutions or structures that enable firms to finance or transfer their exposed risks in a non-traditional way (Culp, 2005). Culp (2005) describes ART as, "all about "convergence"- the convergence of capital markets and insurance, the convergence of corporate finance and risk management" (p. 1). ART allows insurers to transfer risks to another party or to capital market investors and receive financial protection against certain risks the transactions aim to cover (Artemis, 2017d). Hybrid ART products incorporate elements of financial instruments and reinsurance, and include products such as: finite reinsurance, sidecars, industry loss warranties, and multiple-trigger products (Cummins & Weiss, 2009). These hybrid products extend the capacities of traditional reinsurance and demonstrate the beginning of a convergence between the insurance market and the financial market (Cummins & Weiss, 2009). However, as this convergence has continued to grow in success, the reinsurance aspect has been dissolved from some products, and new risk management tools have been developed which access capital markets directly (Cummins & Weiss, 2009). The primary and most successful capital market insurance instruments or insurance-linked securities (ILS), are catastrophe (cat) bonds, which will be discussed in detail in the next section of this literature review.

2.3 Catastrophe (Cat) Bonds

2.3.1 Purpose and Development

As discussed in section 2.2.3, there has been a convergence of the financial market and insurance risk management of property liability (Cummins & Weiss, 2009). While reinsurers have typically covered insurance risk, risk sharing has now expanded past reinsurers, reaching to the global financial market (Phillips, 2014). Insurance-linked securities (ILS) are a type of ART in that they transfer particular risks to capital market investors. ILS are defined as, "financial instruments which are sold to investors whose value is affected by an insured loss event" (Artemis, 2017c). The most prominent type of ILS is the cat bond (Cummins, 2012; Panko, 2013; Nguyen & Lindenmeier, 2014), which is a fully collateralized financial instrument, which pays off on the occurrence of a particular catastrophic event (Cummins, 2012). Edesess (2015) explains that the purpose of cat bonds are to "crowd-source reinsurance coverage, in order to reduce reinsurers', insurers', and self-insurers' reserve requirements and reduce their cost of coverage" (p. 1).

Following severe natural disasters in the early 1990's, a lack of financial capacity in the reinsurance market was generated, sparking the need for innovative products that could diversify insurance risk (Loubergé et al., 1999). Cat bonds allow for this diversification as they access the capital market directly and find reinsurance coverage through global investors. Phillips (2014) argues, "the only pool of cash large enough to underwrite such losses lies in capital markets- the collection of big investors like pension funds, hedge funds, and sovereign wealth funds that normally invest in stocks and bonds" (para. 4). While correlated losses in the billions could bankrupt insurers, or even

reinsurers, these extreme losses would hardly affect the global financial market (Phillips, 2014), whose 2016 market capitalization was 68 trillion (World Bank, 2016).

Cat bonds were developed in order to spread excess risks more widely among investors internationally (Loubergé et al., 1999). Nell and Richter (2004) argue the existence of cat bonds is owed to their ability to close the capacity gap of insurance supply and to address imperfections in the reinsurance market. The reinsurance underwriting cycle of alternating hard and soft markets created uncertainties in insurers seeking coverage in a period of unease over increasing natural catastrophe events (Nell & Richter, 2004; Cummins & Weiss, 2009; Edesess, 2015). Cat bonds "shelter the sponsor from cyclical price fluctuations in the reinsurance market" (Cummins 2012). They allow insurers to bypass the volatility and limited capacity of the reinsurance market and raise risk capital directly from the global market (Cummins, 2012).

Unlike traditional reinsurance, which usually only provides coverage for a one year period, cat bonds can have multiyear protection (Cummins, 2012), generally up to three years (Phillips, 2014). While reinsurance runs the risk of defaulting, cat bonds are fully collateralized (Trottier & Son Lai, 2015). Cat bonds provide reinsurance coverage for ceding companies that traditional reinsurers often refuse to insure. "High layers" of reinsurance protection, or those events that have lower probability of occurrence and higher estimated damage losses, are often not covered by reinsurers (Cummins, 2012). Cummins (2012) argues that the reason these higher layers of protection often go without reinsurance is because, "1) for events of this magnitude, ceding insurers are more concerned about the credit risk of the reinsurer, and 2) high layers tend to have the highest reinsurance margins or pricing spreads above the expected loss" (p. 5). These

concerns do not apply to cat bonds as they are fully collateralized, thus eliminating credit risk concerns. In addition, cat bond pricing for high layer protection is often lower than reinsurance as the bonds are attractive to investors for diversification purposes (Cummins, 2012). In general, however, cat bond prices are competitive with traditional reinsurance as spreads are comparable to the cost of reinsurance for similar layers of coverage (Cummins, 2012).

Cat bonds have also been noted to reduce moral hazard (Nell & Richter, 2004; Cummins, 2008). The payoff from cat bonds come from assets in a trust, therefore, "the bond sponsor retains a strong interest in the quality of the assets backing the bond" (Cummins, 2008, p. 5). In addition, in the case of index-triggered bonds, the pay-off from cat bonds can be based on an underlying stochastic which cannot be heavily influenced by the buyer, therefore reducing the risk of moral hazard. With traditional reinsurance, the insured can influence loss distributions (Nell & Richter, 2004). However, this finding is disputed in the literature, with other scholars arguing that moral hazard risk is significantly smaller for reinsurers as they are more easily able to monitor insurers as they generally have a relationship with the insurer, whereas cat bond investors have a much more limited ability for surveillance due to their having no personal or business relationship with insurers (Nguyen & Lindenmeier, 2014; Trottier & Son Lai, 2015).

Cat bonds allow insurers to expand their underwriting capacities for catastrophe risks while offering high returns for investors and clear and unambiguous payment terms (Nguyen & Lindenmeier, 2012). For insurers, cat bonds allow them to spread their risks throughout the marketplace, rather than solely depending on reinsurers (Loubergé et al., 1999; Nell & Richter, 2004). For investors, cat bonds are attractive as they offer

diversification to their portfolio, they are uncorrelated to the broader financial market, and are fully collateralized (Cummins, 2008; Phillips, 2014). Cummins (2008) argues that cat bonds are innovative financial vehicles that have an increasingly important role to play in financing catastrophes due to their direct access to capital markets.

Cat bonds have also been touted as an especially helpful tool for future use in developing countries through their ability to transfer catastrophe risk from government to the private sector (Phillips, 2014). Cat bonds can "give developing countries an opportunity to use financial mechanisms to proactively manage the risk of economic loss from extreme weather events through risk transfer" (Bennett & Smyth, 2016, p. 254). For example, in June 2014, the World Bank issued a catastrophe bond on behalf of a private climate risk insurance company, which covers some of the economic risks of earthquakes and tropical cyclones in sixteen Caribbean countries (Bennett & Smyth, 2016). This bond demonstrates the potential for cat bonds in the developing world as it could enable third world governments to transfer some of their economic risk to capital market investors globally (Bennett & Smyth, 2016).

Cat bonds provide insurers with excess risk coverage as natural catastrophe risk continues to grow as a result of climate change (Van Aalst, 2006; López Vega et al., 2015; Phalkey & Louis, 2016). These bonds address the limits of the reinsurance market and diversify insurance risk (Loubergé et al., 1999; Nell & Richter, 2004; Cummins, 2012). Cat bonds allow insurers to expand their coverage while providing financial incentives for capital market investors (Cummins, 2008; Nguyen & Lindenmeier, 2012). The next section of this literature review will look at the popularity of cat bonds, their success in the market and predictions for future growth in the industry.

2.3.2 Success and Future Outlook

The cat bond market has become a steady source of capacity for insurers and reinsurers and has continued to see steady growth since 2009 (Cummins, 2008; Edesess, 2015). The outstanding cat bond market size at the end of the first-quarter of 2017 is $27.19 billion, the largest ever, with $2.76 billion issued in the first-quarter of 2017 (Artemis, 2017a). This marks the strongest opening quarter, in terms of new risk capital issued, since the inception of ILS approximately 20 years ago, and is the fourth first-quarter in a row to beat issuance records (Artemis, 2017a). The cat bond industry is very popular and continually gaining ground. In fact, in 2013, demand for the bonds even exceeded supply (Lewis, 2014; Edesess, 2015). The rates of return on cat bonds have averaged 7-9% annually since 2002 (Edesess, 2015). Cat bond defaults have been very rare, with only twelve defaults in total from 1990 to 2013, four of which were a result of the Lehman bankruptcy (Edesess, 2015).

Although they have extremely poor credit ratings as a result of their high risk, cat bonds have become incredibly popular for investors (Phillips, 2014). They offer high rates of interest and permit investors to profit even at times of market decline due to their separation from the wider stock and bond markets (Phillips, 2014). Edesess (2015) argues that the reason the cat bond market is likely to remain very attractive to investors in the long-term is owed to the fact that the bonds are uncorrelated with the broader market, "namely the risk of equity market fluctuations, credit risk, and interest rate risk" (p. 7). As the risks of natural catastrophes are generally uncorrelated with risks in the economy, cat bonds allow investors to diversify the risk of their portfolios (Phillips, 2014; Edesess, 2015). Cat bonds are one of very few assets investors can add to their portfolios that are

uncorrelated to the broader financial market, offering them significant diversification benefits (Lewis, 2014).

Panko (2013) argues that what significantly sold investors on cat bonds was the financial crisis of 2008. While the financial market crashed, the cat bond market was stable and the prices stayed resilient (Panko, 2013). In addition, the liquidity of the cat bond market also allures investors, as they can easily trade the bonds through "live cat-bond trading" in the event they may change their mind or get cold feet (Panko, 2013; Phillips, 2014). Panko (2013) and Lewis (2014) explain the success of the cat bond market as a result of the offer of compelling returns and transparency, especially with recent touted improvements in climate modelling. In addition, "cat bonds have only modest costs of acquisition, monitoring, and loss adjustment, which are usually quite considerable in insurance markets" (Nell & Richter, 2004, p. 185). This has also contributed to their popularity as an alternative to reinsurance.

Although awareness of the risks that climate change poses for increases in natural catastrophes is growing, there have been few catastrophic events in the past decade (Phillips, 2014). This has allowed for losses on catastrophe bonds to be rare so far, thus increasing investor interest in the bonds (Phillips, 2014). Returns on cat bonds have continued to be high for investors and very few cat bonds have been triggered (Edesess, 2015). Only 13 of over 400 cat bonds have reached their triggering events and required claims payments (Artemis, 2016b). Of these 13 bonds, only one resulted in a loss payment being delayed, while the remainder paid out in a timely manner, similar to payments made by traditional reinsurers (Artemis, 2016b). As the bonds are fully collateralized, insurers were able to receive their payments quickly and without issue,

thus increasing insurer confidence in the bonds as an alternative to reinsurance (Artemis, 2016b). The increased use of indemnity triggers has also prompted increased confidence for insurers in cat bonds. As indexed cat bonds can result in imperfect risk allocation as they are based on variables not identical with the actual losses to be covered, insurers face basis risk, or a variance between the price of losses and the price of coverage (Nell & Richter, 2004). An indemnity trigger signifies that the bond pays out on the insurer's actual loss, which is typically the same trigger type used for traditional reinsurance coverage. Through the increased use of indemnity triggers, calculations of basis risk are negated and insurers can feel sure of full losses being covered (Panko, 2013).

The cat bond market is predicted to see increased growth in the coming years (Phillips, 2014; Edesess, 2015). Companies outside of the insurance realm as well as the public-sector have begun to become involved in the trading and issuing of cat bonds, with the New York Metropolitan Transit Authority and the Mexican government issuing their first cat bonds in the last few years (Phillips, 2014). While the majority of the cat bond market remains focused on the global north, the bonds are beginning to be investigated internationally and touted as a state solution for climate resilience in developing nations (Phillips, 2014). Experts have also considered Beijing as the next route for cat bond development based on their annual losses from extreme weather events (Phillips, 2014). Cummins (2012) argues that, "cat bonds make sound economic sense as a mechanism for funding mega-catastrophes" (p. 10) and predicts with certainty that the market will continue to grow, eventually seeing issuance in the public securities market rather than confinement to private placements.

Despite predictions for the future success of the market, the benefits of cat bonds are dependent on the accuracy with which environmental risks are modelled. The following section explores catastrophic risk modelling.

2.3.3 Catastrophe Risk Modelling

Traditional insurance risk modelling follows a stochastic process where present or future risks are based on fluctuations observed in historical data (Daníelsson, 2002). Stochastic modelling attempts to reproduce possible scenarios or outcomes by randomly simulating numerous possible outcomes based on historical event data (Wild & Hockman, 2007). Ermoliev et al., (2000) explain, "traditional insurance operates on the assumption of independent, frequent, low-consequence (conventional) risks, such as car accidents, for which decisions on premiums, estimates of claims and probability of ruin can be calculated by using rich historical data" (p. 207). Classical stochastic modelling is strongly based on small and frequent events, rather than taking extreme-events into account (Embrechts & Schmidli, 1994). Ermoliev et al., (2000) argue that insurance runs on a "more-risks-are-better" (p. 208) approach, with more numbers of independent risks in insurance portfolios leading to lower variance of aggregate claims, lower premiums, and higher demands for insurance, increasing stability in the industry. Stochastic modelling allows for the forecasting of smaller and more frequent events, however, these stochastic risk models provide little guidance in times of crisis or catastrophe (Daníelsson, 2002).

Large catastrophic events such as the Northridge earthquake and Hurricane Andrew cost the insurance industry billions of dollars and illustrated the potential vulnerability the industry faced from potential major catastrophes (Cummins et al., 2002).

These rare catastrophic risks require new approaches to risk modelling in the insurance industry as "catastrophes produce heavy losses highly correlated in space and time, which depend on the clustering of regional values and on geographical patterns of catastrophes" (Ermoliev et al., 2000, p. 208). The "more-risks-are-better" strategy could increase the probability for insolvency for insurers as higher exposure to similar losses increase the risks of correlated losses based on catastrophes (Ermoliev et al., 2000). The time and space correlations of natural catastrophes call into question the use of stochastic modelling and emphasize the importance of new modelling tools "that account for the complexity implied by the manifold dependencies in the stochastic process of catastrophic events, decisions and losses" (Amendola et al., 2000, p. 381). Future potential losses at particular locations may be unlike anything experienced in the past, indicating the ineffectiveness that historical data provides for catastrophic risks and highlighting the issues with stochastic modelling in forecasting catastrophic losses (Ermoliev et al., 2000). Based on the limitations of stochastic modelling, "so-called catastrophe modeling is becoming increasingly important to insurance companies as they make decisions on catastrophe coverages, premiums, reinsurance agreements, and the effects of mitigation measures" (Ermoliev et al., 2000, p. 208).

In the late 1980's, two separate developments for measuring catastrophes came together through catastrophe modelling. These two developments were mapping risk and measuring hazard (Grossi et al., 2005). Catastrophe models link the stochastic process of studying historical occurrences with new information technology, geographic information systems, and scientific studies of natural hazard measures (Grossi et al., 2005). As catastrophe modelling developed, three major modelling firms emerged, AIR Worldwide,

Risk Management Solutions (RMS), and EQECAT (Grossi et al., 2005). As insurers became more aware of their vulnerability to catastrophe risk, many began to turn to these catastrophe modellers for support in pricing their policies and determining the amount of coverage they should offer in hazard-prone areas (Grossi et al., 2005).

Catastrophe models are "essentially computer-based systems for measuring anticipated disaster losses, whose outputs are derived from various scientific assumptions. They do so by identifying and quantifying the likelihood of occurrence of specific events in a particular location and estimating the extent of potential losses" (Joyette et al., 2015, p. 473). Typical catastrophe models consist of four components: event module, hazard module, vulnerability or exposure module, and loss or financial module (Grossi et al., 2005; Joynette et al., 2015; Van Leer, 2015). The event module "incorporates data to generate thousands of stochastic, or representative, catastrophic events. Each kind of catastrophe has a method for calculating potential damages taking into account history, geography, geology" (Van Leer, 2015, para. 7). The hazard module determines the level of anticipated hazards, areas of occurrence, frequency and severity and, "characterises the risk of natural hazard phenomena and generates an estimate for each area within the affected location" (Joynette et al., 2015, p. 474). The vulnerability or exposure model assess the level of damage the hazard may have on insured properties (Joynette et al., 2015; Van Leer, 2015). Finally the loss or financial model translates the vulnerability or exposure model into estimates of monetary loss for the insurer (AIR Worldwide, 2012).

Catastrophe models are presented to insurers through model outputs by quantifying data and presenting it in a useful way to stakeholders (Grossi et al., 2005).

These metrics are used to inform insurance rates and underwriting guidelines, analyze existing policies, and help to make decisions regarding the purchase of reinsurance or cat bonds (AIR Worldwide, 2012). AIR Worldwide (2012) notes that catastrophe models do not determine insurance companies rates as catastrophe risk is only one input and does not account for operational expenses, profit margins, or other external factors. However, as cat bonds are created solely to cover catastrophe risks, catastrophe modelling is a crucial factor in pricing the bonds based on projected possible losses (Lane & Mahul, 2008; Bodoff & Gan, 2009; Braun, 2014; PartnerRe, 2015). Braun (2014) argues that expected losses, which are determined through catastrophe models, are the most important factor in the pricing of cat bonds. Catastrophe modelling is continuing to grow in popularity within the insurance industry as awareness of the risks of climate change continues to grow (RMS, 2008) and as the cat bond market sees continued success (Edesess, 2015). Governments and maturing markets such as China and India have also begun to make use of catastrophe modelling as they recognize their catastrophe risks (AIR Worldwide, 2012).

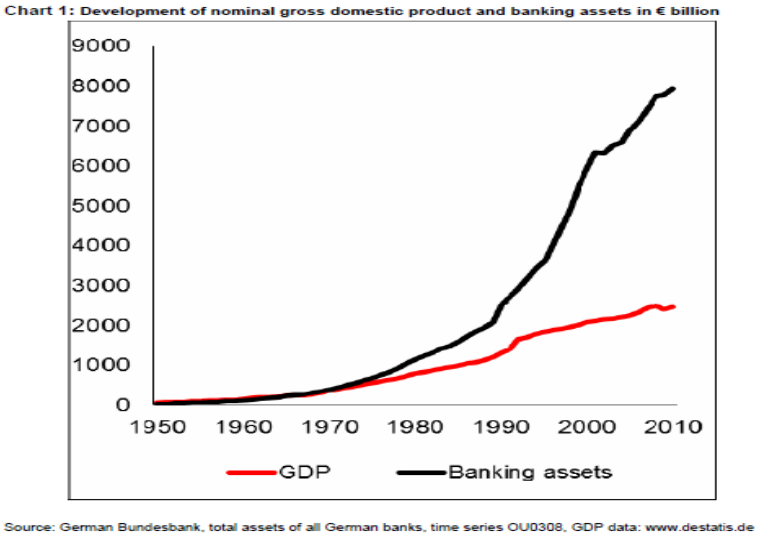
2.4 Theoretical Literature

2.4.1 Exploring Financialization Conceptually

The origins of the term 'financialization' are unclear, although it began to appear frequently in the early 1990's (Foster, 2007). Foster (2007) notes that the current usage of the term 'financialization' owes much to the work of Kevin Phillips, who devoted a chapter of the book, *Arrogant Capital,* to the 'Financialization of America', where he defined financialization as "a prolonged split between the divergent real and financial economies" (Phillips, 1994, p. 82). Figure 3 below illustrates this split by comparing banking assets with GDP and exposing a gross incongruity between the two.

Financialization generally refers to the pervasive and growing role of finance in the economy (Epstein, 2005; Luo, 2017; Van der Zwan, 2014). Van der Zwan (2014) explores studies of financialization and argues that these studies "interrogate how an increasingly autonomous realm of global finance has altered the underlying logics of the industrial economy and the inner workings of democratic society" (p. 1). Financialization has been conceptualized as a new regime of accumulation, a guiding principle of corporate behaviour, and a central feature of everyday life (Van der Zwan, 2014). While capitalism has been largely associated with a trio of terms: neoliberalism, globalization, and financialization, the latter is often given the least attention, yet is increasingly seen as the dominant force in this triad (Foster, 2007).

Figure 3: Development of GDP and Banking Assets



(German Bundesbank, www.destatis.de).

While there is no universal agreement on a particular definition of financialization, for the purpose of this thesis, I will be referring primarily to Knox-Hayes' (2013) definition of financialization as:

> "The process of reducing value that is exchanged into financial instruments or derivatives of financial instruments. Financialization is intended to accelerate the rate of profit accumulation from the exchange of financial instruments. As such, I conceptualize financialization as an extension of the conversion of use to exchange value in commodification" (p. 120).

Knox-Hayes (2013) argues that financialization is a trend based on the increasing role of financial processes and actors in the economy and involves the process of making profit from financial channels rather than trade and commodity production. Over the years, there have been varying definitions and progressions in defining financialization. Knox-Hayes' definition is a progression from other definitions, highlighting the transition from use value to exchange value. Krippner (2005) defines financialization as "a pattern of accumulation in which profits accrue primarily through financial channels rather than through trade and commodity production" (p. 175) and argues that financialization is the

key development in the US economy in recent decades. Epstein (2005) similarly defines financialization as "the increasing role of financial motives, financial markets, financial actors, and financial institutions in the operation of domestic and international economies" (p. 3). Lapavitsas (2011) outlines the specific features of how financialization has affected and altered the behaviours of corporations, banks, and the individual. Through financialization, large corporations have reduced their reliance on banks, banking institutions have expanded their lending practices and mediating activities, and households and individuals have become increasingly involved in financial operations. In this sense, financial markets have transformed, spreading away from banking institutions and beginning to pervade all other aspects of society, including corporations and the individual. Lapavitsas posits financialization as a symptom of mature capitalist economies resulting in systemic transformation.

Similarly, Davis (2009) argues that financialization has led to a transition from a society relying on organizations such as banks and large corporations, to a "portfolio society" (p. 40), where individuals are deeply connected to financial markets through the expansion of the retail sector of banking. Davis (2009) articulates this shift from the "organization man", those whose worldview and lifestyle depended on their job, to the "investor", those who buy and sell capital daily. Individuals no longer leave financial matters at the bank or at work, but rather, financial values pervade almost every aspect of their lives and decisions (Davis, 2009). Davis illustrates this transition through households, as home purchases are now considered investments, with buyers making their home decision based on future price increases. In another example, careers or educational decisions are now made based on future salary expectations and the state of

the market (Davis, 2009). Individuals are expected to act as investors and incorporate the financial market into their everyday decisions.

The emergence of financialization in the economy is believed to be the result of a surplus in production that could not be absorbed by the economy, resulting in the slowing of capital accumulation (Luo, 2017; Magdoff & Foster, 2014). By expanding the financial sector and increasing capital through the rise of the elite, this economic surplus could be absorbed and the economy would be stimulated (Baran & Sweezy, 1966; Magdoff & Sweezy, 1983). However, this expansion of the financial sector has seen unparalleled growth, diminishing the importance of use value and increasing the importance of financial speculation and exchange value (Luo, 2017).

In an article by Sawyer (2013), two common perspectives of financialization are evaluated in an attempt to distinguish between different meanings of the term. The first perspective relates financialization to the overall growth and expanding power of the financial sector throughout history, while the second looks at financialization as a specific modern stage of capitalism in which finance has become a dominant force. Luo (2017) couples the first conceptualization of financialization with neoclassical economics as these scholars tend to think of financialization as not exclusively occurring within capitalism, but rather, existing throughout all of human history. Luo also rejects the idea that financialization is a unique feature of capitalism, but rather, sees it as a result of changes in the monetary system and an embodiment of late modernity. In this article, financialization is conceptualized as an unintended consequence of the collapse of the Bretton Woods system and the transition from commodity money to credit money rather than a specific symptom of capitalism.

For the purposes of this thesis, whether or not financialization is a direct symptom of capitalism or a result of the growth of the financial sector is not at the heart of this definition. Similarly, this thesis will not focus on this debate or condemn capitalism as the driving force of financialization, but rather, it will consider financialization as the increasing role of financial institutions and motives and the diminishing importance of use value over exchange value.

2.4.2 Critics of the Impacts of Financialization

The emergence of financialization has given rise to many critics. Opponents of financialization critique it from a variety of perspectives: arguing that it leads to economic collapse: it is a leading contributor to social inequality: or it is a significant factor in the devaluation of the natural environment. This section will provide an overview of the common critiques of financialization through an analysis of some normative, empirical and theoretical critical literature on the subject.

One of the major critiques of the financialization of the economy has been that it leads to systemic economic crisis. Following the 2008 financial crisis, these criticisms intensified. Arrighi (2007) identified financialization as the leading force of recession and depression in the economy. Financialization transforms the global economy by moving away from material accumulation and towards financial expansion. This financial expansion leads to crises of over-accumulation, resulting in increases in the amount of cash held by large corporations. At the same time, the expansion of the retail sector of the financial industry leads to increased credit lending and the accumulation of debt for the general population. This over-accumulation of businesses coupled with the increasing debt of the population leads to economic recession and crisis (Arrighi, 2007; Arrighi &

Silver, 2001). Plys (2014) also found that financialization is associated with and precedes financial crisis through the declining rate of profit which occurs in the financialized global economy. Financialization creates assets out of financial channels rather than raw material goods. This deters speculation and results in the unlimited creation of new asset streams (Leyshon & Thrift, 2007). This ability results in lenders creating new classes of assets and fuelling the expansion of debt through increased credit lending based on debt accumulation rather than earnings or increased income (Leyshon & Thrift, 2007; Davis & Kim, 2015).

This increased credit lending and debt accumulation has been considered a leading contributor to the subprime mortgage crisis that began in 2007. The unsustainable growth and expansion of the financialization of the economy based on unlimited asset creation and financial expansion led to a collapse of the market (Demyanyk & Van Hemert, 2011). This subprime market collapse is illustrative of the inherent problems of financialization, as rapid market growth and expansion of financial processes result in unlimited asset creation, lower underwriting standards, and debt accumulation (Demyanyk & Van Hemert, 2011). Davis (2010) argues that the mortgage meltdown was the result of the tie between the financial system and the general population,

> "The mortgage bubble was just one part of a broader shift in the economy toward a finance-centered system that ties the fates of households, businesses and governments to the vagaries of financial markets through the device of securitization- packaging capital assets (essentially any claim on future cash flows) into tradable securities" (p. 75).

The subprime mortgage crisis demonstrates how financial systems pervade families and households, transforming the general public into investors and issuers (Davis, 2010). Through mortgages, credit loans, and insurance, the lives of the general public are

entangled in the financial system and households become investments. Financialization creates value out of future credits rather than commodities, blurring the boundary between real materials and financial assets (Luo, 2017). The growing influence of the financial system over every aspect of society creates misrepresentations of value and can lead to unsustainable growth and financial crisis (Davis, 2010; Leyshon & Thrift, 2007; Davis & Kim, 2015).

Financialization is also seen as a leading contributor of social inequality and polarization. Walks (2014) argues that financialization creates rising levels of household debt. It does so by transforming the citizen into the investor and engaging households in the financial market. Households are then encouraged to take on financial commitments by taking out mortgages and credit loans. The financial system's pervading influence on the household has created an increase in the number of loans and debt (Walks, 2014). The distribution of household debt is regressive with respect to income and exacerbates class differences. Walks (2014) links financialization to driving debt levels by arguing that migrants or younger generations trying to enter the housing market are forced to take on significant debt in order to afford housing, which in turn, drives debt levels and further increases the price of housing. In this sense, financialization increases debt and income inequality, reproducing socio-spatial class relations (Walks, 2014). Davis and Kim (2015) also argue that financialization is a driving force for social inequality as it forces financial markets into areas where they were previously absent and pervades all aspects of social life. Financialization transforms debt into marketable securities, incentivizing lower underwriting standards and undervaluation (Davis & Kim, 2015). Financialization has resulted in a transformation of the population from savers to borrowers, with the lowest

class being forced to borrow most with the least sources for repayment (Hodson et al., 2014).

A final critique of financialization, and the critique most relevant to this thesis research, involves the devaluation of use value that occurs in the financialization of the economy. Marx originally identified this devaluation through his formula of capital in which money is invested and profit is generated, eliminating the commodity step (Marx & Nicolaus, 1973). For Marx, capital meant converting use value into potential exchange value, thus diminishing the value of labour. Critics argue that financialization creates economic growth that is not grounded in real productivity growth (Bryan & Rafferty, 2006; Leyshon & Thrift, 2007). In other words, through financialization, the potential exchange value is no longer representative of use value. Knox-Hayes (2013) expresses this view of financialization, arguing that it leads to the distortion of material values by abstracting commodities from their real space and time. Financialization treats future use value as present value. Knox-Hayes (2013) argues that, "financialization reduces material resources to financial exchange value and information, while simultaneously divorcing the resources from their materiality" (p. 120). As the importance of financial activities grows in society and drives profits, exchange value becomes more important and increasingly abstracted from use value (Knox-Hayes, 2013). Castree (2003) similarly argues that financialization can result in the physical and temporal materiality of natural systems being ignored through their evaluation in financial markets. Leyshon and Thrift (2007) critique financialization by arguing that it deters speculation, as it is entirely dependent on the constant search for new asset streams and makes it possible to use anything as a platform for financial activity. They argue that this process of transforming

anything into a financial representation compresses space and time representations. Thus, the real values which are supposed to be represented by exchange values have been abstracted to such an extent, that they are no longer representative (Leyshon & Thrift, 2007; Bryan & Rafferty, 2006).

2.4.3 Time-space Compression

The connection between financialization and a compression or misrepresentation of space and time dates back to 1989 with David Harvey's time-space compression concept. This concept was used to refer to how capitalism and financialization have changed our relationship to time and space. Harvey (1989) argues that the acceleration of economic production and circulation of capital has led to a disassociation with spatial and temporal aspects and materiality. The rate that capital is moved around globally is accelerated to such a degree that it is almost non-existent, thus compressing temporal and spatial reality (Harvey, 1989). Harvey (1989) argues that capitalism has "annihilated space by time" (p. 294) and that diminishing spatial barriers alter perspectives and exploit spatial differentiations.

Geographers have studied the concept of time-space compression as a result of globalization and the 'shrinking world' through transport technologies including physical transport such as trains or planes, and network transport such as the telephone or the Internet (Vance, 1986; Whitelegg, 1993; Brunn & Leinbach, 1991; Kirsch, 1995). Through these new technological advances, time and space are 'collapsed' or reimagined (Brunn & Leinbach, 1991). Warf (2011) argues,

> "Time-space compression subsumes not only physical movement through space and time, but also how people experience these dimensions symbolically, that is how people's understandings of the world and their interactions over the earth's surface are reconfigured, not simply one of measuring time or conquering distance but of the social construction of temporality and spatiality" (p. 148).

This conception of time-space compression moves away from strictly geographical notions, and towards how conceptions of space and time are altered through the rapidity of the capitalist system and economics (Warf, 2011). As Harvey (1989) noted, capitalism faces an endemic problem of overproduction, and thus must constantly expand in order to deal with its endless accumulation. The endless search for new markets results in economic, political, social and cultural upheaval as time and space are continually destroyed and re-imagined (Warf, 2011). Warf argues, "in the context of contemporary capitalism and globalization, industrial capital has been largely supplanted by financial capital, with unprecedented spatial mobility. Financial capital's ability to flow effortlessly across the globe gives it enormous abilities" (p. 150). The financial market dislocates places from their spatial elements, and instead, embeds places based on processes or activities (Warf, 2011). Warf gives the example of how "decisions made by financial managers in New York affect the lives of millions of people in locations as distant as East Asia" (p. 151). As these financial spaces are not evenly distributed across the Earth, these spatial complexities are more representative of the powerful, resulting in unevenly connected chains, which reinforce existing geographies of power (Warf, 2011).

Knox-Hayes (2013) refers to time-space compression as the process of valuing social space and time over physical space and time. The increasing emphasis on exchange value over use value liberates the existence of value from present space and real time.

Financialization reduces material values into financial exchange values, thus removing these values from their spatial materiality.

This connection between financialization and the compression of space and time will be a primary point of analysis for this thesis and offer a theoretical basis for the research on catastrophe bonds.

2.4.4 Conceptual Framework: Mechanisms of Financialization

The conceptual framework that will be used in this thesis is derived from a concept by Castree (2003) and demonstrated by Knox-Hayes (2013). Castree identifies three mechanisms of financialization from the perspective of space and time: *privatization through ownership, individuation through commensuration, and displacement through mobilization* (Castree, 2003).

Privatization through ownership refers to how something is commodified through ownership and legal definition of credit. This first step in the process of financialization and commodification involves privatization, referring to "the assignation of legal title to a named individual, group or institution. The title gives more-or-less exclusive rights of the owner to dispose of that which is named by the title as they wish" (Castree, 2003, p. 279). Privatization is a precondition for commodification in that things cannot be exchanged unless they belong to different parties that are able to alienate them and use them for exchange. Castree (2003) argues that, "privatization is thus as much about control over commodities- prior to, during and after exchange- as it is about ownership in the technical, legalistic sense" (p 279).

Individuation through commensuration refers to the liquidity process, or the conversion of assets into cash. This second step in the process of financialization and

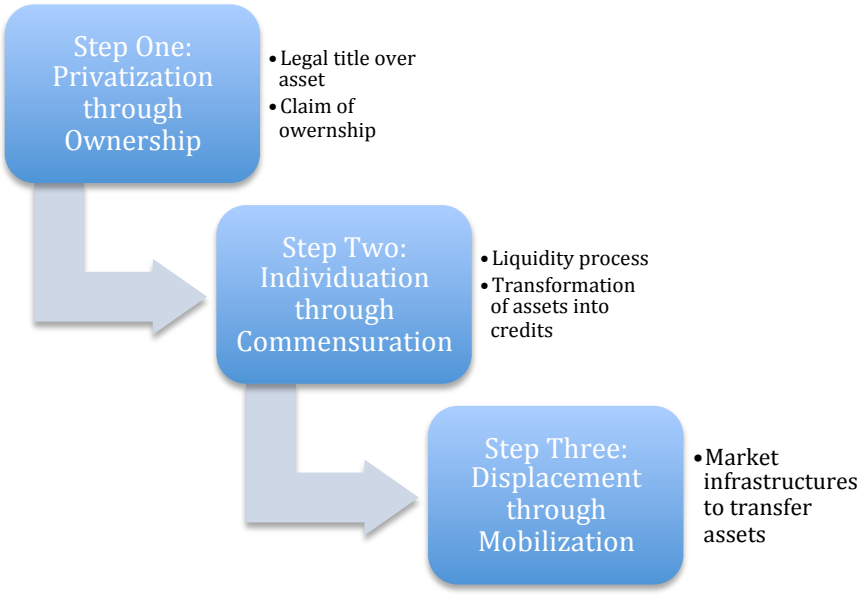
commodification involves the liquidity process, or the conversion of assets into cash. Castree (2003) describes this process as, "putting legal and material boundaries around phenomena so that they can be bought, sold and used by equally 'bounded' individuals, groups or institutions (like a firm)" (p. 280). Individuation is necessary for commodification as credits can only be exchanged if they are given a transferable value. This step of the financialization process involves transforming assets into credits that can be owned and traded. Knox-Hayes (2013) explains the commensuration process as it, "defines a metric of evaluation and simplifies the variables used to calculate the exchange value of the resource and equivalencies; this defines the standard" (p. 123).

Displacement through mobilization refers to the exchange process. In the case of cat bonds, this refers to the securitization and selling of the cat bond securities. This third stage in the process of financialization and commodification involves the process of exchange based on mobility. While resources are embedded to a specific time and place, transforming resources into a financial representation enhances their mobility. Knox-Hayes (2013) explains, "mobility requires the conversion of the products from materials to information. The greater the extent that the product is composed of information the greater its reach or ability to be mobilized and accessed in different places and across time" (p. 125). In order to transform a product from material to information, it is represented by an electronic certificate that "can be accessed from the portals of traders all over the world" (Knox-Hayes, 2013, p. 125). In order for this to occur, there need to be market infrastructures that can connect and facilitate trades. This process of exchange through market infrastructures displaces resources from their real spatial and temporal

aspects and allows for "tremendous spatial and temporal mobility" (Knox-Hayes, 2013, p. 123).

Figure 4 below illustrates this process of financialization through the three steps. I will use these three mechanisms of financialization as a framework for cat bond analysis in order to map the processes and actors involved under each mechanism. By analyzing cat bonds through each of these mechanisms, I will break down the actors and procedures involved in creating and selling cat bonds while exposing them as a form of financialization that enables time-space compression.

Figure 4: Three Mechanisms of Financialization



2.5 Critical Literature

2.5.1 Critiques of Catastrophe Bonds

While the success and growth of the cat bond and ILS market is often viewed as a positive development for managing risk, there are many critics of these tools who doubt their ability to adequately address climate change risks, question their function on ethical grounds, or attribute their development to increased systemic risk.

Duus-Otterström and Jagers (2011) take a normative stance against climate insurance tools such as cat bonds, arguing that the most vulnerable are those least likely to be insured through this system. They demonstrate that climate insurance tools leave the poorest, low-emitting countries responsible for paying the highest premiums based on their exposure to risk. The poorest regions are those most at risk for climate disasters, despite the fact that they have contributed least to climate change in terms of CO2 emissions. Climate insurance tools leave these most vulnerable populations to pay the most for financial protection and result in innocent parties co-financing the costs of environmental risks that wealthy nations have imposed on them. Tools such as cat bonds are designed to transfer wealth from those most at risk to investors, usually in the North. If cat bonds begin to be used in developing nations to manage risk, their use would result in a transferring of wealth from the south to the north and further perpetuate wealth disparities.

Phillips (2014) addresses concerns about cat bonds as a new source of systemic risk in the financial system. Much of the cat bond business operates out of offshore accounts in Bermuda or the Cayman Islands, as these areas are less strict regarding capital requirements and the disclosure of financial information. This leads to increased

concerns about a lack of transparency and the ability for investors to monitor their risk exposure. Insurance regulators, such as the European Insurance and Occupational Pensions Authority (EIOPA), have expressed concerns about underpricing catastrophe risk through cat bonds. If institutional investors continue to invest in the likelihood that catastrophic weather events will not occur, it will likely lead to a collective underpricing of these risks. Investors in cat bonds often have insufficient knowledge of climate change risks and are enticed by high returns without properly addressing their risks prior to investing. While investors in cat bonds believe they are receiving consistently high returns on these investments, by underpricing the risks of climate disasters, large sums of investments in these products could be lost unexpectedly. This type of loss could result in a ripple effect throughout the financial system and lead to crisis or a collapse of the market. Kolivakis (2013) expresses concern in the increased investment of pension funds in the cat bond market, arguing that this could result in systemic risk for the insurance industry. Kolivakis worries that pensions investing in cat bonds are underestimating the risks of natural disasters while creating problems for the insurance industry by drawing closer scrutiny from regulators. Global warming is resulting in an increase in natural disasters; however, cat bond investors may be underestimating these risks prior to investing.

Joyette et al., (2015) identify issues in the field of catastrophe modelling and the pricing of cat bonds. They argue that the science of catastrophe models is highly uncertain and should be improved before users can apply it with any confidence. The complex, multidisciplinary nature of catastrophe models requires meteorologists, geologists, structural engineers, and actuaries to interact and collaborate to create these

models. Joyette et al., explain the issues with this collaboration as, "complicating the process are the assumptions underlying the models of each discipline, which contribute uncertainty to the process, and thus may affect the validity and reliability of the final outcome" (p. 480). Estimations of loss also pose critical valuation issues for risk modelling, with significant discrepancies between computed and modelled property values or losses. Deficiencies in data pose issues for projections, resulting in uncertainty of models. Hazard modelling uncertainty is a main issue for catastrophe modelling as it is nearly impossible to overcome and, "exists through errors in the input data, errors in observations used to validate a model, errors in model physics and scaling, short-duration datasets, especially when assessing event return periods, and changes in the environment" (p. 482). Joyette et al., maintain that data quality and model techniques need to see significant improvements before they can be applied and used for pricing with confidence.

Critics of cat bonds have also argued that their usage results in increased exposure to moral hazard (Nguyen & Lindenmeier, 2014; Trottier & Son Lai, 2015). Nguyen and Lindenmeier (2014) argue that catastrophe bonds can result in moral hazard issues for insured agents. While it may seem that moral hazard would not be an issue in regard to catastrophe risk as the insured do not have control over catastrophic events and cannot increase probability of catastrophes based on their behaviour, cat bonds can influence insurer risks in other ways. Nguyen and Lindenmeier explain, "with the availability of insurance, the insured can act in a more risky manner, such as construction in more vulnerable regions or using dangerous technologies" (p. 80). Cat bonds can result in increased risky behaviour or less concern about catastrophic risks. Trottier and Son Lai

(2015) argue that cat bonds result in more exposure to moral hazard than traditional reinsurance. While traditional reinsurance usually consists of a beneficial business relationship between the insurer and the reinsurer, cat bond investors do not usually have any relationship to the insured. This relationship can reduce moral hazard, as reinsurers are able to monitor the insurer, while cat bond investors have a limited ability to monitor insurer behaviour. In addition, reinsurers and insurers can both benefit from a long-term business relationship, which establishes trust and makes the two affiliates in business. Cat bonds, on the other hand, do not require any relationship between the insured and investors, lowering surveillance abilities and reducing the incentive for insurers to avoid riskier behaviour. The fully collateralized structure of cat bonds also increases moral hazard risk while the credit vulnerability of the reinsurance sector reduces moral hazard.

This literature review will now focus on critiques of financialization as it relates to cat bonds and their ability to address environmental problems.

2.5.2 Implications of Financialization for Insurance and the Environment

The convergence of property-liability insurance and the capital market in dealing with natural catastrophe risk has been referred to as the "financialization of disaster management" (Grove, 2012, p. 140). Grove argues that this process is a clear illustration of financialization as it seeks to reorganize disaster management around the requirements of financial speculation. Disaster management is financialized, "through a process of appropriation and accumulation that transforms environmental insecurities into catastrophe risks that states leverage on financial markets to increase their adaptive capacity" (p. 141). Grove (2012) continues, "Financialized disaster management is not preoccupied with reducing a population's existing vulnerabilities; instead, it speculatively

envisions and acts against potential threats disasters pose to capitalist order" (p. 141). By converging insurance with the capital market, future risks are imagined in ways that make the present profitable and environmental insecurities are transformed into marketable products (Grove, 2012). This approach to disaster management allows for the quantification, valuing, and commodification of adaptive capacity to catastrophe risks and transforms possible future threats into "an untapped reservoir of capital" (Grove, 2012, p. 141).

Johnson (2015) similarly argues that this approach to disaster management makes modes of governing uncertain futures exchangeable and profitable in financial markets. Johnson argues that insurance offers a concrete example of Harvey's concept of time-space compression through its cycling of capital from financial markets into the built environment. There is an over accumulation of capital within the insurance industry, which is being further perpetuated through climate change risks. The industry relies on catastrophic losses in one year in order to earn extraordinary returns in the next as it can use scientific evidence of climate change in order to raise rates. There is a clear contradiction in the insurance industry as on the one hand, it offers protection and security to protect exchange value, but on the other, the services of the industry are only necessary as long as the physical environment continues to be devalued (Johnson, 2015). This point is furthered through Sturm and Oh's 2010 paper, which demonstrates how the insurance industry profits from the increasing incidences of natural disasters through their spreading of risk and displacement arrangements. This advances the discussion of the ILS market as an illustration of moral hazard as the industry in fact benefits from increasing frequencies of natural disasters through raised premiums and spreading risks through the

financial markets (Sturm & Oh, 2010). Lehtonen (2017) expands this point by arguing that climate change in fact poses new kinds of opportunities for the insurance sector, "as regards the financialization of the biosphere on a planetary scale" (p. 33). Lehtonen argues that reinsurance objectifies weather related natural catastrophes, while simultaneously providing economic protection from them. Climate change is viewed as a strategic issue, "with the growing numbers of climate-change-related catastrophes and with ever more value at risk, such potential is also growing, and so is the market for insurance" (p. 42). Tools such as catastrophe bonds become objectifications of climate change, enhancing the value of insurance companies through their extraction of value from non-existing future events or uncertainties. Johnson (2015) highlights the limits of the belief that operations from the insurance market can help environmental adaptation efforts, and instead argues that it will more likely result in insurance only for the wealthy, leaving the state to manage less wealthy populations and areas.

In a 2013 paper, Johnson sees the analysis and hedging of financial risks in the insurance industry as new patterns of accumulation and a clear representation of financialization. Johnson (2013) integrates ILS markets, in which the speculation of natural catastrophes constitute part of an accumulation strategy, with Smith's (2007) idea of the "vertical integration of nature into capital" which entails, "not just the production of nature 'all the way down', but its simultaneous financialization 'all the way up'" (p. 33). Johnson (2013) notes that insurance risk management tools such as catastrophe bonds offer a prime lens for considering these hybrid techniques of capital accumulation in the insurance industry. Johnson (2013) examines the problems of catastrophe bonds and their exploitation of nature by exposing catastrophe modelling as a tool to create

contingent assets out of environmental and financial vulnerabilities. The article states that the "entire ILS apparatus further advances the financialization of both geophysical nature and life itself" (Johnson, 2013, p. 39). Johnson argues that ILS markets should be considered as an even more complete encompassment of labour and nature into capital.

Based on these critiques, the financialization of insurance risk management could have potentially dangerous consequences for the environment. By exploiting environmental vulnerabilities in order to create economic gain, the need to physically address these risks is diminished. Addressing environmental risks through market mechanisms gives off the impression that actions are being taken to mitigate risks, however, in reality there are no physical changes in behaviour. The financialization of catastrophic risks requires further scrutiny as a result of the inability of market mechanisms to physically address environmental risks. The possible underestimation or inadequate modelling of environmental risks is also a source of concern when analyzing the financialization of insurance risk management.

2.6 Research Question and Hypothesis Development

While research on financialization, time-space compression, and insurance risk management is widespread, there has been limited research connecting these concepts, particularly regarding the cat bond market. This thesis research seeks to fill a gap in analyzing cat bonds from a critical financialization lens. The research aims to analyze cat bonds and expose them as a form of financialization enabling time-space compression. The theories of financialization and time-space compression will be connected with climate change risk management in the insurance industry through an in-depth analysis of

cat bonds. The research will contribute to critical literature on cat bonds by exposing this method of insurance risk management as a potentially dangerous tool for addressing environmental risks.

This literature review has informed the research objectives of this thesis while contributing to hypothesis development. The critical literature surrounding financialization and the diminishing of 'use-value' helps to illustrate the problems associated with cat bonds and their financialization of natural catastrophes. The theory of time-space compression helps to extend critiques of financialization by exposing how this process can separate material realities from their spatial and temporal aspects, rendering cat bonds as pure exchange values. Research on cat bonds to date has primarily focused on their structure, development, popularity, and what their usage means for the insurance and investment market. While there has been some significant critical literature on cat bonds, this thesis aims to extend these critiques by directly linking the bonds with the process of financialization. By mapping the infrastructure and networks of catastrophe bonds, their function as a form of financialization can be evaluated.

The primary hypothesis for this research is that cat bonds are indeed a form of financialization enabling the compression of the temporal and spatial elements of natural catastrophes. The conceptual framework developed by Castree (2003) demonstrates the steps necessary in the financialization of natural phenomena. These steps are privatization through ownership, individuation through commensuration, and displacement through mobilization. By demonstrating that cat bonds exemplify each of these steps, they will be exposed as a form of financialization.

3. Methods

3.1 Introduction and Research Question

This chapter presents the methodology used for conducting research for this thesis. The main objective of this study was to map the infrastructure and networks of catastrophe bonds in order to evaluate their function as a form of financialization. This objective represents an analytical approach called relational economic geography, "an approach that analyzes complex economic action and its localized consequences by focusing on the people, firms, institutions and other organizations involved in and subject to the consequences of economic decision-making" (Knox-Hayes, 2013, p. 118). The goal of this research has been to analyze cat bonds through the actors, processes, and infrastructure that contribute to their development and mobilization.

In order to approach cat bonds through this lens, data on existing cat bonds was required in order to reveal these factors. The data used to analyze cat bonds was sourced from Artemis, an online publicly available database with a comprehensive deal directory of most of the cat bond transactions issued since the market's inception in 1990. In collaboration with this data from Artemis, semi-structured interviews have also been conducted in order to assist in an interpretation of the data results.

To answer the primary research question for this thesis: How do catastrophe bonds represent a form of financialization that uses time-space compression?, this thesis follows an explanatory sequential mixed method approach. The first research stage was to gain an understanding of the typical processes, actors, and structure of cat bonds by mapping the key factors involved in each transaction. The second stage was to clarify

complexities and deepen the understanding of cat bonds by interviewing key informants including experts and traders.

The subsequent sections of this chapter will detail the exact procedures used in conducting research on this topic. First, a general description and justification of the methodology will be explained. Secondly, a more in-depth description of the exact quantitative design including data collection and analysis techniques will be described. Next, the qualitative design including participant selection, interview questions, and analysis techniques will be explained. Finally, credibility concerns and limitations or boundaries will be addressed in order to conclude this section.

3.2 Research Design

This study employed a deductive approach, meaning, "an approach to inquiry that begins with the statement of a theory from which hypotheses may be derived and tested" (Bryman et al., 2012). As this research is testing the theory of financialization enabling time-space compression through cat bonds, it is deducing a specific hypothesis from an existing theory rather than contributing to the development of new theory. Following data analysis and interpretation, the hypothesis that cat bonds are a form of financialization enabling time-space compression will either be accepted or disputed. Thus, the chosen theoretical framework would be supported through the acceptance of the hypothesis.

The thesis research follows a mixed method design. A mixed method approach is a methodology for conducting research that involves the collection and integration of quantitative and qualitative research and data in a study (Creswell, 2014). Based on the deductive nature of this research, this study employed an explanatory sequential mixed method approach. This approach involves two-phases, beginning with the collection and

analysis of quantitative data, followed by the collection and analysis of qualitative data (Creswell, 2014). Creswell explains, "the overall intent of this design is to have the qualitative data help explain in more detail the initial quantitative results" (p. 224). This approach was chosen as the topic in question can be difficult to understand without expertise in the industry. As the quantitative data was the most comprehensive source of information of the cat bond industry, it was chosen as the primary source of data. However, qualitative data was included in order to help clarify the quantitative findings and explain any complexities or misinterpretations.

The research approach began with the collection of data from the Artemis cat bond deal directory. This data was exported onto Excel, organized, and then analyzed. The specific details of the quantitative data collection and analysis will be discussed in the next section of this chapter. Following an initial analysis of trends and key factors in the quantitative data, qualitative semi-structured interviews with key stakeholders in the industry were conducted. The quantitative analysis helped to inform the interview questions based on areas of interest or in need of further clarification. More details on the specifics of the qualitative data collection and analysis will be discussed later in the chapter.

A mixed method approach was chosen for this study in order to offer the most convincing and accurate results possible. Many scholars have demonstrated that quantitative and qualitative methods complement each other and when used in combination, allow for a more robust and valuable analysis (Green et al., 1989; Miles & Huberman, 1994; Green & Caracelli, 1997; Tashakkori & Teddlie, 1998; Ivankova et al., 2006). Explanatory sequential mixed methods were chosen as the design for this research

based on the need for further explanation and clarification of quantitative results in order to enhance the reliability of the data. Krohwinkel (2015) argues that explanatory sequential mixed method designs, "can serve the dual role of confirming and elaborating findings, allowing for a more refined understanding of interactions among factors that would not have been achieved with the use of any one of the analysis techniques alone" (p. 336). In Krohwinkel's 2015 study of organizational project delays, explanatory sequential mixed methods were used based on their ability to single out explanatory variables for project delays through quantitative data while also explaining nuances, such as the particular reasons for delays, through qualitative data. Krohwinkel (2015) claims, "this study utilized the strengths of each method, using the quantitative phase to locate significant explanatory variables across the sample, and the qualitative phase to nuance these findings by demonstrating differences in how variables combine" (p. 351).

This study employs explanatory sequential mixed methods for the same purposes as Krohwinkel. While the quantitative data provides a comprehensive source of information on cat bond transactions, indicating significant trends, themes and variables, the qualitative data can help to discern nuances and explain the complexities of a complicated topic to a researcher that is not an expert in the field. The qualitative results can greatly aid in exploring statistical results in more depth (Ivankova et al., 2006). The following section of this chapter will detail the exact steps taken in collecting and analyzing the quantitative results, followed by a detailed description of the qualitative practices.

3.3 Phase One: Quantitative Design

3.3.1 Data Selection

This research used the Artemis Catastrophe Bond and Insurance-Linked Securities Deal Directory as its primary source of data. This dataset is publicly available and free to access. In studying cat bonds, it was incredibly fortunate that this comprehensive database was available for use. The Artemis database details 472 cat bond transactions, starting in 1996. This database contains details about most of the cat bond transactions issued since the creation of the ILS market in the mid 1990's. The transactions that are included in the database give details on: issuer/SPV, cedent/sponsor, placement/structuring agents, risk modelling/calculation agents, risks/perils covered, size, trigger type, ratings, and date of issue, with some exceptions based on undisclosed information or sources.

This dataset was chosen for this research as it offered the most comprehensive and relevant information on cat bonds. The primary objective of this research was to map the infrastructure and networks of catastrophe bonds in order to evaluate their function as a form of financialization. In order to accomplish this, it was necessary to gain an understanding of the typical processes, actors, and structure of cat bonds by discovering the key factors involved in each transaction. The Artemis database provided all of the relevant factors involved in the development of a cat bond and offered the opportunity for longitudinal analysis of the topic. In this case, the use of this secondary data source allowed for longitudinal analysis beginning in 1996, meaning that trends from over two decades could be charted and analyzed (Bryman et al., 2012).

In addition to the advantage of longitudinal analysis, the use of secondary analysis can offer other benefits for researchers. Using secondary data allows for high-quality information while being less costly and timely for the researcher (Bryman et al., 2012). By using the Artemis database, detailed data could be exported and analyzed efficiently. As the data was already collected and available, this allowed for more time focused solely on data analysis and interpretation (Bryman et al., 2012). The Artemis data also allowed for international analysis, rather than being constricted to North America. As Artemis collects cat bond data globally, the use of this database allowed for significant global geographic analysis of the cat bond market.

3.3.2 Data Collection Process

Based on the objectives of this research, data was retrieved from the Artemis database and manually exported into an Excel spreadsheet. All cat bond transactions were included in the data that was exported, which amounted to a total of 472. There was no sampling used for the purposes of this research, allowing all transactions to be included in the analysis. Any recent transactions on the database were also manually exported up until the end of the data collection process on June 1st, 2017. This date was chosen to end data collection because data analysis was to begin following this date. In addition, there appeared to be no new trends in the most recent transactions, with similar factors continuing to be reflected in the newer transactions as seen in prior transactions. Bryman et al., (2012) refer to this concept as data saturation, meaning "the point at which there is nothing to be gained by further reviewing of old data or collection of new information to see how it fits with emerging concepts or categories; new data are no longer illuminating" (p. 259). The decision was made to end the data collection process on June 1st, 2017

because new trends and concepts were no longer appearing and the process of data analysis needed to begin. Based on the decision to include all Artemis transaction data in the analysis, the data and findings from this research are representative of cumulative growth and trends in the industry, rather than simply studying the outstanding market.

All listed factors were included in the exportation of the data including: issuer/SPV, cedent/sponsor, placement/structuring agent(s), risk modelling/calculation agent(s), risks/perils covered, size, trigger type, ratings and date of issue. Table 1 provides descriptions of these data items. The transactions were organized by date, as they are presented on Artemis, and each factor was given a column. Any missing data were represented with a question mark. All information was manually copied onto Excel exactly as listed on the Artemis database.

Table 1: Data Items and Descriptions

Data Item	Description
Issuer/SPV	The issuing vehicle of the bond, usually a subsidiary company created for the purpose of the transaction
Cedent/Sponsor	The sponsoring company, i.e. the insurer, reinsurer, or organization from who the risk comes from
Placement/Structuring Agent(s)	The brokers, broker dealers, or book-runners who arrange and facilitate a transaction
Risk Modelling/Calculation Agent(s)	The organization that estimates possible losses through risk modelling analysis and contributes to the structuring and pricing of catastrophe bonds
Risks/Perils Covered	The location and natural catastrophe risk that the bond provides coverage for
Size	The price of the catastrophe bond
Trigger Type	The event that will trigger the payout of the catastrophe bond, 4 most common types: *Indemnity*: covers actual excess claims or losses of the issuer *Industry loss*: coverage based on whole industry losses of the event *Parametric*: coverage based on exceeding of specified natural parameters *Modelled*: coverage based on claims estimated by a computer model (Edesess, 2015).
Ratings	The investment rating of the catastrophe bond
Date of Issue	The month and year the catastrophe bond was issued

3.3.3 Data Cleaning and Organization

Several steps were taken in order to make the data functional for analysis and comparison. The factors that were included in the cat bond analyses were sorted and analyzed from two perspectives, their respective dollar value and the number of bonds issued. In order to analyze the data from these perspectives, the values had to be

comparable. In the original dataset, the dollar values of the catastrophe bonds were represented in various currencies. Therefore, in order for a workable comparison between factors based on values, all dollar values were converted to USD based on the exchange rate on May 15th, 2017. See Table 2 below for a list of the exchange rates used for the conversion to USD. Once all the values had been converted, the bonds could be broken down and analyzed through comparable valuations.

Table 2: Exchange Rates

Currency	**Exchange Rate**	**US Dollar Value**
1 Euro	1.0978	1.1 USD
1 CAD	0.73353	0.74 USD
1 CHF	1.004	1 USD
1 DEM	0.55868	0.56 USD

Sourced from: Exchange-Rates.org on May 15th, 2017.

Further data cleaning techniques were used in order to merge data in separate analysis categories. In order to evaluate the location of the cat bonds, the information under "risks/perils covered" from the raw dataset was separated. As data under the category of risks provided information about the specific risks covered and the location of the risks covered, this data was separated so that location could be analyzed as its own factor. Thus, the information under risks was divided into two separate columns; location and risk type. Location data was then further categorized by dividing data based on continent. The categories included were North America, Europe, Asia, South/Latin America, Australia, Worldwide and Unknown. Data was merged by sorting countries based on their continent. Some decisions based on continent classification require further clarification. Any bonds covering risks in Turkey or the Mediterranean were placed under Europe (rather than Asia). Mexico, Puerto Rico, Caribbean and Central America were

included as South/Latin America. While these countries are sometimes considered part of North America, the decision was made to group them separately as it would result in a more accurate reflection of the economic conditions of particular regions that have higher catastrophe bond issuance. These areas have very different economic, political and cultural conditions than North America. Therefore, for research purposes, more informative and representative analysis could be gained by grouping these countries separately.

Where some bonds provided coverage that spanned more than one continent, these values were represented more than once for each respective continent they provided coverage for. For example, one bond provided coverage for the United States, Canada, Europe and Australia. This bond was represented fully in three different continent categories: North America, Europe and Australia. The dollar value was represented fully in each category, therefore, in the location section of analysis, the final figures would add up to more than the actual cumulative issuance of the bonds. The decision to represent these types of bonds under each category was made so that each continent could be accurately reflected as holding a particular percentage of the cat bond market. Rather than having a large worldwide category, which would lack granularity, it was decided that representing the bonds within each continent category they provided any coverage for would result in a more accurate depiction of where the cat bond market provided the most coverage.

Following the separation of risks from their location details, the risks were merged based on specific categories. The categories of risks included were: multi-peril, windstorm, earthquake, extreme/excess mortality, named storms, temperature risks,

operational risk, property catastrophe risk, mortgage insurance risks, life embedded value, lottery winning risk, typhoon, hurricane, healthcare, motor, thunderstorm and unknown. Any bonds that covered more than one risk type were placed under the multi-peril category. Bonds labelled extreme mortality or excess mortality were placed under the same inclusive category. Casualty losses, credit reinsurance, event cancellation and operational risks were merged under the category of operational risk. Longevity risk, life insurance mortality and life reinsurance were merged under the category of life embedded value. Motor liability losses and motor policies were merged under the category motor risk. And finally, medical benefit claims levels were placed under the healthcare risk category.

In order to evaluate risk modellers, data under the same risk modelling companies were merged. Where information on the reporting agency and the calculation/reset agent were both provided, the calculation/reset agent information was represented rather than the reporting agency information. As the topic of interest is catastrophe risk modelling, reporting agents are typically accounting services and are not involved in risk modelling procedures. The calculation/reset agents are those that provide risk-modelling services and are more relevant to the required data information. Trigger types were also merged under specific categories. These categories were indemnity, industry loss, medical benefit ratio, modelled loss, parametric, mortality index, multiple triggers and unknown. Any data that listed more than one trigger type were placed under the multiple triggers category. In all cases, any data that was missing information was placed under an unknown category and represented in the final data set numbers as unknown.

3.3.4 Data Analysis

Based on the relational economic geographical approach of this research, the focus of analyzing the dataset was to evaluate how each specific factor was represented and affected the cat bond market. Therefore, by dividing the data based on each specific factor along with their corresponding dollar values and the number of bonds issued, each factor could be analyzed based on how often it was represented in cat bond transactions. For each specific factor: cedent/sponsor, placement/structuring agent(s), risk modelling/calculation agent(s), risks/perils covered, location, trigger type, and rating, a separate Excel worksheet was created. For each bond, every specific factor was copied onto a separate datasheet from the original dataset along with the value of that bond. Each bond was labeled by factor and the number of the bond based on the date of issuance (#1 to #472) along with the dollar value.

Pivot tables on Excel were used in order to combine, sort and count the data based on the specified factor. A pivot table is a data processing tool that aids in data analysis by counting, sorting, totalling or otherwise organizing large datasets. Jelen (2010) argues, "pivot tables are a powerful tool for turning thousands of records of detail data into a concise summary in a few clicks" (p. 54). By utilizing pivot tables, the data could be sorted and the sum of specific factors could be totalled. The bonds were grouped together and dollar values or the numbers of bonds issued were combined based on whichever factor was being analyzed. For example, for trigger type, all bonds under the indemnity trigger were grouped together and the total values and number of bonds under that specific trigger type were added.

Using pivot tables, the Row Labels and Value field were utilized. The Row Labels section filters data based on a specified factor. The Values field sorts data based on total sums or a count of each row label. The specific factor that was being analyzed was dragged into the Row Labels field and the total dollar value and the numbers of bonds issued were dragged into the Values field. The values field was changed to "sum of", ensuring that it would add up all of the same Row Labels fields. This would group all of the same factors into one field and add up the total dollar value and number of bonds issued under this specific factor. After pivot tables were generated, the data could be sorted from largest to smallest through an Excel function. This would give a concise list of each factor's representation in the cat bond market by showing the total value of the market that each specific factor had while also showing how many of the total bonds issued fell into each factor's category. Through Excel, charts could then be generated which would indicate the percentage of the market each factor had based on either values (in millions USD) or the number of bonds issued.

Following the quantitative data collection and analysis process, qualitative research was collected and analyzed. The next section of this chapter details the methods taken in the design, collection and analysis of the qualitative data used for this research.

3.4 Phase Two: Qualitative Design

Given the complexity of this topic, it was decided that qualitative interviews should be conducted following quantitative data analysis. Secondary data analysis poses some limitations for researchers. When researchers employ secondary data analysis as the primary source of data collection, they can be limited by the complexity of the data and a lack of familiarly with the data (Bryman et al., 2012). In order to overcome these

limitations by ensuring the quantitative data was not misrepresented or understood incorrectly, semi-structured interviews with industry experts were conducted as a follow up to quantitative data analysis. These interviews also aimed to further explain the development of cat bonds while offering the potential for expert critical opinions.

3.4.1 Participant Selection

In order to select participants for the study, convenience sampling was used to recruit candidates. Based on the small number of industry experts in the field, only three interviews were conducted. While three interviews may seem to be a small sample size, the cat bond industry has very few companies and experts, thus, three qualified experts in the field offered adequate and representative data. With a high degree of agreement between participant responses, I was confident that the point of theoretical saturation had been reached and additional participants would not have yielded new information to the study. Marshall (1996) explains that small samples can be most effective for qualitative research and can offer improved understandings of complex issues that are more important than generalizability of results. However, in this case, as the industry being studied is so small and experts in the field have been chosen, this sample size can be generalizable for the industry.

Convenience sampling was used to recruit participants based on members of the thesis committee's contacts. However, these participants were not recruited without a thoughtful analysis of how they could contribute to the research. In this sense, it may be more accurate to refer to the sampling method as a judgement or purposeful sample. Marshall (1996) described a judgement or purposeful sample as, "the researcher actively selects the most productive sample to answer the research question" (p. 523). By working

closely with the thesis committee and discussing the best candidates for the interviews, it was decided that based on the committee's connections, they could recruit key actors in the industry that would offer extensive and qualified expertise of the topic. The participants were included in the study based on their expert roles in the development and mobilization of cat bonds. All participants included in the study are qualified experts in the field of ILS, and have years of experience in the industry of cat bonds. These key stakeholders offer insight and a richer understanding of the data through their expertise (Marshall, 1996).

The participants were invited to participate in the study by email. In one case, based on the connection the committee members had with one of the possible participants, they contacted them first. For the other two interviews, I contacted them directly via email. A recruitment email was sent out to the informants offering a brief description of the project and inviting the participant for an interview either in person, on Skype, or by telephone. In total, six interview requests were sent out, with three responses. After receiving a response expressing interest in the study, I reached out to them with a second email, detailing the purpose of the thesis research and arranging a convenient time and format for the interview. Informants were assured confidentiality and informed of their legal rights to terminate their participation at any time. They were also asked to review a consent form approved by the University of Waterloo's Office of Research Ethics and provide their informed consent to participate over email. Participants were assured their identities would be kept anonymous and not revealed in the study unless they elected to waive their anonymity. Participants were informed the interviews would take between 45 to 60 minutes.

3.4.2 Interview Questions and Procedures

Based on the explanatory purpose of the qualitative interviews, in-depth semi-structured interviews were chosen as the method for qualitative data collection. Drever (1995) describes semi-structured interviews as,

> "The interviewer sets up a general structure by deciding in advance the ground to be covered and the main questions to be asked. The detailed structure is left to be worked out during the interview, and the person being interviewed has a fair degree of freedom in what to talk about, how much to say, and how to express it" (p. 1).

By employing a semi-structured interview method, the researcher is able to create a set of predetermined questions to aid in structuring and focusing the interview, however, the open-ended nature of the questions allows participants to answer them freely. Bryman et al., (2012) view semi-structured interview questions as a guide for the interviewer that can help to lead them into an in-depth conversation with the participant. Drever (1995) considers semi-structured interviews to be a flexible and appropriate method for small-scale, in-depth research.

The primary objective of this research was to evaluate catastrophe bonds as a form of financialization by mapping the infrastructure and networks involved in their creation and distribution. In order to accomplish this objective, in-depth knowledge of the typical processes and actors in the industry was needed. Although the Artemis database provided a comprehensive source of information of the cat bond industry, the complexity of this industry can cause difficulties or misunderstandings in its analysis. The purpose of the qualitative interviews was to help to clarify the quantitative findings and offer personal, nuanced understandings of the market from top experts in the field. Semi-structured interviews were the most suitable method for providing focused and detailed information and opinions from industry experts to help in clarifying an understanding of

the topic. Semi-structured interviews allowed for detail and focus, while also accounting for the complexities of the topic and allowing participants to provide detailed, complex information. They also granted the participant the freedom to highlight other important topics that may have not been included in the original questions.

The interview questions were informed based on initial findings from the quantitative data analysis. They were developed in order to provide more information on areas of interest or in need of further explanation. The questions were submitted to the University Ethics Office and received their approval under ORE #22203. The questions remained the same for all three interviews, but were presented in a slightly different order than shown in Appendix A, based on how the conversation progressed.

The interviews were conducted in late May and early June 2017. As all three participants were based outside of Canada, interviews did not take place in person. The first interview took place over Skype while the other two interviews were conducted through a conference call system. The interviews lasted between 40 to 45 minutes in total. All three interviews were recorded and manually transcribed afterwards. Each interview was approximately 1600 words in total after transcription.

3.4.3 Interview Analysis

The interview transcripts were analyzed deductively based on the fact that the research aimed to accept or refute an existing theory. The primary goal of the qualitative data was to help explain and clarify quantitative data results while also offering expert opinions. In this sense, the analysis was deductive as the aim was to use the interview results to support the quantitative results and in turn, support the hypothesis. The data was interpreted following a qualitative descriptive design. Sandelowski (2000) describes

qualitative descriptive studies as, "[they] offer a comprehensive summary of an event in everyday terms of those events" (p. 336). Qualitative descriptive studies aim to accurately account events descriptively and view "language as a vehicle of communication, not itself an interpretive structure that must be read" (Sandelowski, 2000, p. 336). By using a qualitative descriptive approach to analysis, the surface meaning of the words and descriptions used in the interviews remained of primary importance. Sandelowski (2000) explains, "the qualitative descriptive study is the method of choice when straight descriptions of phenomena are desired. Such study is especially useful for researchers wanting to know the who, what, and where of events" (p. 339). As the primary goal of this research is to map the who, what and where in the development of cat bonds, a qualitative descriptive approach to analysis was the most suitable. The approach offers a primary lens for comprehensively explaining qualitative findings and using them to explain quantitative results.

As the quantitative data was used to inform the qualitative interview questions, the order of these questions helped to group data prior to analysis. The intended framework mentioned in section 2.2.4, the mechanisms of financialization, also informed the interview questions. By grouping the questions into the framework categories and sub-categories prior to conducting the interviews, the analysis was made sufficiently easier and more productive. In analyzing the transcripts, framework analysis was used by sorting the data into categories based on which part of the framework they belonged to. Each question that was asked of participants already belonged to a particular section of the framework; therefore, the data could be categorized into relevant framework categories based on the question. Srivastava and Thomson (2009) explain the process of

framework analysis as ”the key issues, concepts and themes that have been expressed by the participants now form the basis of a thematic framework that can be used to filter and classify the data” (p. 76). The key difference between the approach described by them and the approach used in this study is that the thematic framework was not formed by the results from interviews, but rather, it was informed by the quantitative data analysis and literature review. The qualitative results were categorized based on the existing framework that was created prior to the interviews.

As this research followed an explanatory sequential mixed-methods approach, the primary source of data was the quantitative results. The goal of the qualitative results was to help clarify and nuance the quantitative data results. For this reason, the qualitative results are embedded in the discussion section of the thesis and act as a lens to help interpret or clarify the quantitative data results through the discussion. A separate results section was not included for the qualitative results in order to avoid redundancies.

3.5 Limitations

The primary limitations of this research are a result of the qualitative portion of the research collection and analysis. The sample-size, representativeness and bias of the participants are possible limitations of the study. As the catastrophe bond market is a fairly small and exclusive industry, only three participants were interviewed. While this small sample size is relative to the size of the market, the propensity for bias of participants to affect the results was substantial. As all three participants are directly involved in the catastrophe bond market, there may have been a bias toward a positive representation of the industry. In addition, the sample was unbalanced in terms of gender,

as all three participants were male. However, depending on the actual gender representation in the cat bond market, this may or may not have been an accurate sample size in terms of gender based on the industry. Another limitation to the study is the possible subjectivity involved in the qualitative descriptive analysis. In analyzing qualitative data, there is always a risk of the researcher's bias impacting the analysis or presentation of the results. However, by using a mixed-methods approach, the risk of researcher bias in findings is significantly decreased (Ivankova et al., 2006; Krohwinkel, 2015; Patton, 2015). In addition, by using a qualitative descriptive approach, the qualitative data results are meddled with significantly less and are presented as they were spoken (Sandelowski, 2000), thus, further reducing the possibility for researcher bias.

4. Quantitative Results

4.1 Introduction

This chapter presents the results from the quantitative analysis of each cat bond factor. The focus of this data analysis was to evaluate each factor separately from another in order to determine key actors and processes in the cat bond market. Each factor was analyzed separately, arranging various determinants in each category by the dollar value and bond issuance falling under that specific determinant. Pivot tables were used to sort and merge the data based on dollar and bond issuance. Therefore, the most commonly used determinants in each factor group are exposed through this analysis. This chapter details the key actors and processes used in each factor of developing a cat bond. All results are presented through tables and charts along with further descriptions. Recent observed trends in the market are also discussed and explored in this chapter.

The remainder of this chapter will detail the findings from the pivot tables conducted on each factor. The findings are presented by factor through dollar and bond issuance. The chapter will conclude with a summary of the significant results.

4.2 Quantitative Results by Factor

4.2.1 Sponsor

After separating the sponsor/cedent, dollar value, and bond issuance data from the other factors, there were more than 100 companies listed as sponsors. The same sponsors were merged together to provide total dollar issuance and bond issuance information for each company. As there were over 100 companies, the top five sponsors based on dollar

issuances and bond issuances were chosen as most informative for cat bond sponsor information.

The top five sponsors based on dollar issuance were Swiss Re, USAA, State Farm, Citizens Property and Everest Re. Swiss Re was the top sponsor in the cat bond market with 12 percent of the total dollar issuance of cat bonds and a cumulative total of approximately 10.4 billion USD of the cat bond market. USAA was the second top issuer, with 8 percent of total dollar issuance and 7.3 billion USD of cumulative issuance. Table 3 below details the top five cat bond sponsors by dollar issuance.

Table 3: Top 5 Sponsors by Dollar Issuance

Sponsor/Cedent	Dollar Issuance (Billions USD)	% of Total Dollar Issuance
Swiss Re	10.44	12%
USAA	7.27	8%
State Farm	3.29	4%
Citizens Property	3.10	4%
Everest Re	2.83	3%

In order to show the increasing concentration of sponsors in the cat bond market, the average dollar issuance, number of bonds and sponsors were calculated between two periods of time. Table 4 illustrates how the number of sponsors has significantly decreased while the dollar issuance and the number of bonds issued has increased. Between the years 2000 to 2005 there were more sponsors despite a smaller average dollar issuance. In contrast, between the years 2010 to 2015 there was less than half the number of sponsors despite a significant average dollar issuance increase.

Table 4: Average Number of Sponsors per Time Period

Year	Average # of Sponsors	Average Dollar Issuance (Millions USD)	Average # of Bonds
2000-2005	43	$2007.25	72
2010-2015	21	$7115.10	213

Some sponsor information was listed under “unknown”. 10 bonds and 1.7 billion USD of dollar issuance came from unknown sponsors. The majority of the remaining sponsors were insurance or reinsurance companies that issued less than 8 bonds or 2 billion USD.

4.2.2 Location

Location data was sorted by continent and analyzed by total dollar and bond issuance. Where some bonds provided coverage that spanned more than one continent, these values were represented more than once for each respective continent they provided coverage for. The dollar value was represented fully in each category, therefore, in the location section of analysis, the final figures add up to more than the actual cumulative issuance of the bonds. However, the percentage of total dollar issuance listed for each continent still accurately reflects the portion of the cat bond market each particular continent holds in terms of risk coverage. The figure and chart below represent the percentages of risk coverage particular continents have rather than the percentage of dollar value.

When analyzed from either total dollar issuance or total bond issuance, North America held coverage from over 50 percent of the cat bond market. 64.2 billion USD of the cat bond market provides risk coverage to North America. When analyzed by dollar issuance, 59 percent of the total cat bond market provides risk coverage to countries within North America. Similarly, when analyzed for bond issuance, 57 percent of all bonds issued cover risks in North America. Of the 472 bonds that were analyzed, 335 of them provided coverage to countries within North America. Figure 5 below offers a visual representation of the overwhelming percentage of the market that provides coverage to North America.

Figure 5: Location of Coverage by Dollar Issuance

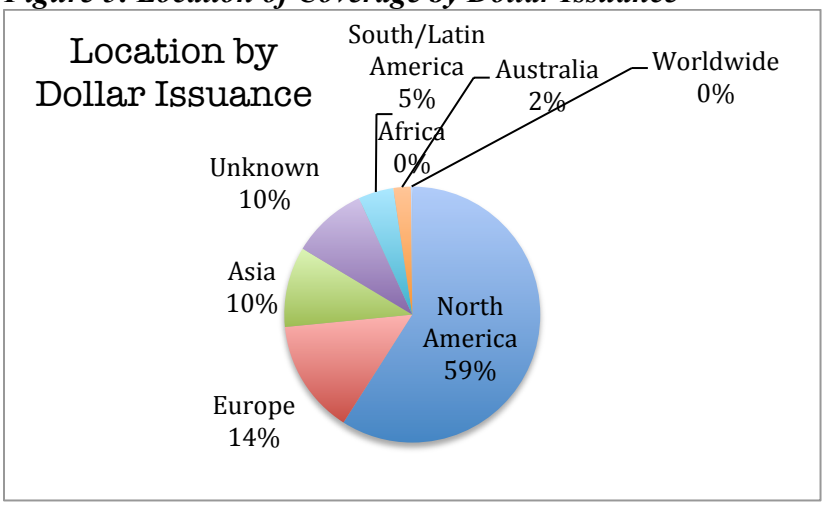


Table 5 below details the dollar issuance and bond issuance of cat bonds based on the continent they provide coverage for. While 24 percent of the total cat bond market provides risk coverage to Europe and Asia, Africa represents 0 percent of the market with 0 bonds being issued providing coverage in that region.

Table 5: Cat Bond Issuance by Continent

Location	Dollar Issuance (Millions USD)	% of Total Dollar Issuance	# of Bonds Issued	% of Total Bond Issuance
North America	64,174.98	59%	335	57%
Europe	15,657.50	14%	97	16%
Asia	11,047.97	10%	71	12%
South America	4,856.75	4%	17	3%
Australia	2,385	2%	13	2%
Africa	0	0%	0	0%
Worldwide	193.80	<1%	2	<1%
Unknown	10,377.33	10%	58	10%

It is worthwhile to note that the only countries in Asia represented in the cat bond market are Japan, China and Taiwan. As bonds and values were represented more than once for each respective area they provided coverage for, "worldwide" refers to those bonds that did not specify countries, but were labeled specifically as providing worldwide coverage. The location of 58 bonds and 10.4 billion USD were not disclosed and were placed under the category of "unknown".

4.2.3 Risks Covered

Risks covered data was separated and analyzed independently from location data. Risks were grouped into either: multi-peril, earthquake, hurricane, windstorm, named storms, extreme mortality, typhoon, healthcare, life embedded value, operational risk, property catastrophe risk, mortgage insurance risks, motor, thunderstorm, lottery winning risk, temperature risks and unknown. Bonds were divided into one of the risk categories based on dollar issuance and bond issuance. Any data that referred to coverage of more than one risk was placed in the multi-peril category.

Table 6 below details the risks covered based on cumulative dollar issuance and bond issuance. Multi-peril was the highest risk coverage category with over 40.6 billion USD or 46 percent of cumulative cat bond issuance providing coverage for multi-peril risks. Earthquakes and hurricanes were the next most common risk coverage types representing 18 and 13 percent of total dollar issuance. Windstorms, named storms and extreme mortality were also notable risk coverage categories, representing between 5 to 3 percent of total dollar issuance.

The only notable difference when analyzing for total dollar issuance and total bond issuance was the high number of bonds issued for property catastrophe risk despite the lower dollar issuance. 26 bonds had been issued to cover property catastrophe risks, representing 6 percent of total bond issuance. However, when analyzed for dollar issuance, property catastrophe risks only represented 1 percent of the cat bond market, with 955 million USD in total cumulative issuance. Although all cat bonds technically refer to property risk coverage, this category represents those bonds that specifically noted property catastrophe risk as the coverage type.

Table 6: Cat Bond Issuance by Risks Covered

Risks Covered	Dollar Issuance (Millions USD)	% of Total Dollar Issuance	# of Bonds Issued	% of Total Bond Issuance
Multi-peril	40,578.10	46%	200	42%
Earthquake	15,868.39	18%	75	16%
Hurricane	11,736.86	13%	60	13%
Windstorm	4,083.90	5%	25	5%
Named Storms	3,900.24	4%	29	6%
Extreme Mortality	2,915.50	3%	10	2%
Typhoon	1,690	1%	9	2%
Healthcare	1,400	1%	8	2%
Life Embedded Value	1,087.80	1%	8	2%
Operational Risk	1,030	1%	4	1%
Property Catastrophe Risk	955.97	1%	26	6%
Mortgage Insurance Risks	808.81	1%	3	1%
Motor	692.10	1%	2	<1%
Thunderstorm	400	<1%	3	1%
Lottery Winning Risk	256.70	<1%	2	<1%
Temperature Risks	132.55	<1%	2	<1%
Unknown	80.75	<1%	6	1%

4.2.4 Risk Modellers

Total dollar issuance and bond issuance was analyzed based on risk modeller by dividing cat bond data based on which company provided risk analysis services. In total, there were six companies that were identified as risk modellers in the cat bond market: AIR Worldwide, RMS, EQECAT, Milliman Inc., Oliver Wyman and Aon Benfield Analytics. In addition to these six companies, three additional categories were added: multiple, for bonds that used more than one risk modeller, unknown, for bonds which did not disclose risk modellers, and investors, a category for bonds where investors undertook their own risk modelling.

Figure 6 below offers a visual representation of how each risk-modelling company is represented in the cat bond market. AIR Worldwide provided risk-modelling

services for 44 percent of the market when analyzed by total dollar issuance. 38.9 billion USD of the cumulative issuance of cat bonds was modelled for risk by AIR Worldwide. In total, 163 bonds identified AIR Worldwide as providing risk-modelling services, compared to 81 bonds from the second highest risk modelling company, RMS. When comparing RMS and AIR Worldwide through total dollar issuance, the difference is even more substantial. While AIR Worldwide provided risk-modelling services for 38.9 billion USD of cat bond issuance, RMS provided these services for 16.5 billion USD. Therefore, while AIR Worldwide represents 44 percent of risk modelling services based on dollar issuance, RMS represents only 19 percent.

Figure 6: Risk Modellers by Total Dollar Issuance

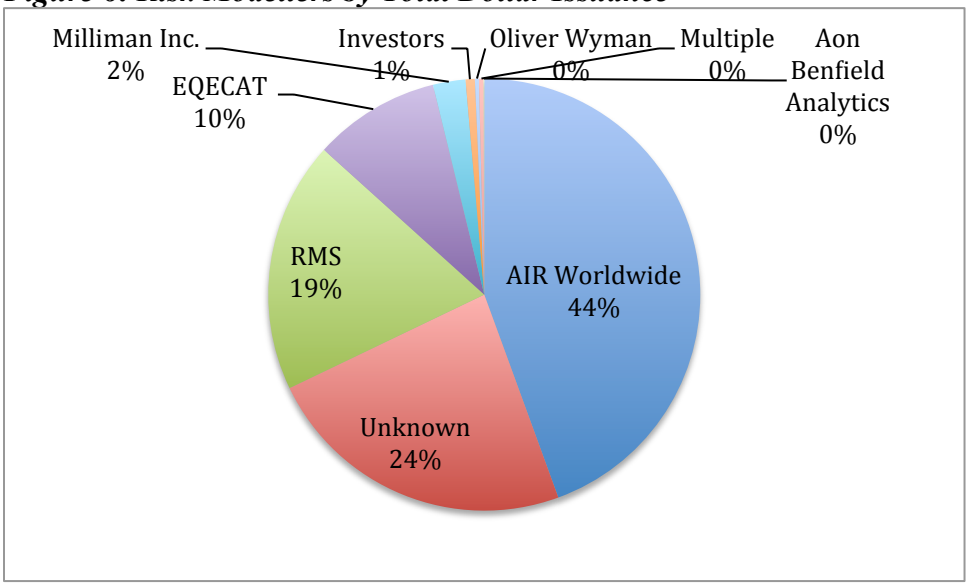


Table 7 below provides specific dollar issuance and bond issuance data for each risk modeller category. A significant portion of cat bond data did not disclose the risk modeller used, resulting in 20.5 billion USD of cumulative issuance and 164 bonds being placed in the unknown category.

Table 7: Cat Bond Issuance by Risk Modeller

Risk Modeller	Dollar Issuance (Millions USD)	% of Total Dollar Issuance	# of Bonds Issued	% of Total Bond Issuance
AIR Worldwide	38,884.40	44%	163	35%
RMS	16,468.65	19%	81	17%
EQECAT	8,303.15	10%	37	8%
Milliman Inc.	2,133.05	2%	13	3%
Investors undertook their own risk modelling	603.67	1%	10	2%
Oliver Wyman	263.80	<1%	2	<1%
Multiple	300	<1%	1	<1%
Aon Benfield Analytics	44	<1%	1	<1%
Unknown	20,516.96	24%	164	35%

4.2.5 Trigger Types

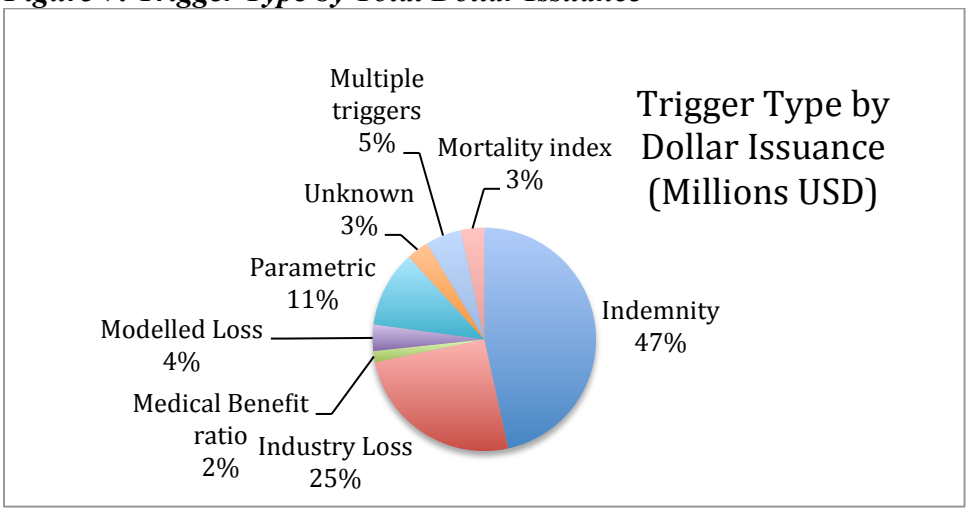
Total cat bond dollar issuance and bond issuance were analyzed based on the assigned trigger type for the bond. Seven trigger types were identified: indemnity, industry loss, parametric, multiple, modelled loss, mortality index and medical benefit ratio (definitions can be found in Table 1). An unknown category was also created in order to represent those bonds that did not specify a trigger type. Table 8 below details the trigger types based on cumulative dollar issuance and bond issuance.

Table 8: Cat Bond Issuance by Trigger Type

Trigger Type	Dollar Issuance (Millions USD)	% of Total Dollar Issuance	# of Bonds Issued	% of Total Bond Issuance
Indemnity	40,757.49	47%	185	39%
Industry Loss	22,007.30	25%	112	24%
Parametric	9,670.35	11%	74	16%
Multiple	4,527.60	5%	26	5%
Modelled Loss	3,343.90	4%	23	5%
Mortality Index	2,965.50	3%	11	2%
Medical Benefit Ratio	1,400	2%	8	2%
Unknown	2,845.50	3%	33	7%

A relatively small portion of the data did not disclose a trigger type, resulting in 2.8 billion USD and 33 bonds being placed in the unknown category. The indemnity trigger represented a vast majority of cat bonds, with 185 bonds and 39 percent of the total bond issuance falling under this trigger type. When analyzed based on dollar issuance, the indemnity trigger represented 47 percent of the market, with 40.8 billion USD in total issuance. Figure 7 below offers a visual representation of the percentage of the cat bond market with an indemnity trigger type. Industry loss was the second most common trigger type in the cat bond market. 22 billion USD or 25 percent of total dollar issuance had an industry loss trigger type. 185 bonds in total used the industry loss trigger, representing 24 percent of total bond issuance.

Figure 7: Trigger Type by Total Dollar Issuance



4.2.6 Ratings

While 45 percent of all bond data did not provide any rating information, investment ratings have decidedly been included in the results section for personal interest but should be given somewhat limited weight. 40.7 billion USD of cumulative dollar issuance and 212 bonds did not provide rating information. However, of those bonds that were rated, 161 bonds were given a substantial credit risk rating, representing 34 percent of all dollar issuance. 27.2 billion USD of total dollar issuance fell under the substantial credit risk rating. Table 9 below gives details of ratings based on dollar issuance and bond issuance. High credit risk was the second most common rating, with 79 bonds and 16.4 billion USD falling under this rating. Moderate credit risk was the third most common rating, with 1.5 billion USD in cumulative issuance being given this rating.

Table 9: Cat Bond Issuance By Investment Rating

Rating	Dollar Issuance (Millions USD)	% of Total Dollar Issuance	# of Bonds Issued	% of Total Bond Issuance
Unknown	40,669.76	46%	212	45%
Substantial Credit Risk	27,177	31%	161	34%
High Credit Risk	16,427.06	19%	79	17%
Moderate Credit Risk	1,500	2%	10	2%
Low Credit Risk	909.90	1%	6	1%
Near Default	486.95	1%	2	1%
Multiple Ratings	200	<1%	1	<1%
Very High Credit Risk	150	<1%	1	<1%

4.2.7 Placement/Structuring Agents

After separating the placement/structuring agent data, dollar value and bond issuance data from the other factors, there were over 30 companies listed as placement/structuring agents. The same companies were merged together to provide total dollar issuance and bond issuance information for each company. As there were over 30 companies, the top five placement/structuring agents based on dollar issuance and bond issuances were chosen as most informative for cat bond bank or broker information.

The top five placement/structuring agents based on cumulative dollar issuance were Goldman Sachs, Aon Benfield Securities, Swiss Re, GC Securities and Willis Capital Markets. Goldman Sachs was the top placement/structuring agent in the cat bond market with 24 percent of the total dollar issuance of cat bonds and a cumulative total of approximately 18.5 billion USD of the cat bond market. Aon Benfield Securities was the second top broker, with 20 percent of total dollar issuance and 14.96 billion USD of cumulative issuance. Table 10 below details the top five cat bond placement/structuring agents by dollar issuance.

Table 10: Top 5 Placement/Structuring Agents by Dollar Issuance

Placement/Structuring Agent	Dollar Issuance (Millions USD)	% of Total Dollar Issuance
Goldman Sachs	18,545	24%
Aon Benfield Securities	14,957	20%
Swiss Re	12,972.15	17%
GC Securities	5,657.50	7%
Willis Capital Markets	3,814.90	5%

When analyzing agents by bond issuance, all of the same companies remained in the top five as when analyzed by dollar issuance, but in a different order. Swiss Re was the top broker for cat bonds with a total of 90 bonds issued, totalling 19 percent of cumulative bond issuance. Goldman Sachs was the second top issuer when analyzed for bond

issuance, with 70 total bonds issued and 15 percent of cumulative bond issuance. Table 11 below details the top five cat bond placement/structuring agents based on bond issuance. Some placement/structuring agent information was listed under "unknown". 92 bonds and 698.9 million of dollar issuance did not disclose placement/structuring agents.

Table 11: Top 5 Placement/Structuring Agents by Bond Issuance

Placement/Structuring Agent	# of Bonds Issued	% of Total Bond Issuance
Swiss Re	90	19%
Goldman Sachs	70	15%
Aon Benfield Securities	61	13%
GC Securities	36	7%
Willis Capital Markets	22	4%

4.3 Observed Trends

In order to analyze and observe recent trends and changes in the cat bond market, the date of issuance was added to the data analysis as a new pivot table factor. By including the year of issuance in the data, each factor could be charted based on yearly issuance and the growth of specific factors within the cat bond market could be analyzed. Based on these observations, particular factors have been included in this results section based on yearly growth.

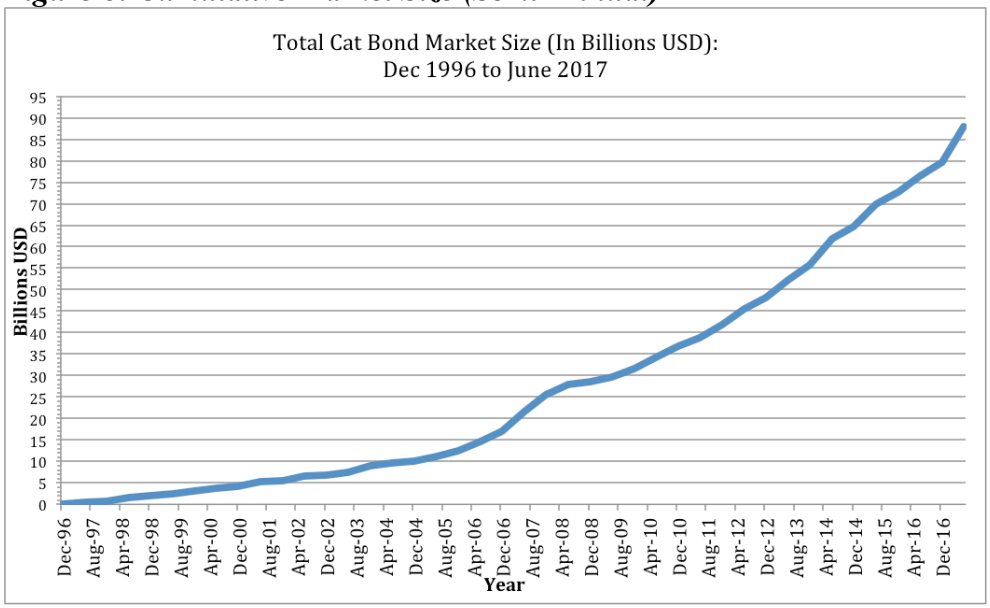
This section will provide an analysis of the yearly growth of particular issuance factors within the cat bond market. The findings are presented through dollar issuance in millions USD. All results are presented through charts created by the pivot table data results.

4.3.1 Catastrophe Bond Market Growth

Figure 8 below charts the cumulative growth and total market size of the cat bond market since its inception in December 1996. The cumulative dollar issuance of the cat bond

market was charted semi-annually each year in June and December. The chart below shows that the market has seen continued steady growth since its inception. The cumulative dollar issuance on June 1st, 2017 was 88.02 billion USD. Since the inception of cat bonds and the first entry on Artemis' transaction database on December 1996, there has not been a period semi-annually that has not seen increased dollar issuance. From December 2016 to June 2017, there has been an increase of 8.3 billion USD in the total market size.

Figure 8: Cumulative Market Size (Semi-Annual)

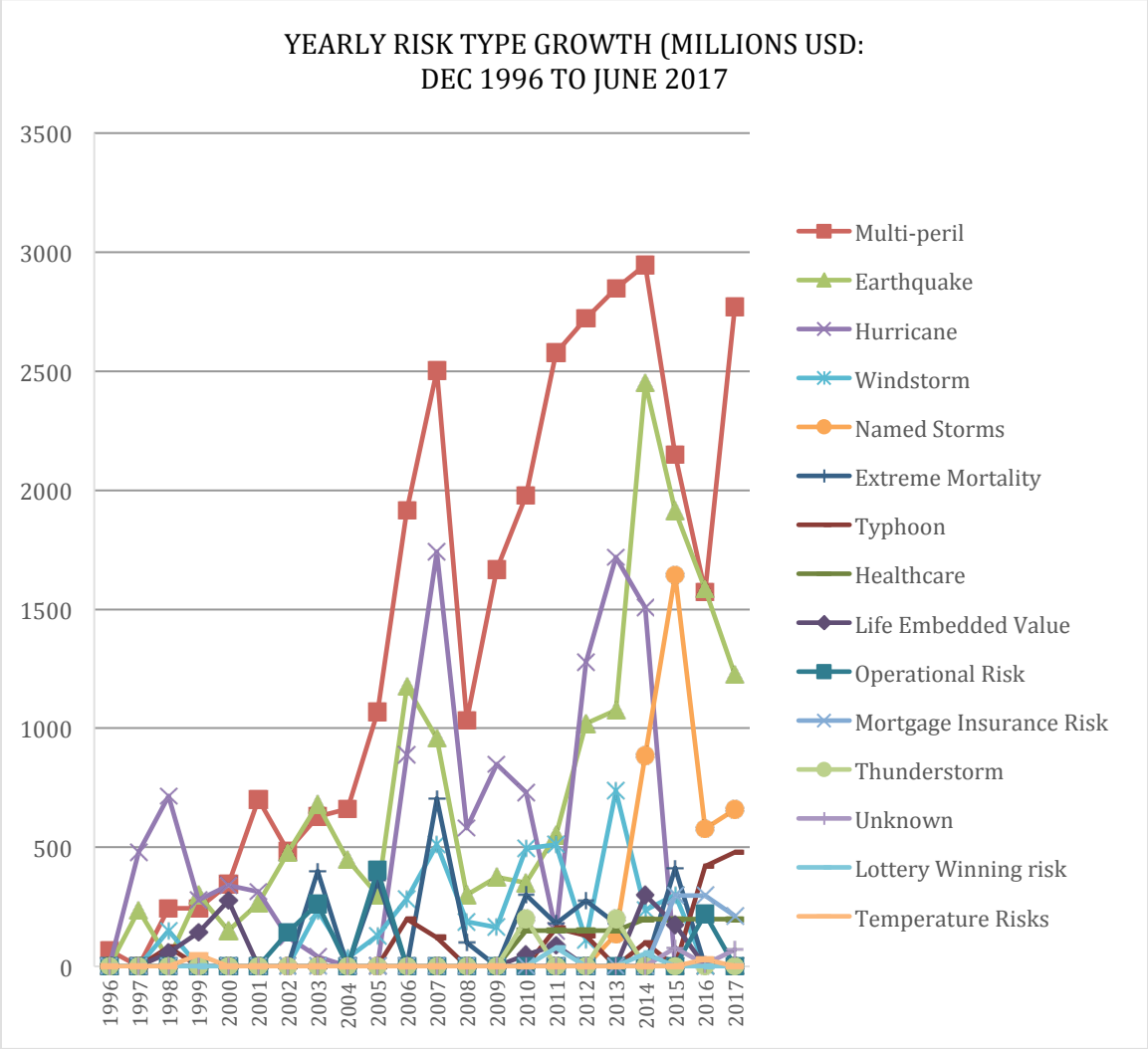


4.3.2 Yearly Risk Type Growth

Figure 9 below charts the cumulative dollar issuance of cat bonds based on risk coverage. The chart shows how coverage of particular types of risks has been reflected in the cat bond market. As discussed in section 4.2.3, multi-peril risk coverage is the most widely used. Since 1998, multi-peril coverage has been the most popular form of risk coverage for cat bonds. In 2014, multi-peril risk coverage reached its highest issuance with peak cumulative issuance at 2.95 billion USD.

Other particular risks have varied in their market representations, seeing different periods of peak dollar issuance. In 1998, hurricanes were the most popular form of risk coverage with 715.1 million USD of cumulative issuance providing hurricane coverage. In 2007, hurricanes were the second most common type of risk following multi-peril, with peak cumulative issuance at 1.74 billion USD. In 2014, earthquake risks were the second most common type of risk coverage following multi-peril, with peak cumulative issuance at 2.45 billion USD. Named storms risk coverage reached its peak in 2015, with peak cumulative issuance at 1.64 billion USD.

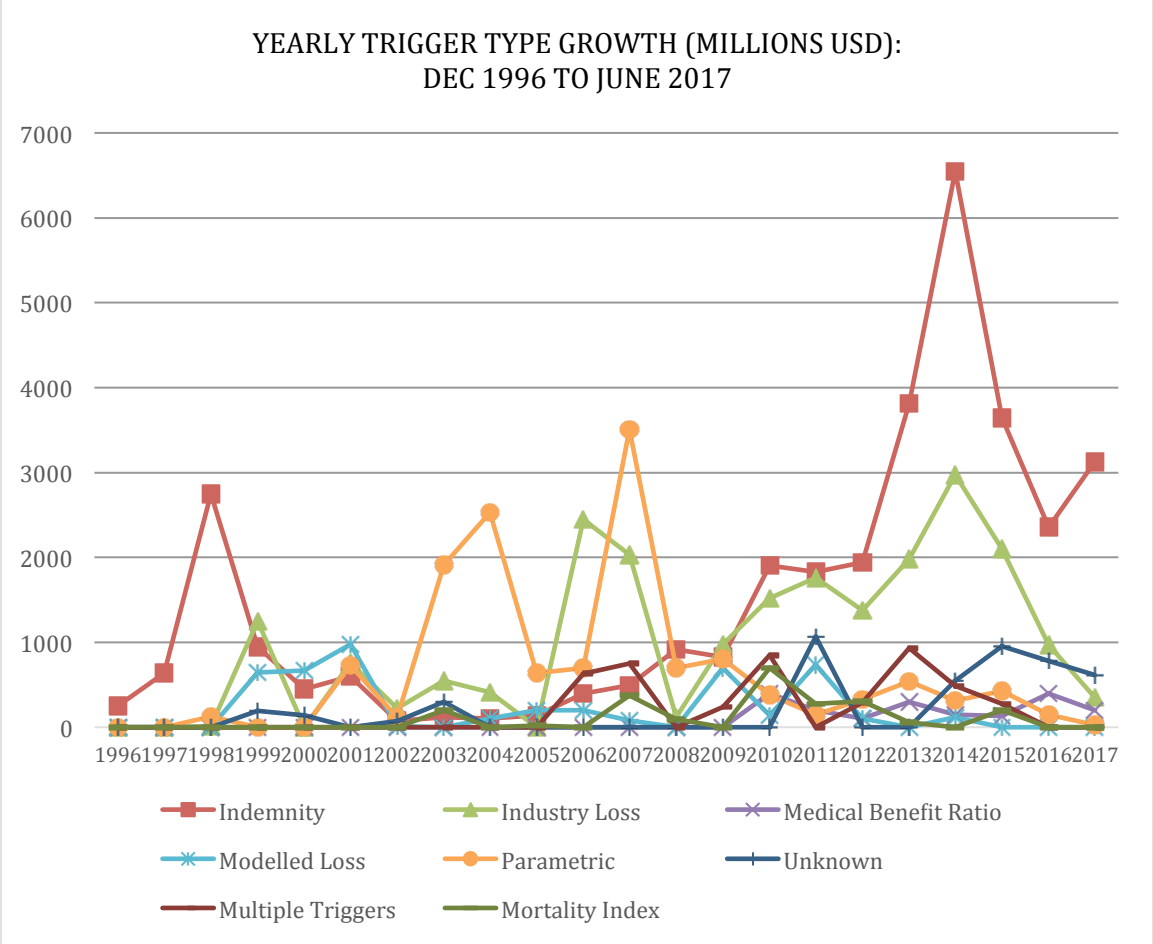
Figure 9: Yearly Risk Type Growth by Dollar Issuance



4.3.3 Yearly Trigger Type Growth

Figure 10 below charts the cumulative dollar issuance of cat bonds based on trigger types. The chart illustrates how particular trigger types have been represented in the cat bond market since inception. As discussed in section 4.2.5, the indemnity trigger is currently the most popular trigger type in the market. The indemnity trigger reached its highest issuance in 2014 with peak cumulative issuance at 6.54 billion USD. The indemnity trigger has steadily been the most popular trigger type since 2010. It was also the most popular trigger type from 1996 to 1999.

Figure 10: Yearly Trigger Type Growth by Dollar Issuance



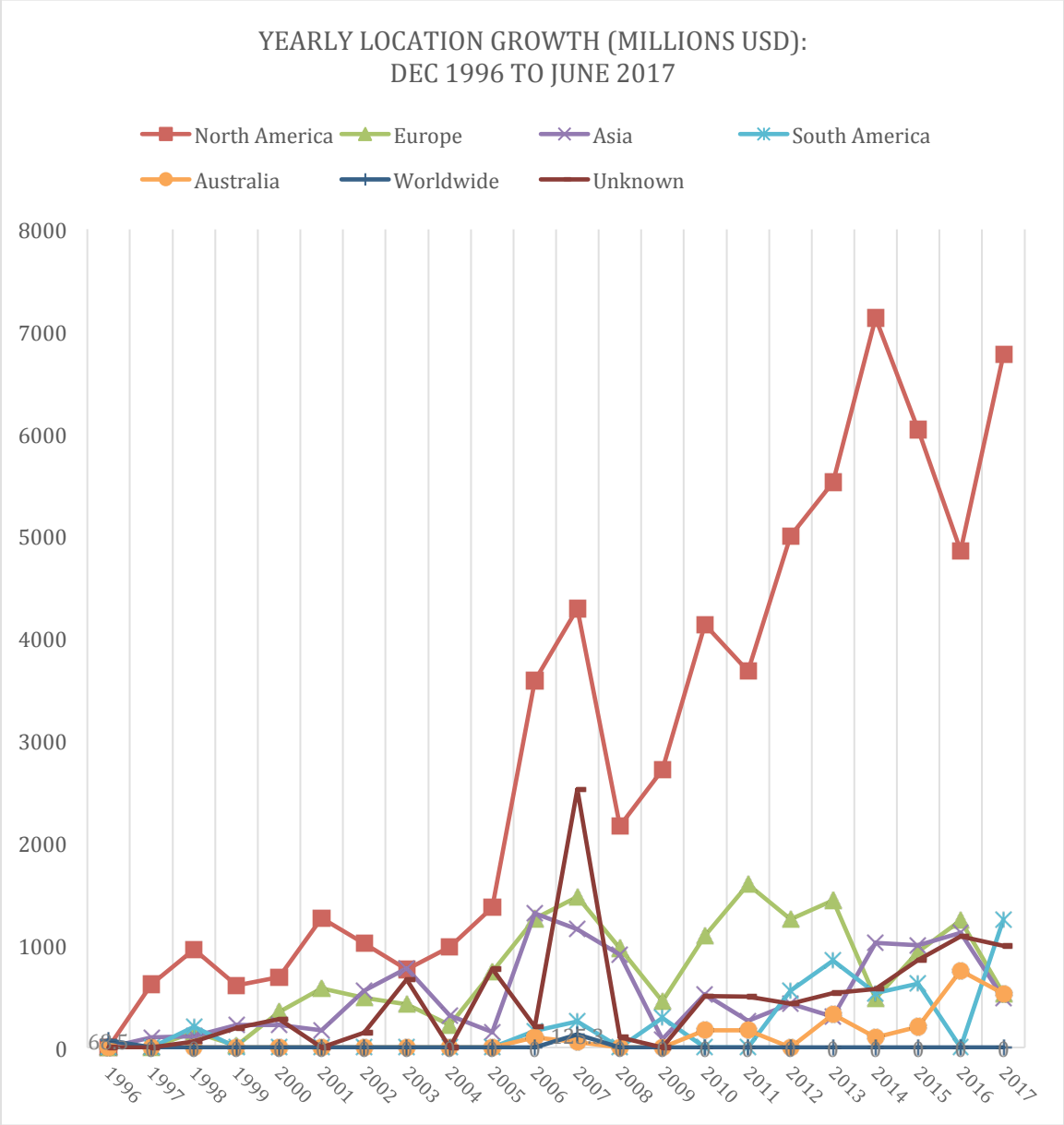
At different periods both industry loss and parametric trigger types have seen peak issuance and even outperformed the indemnity trigger in the market. In 1999, industry loss was the most popular trigger type with 1.3 billion USD in cumulative issuance. It also spiked in 2006, and was the most popular trigger type with 2.45 billion USD in cumulative issuance. In 2014, the industry loss trigger reached its peak issuance at 2.98 billion USD, but was still outperformed by indemnity at 6.54 billion USD. The parametric trigger type outperformed the indemnity trigger from 2001 to 2008, reaching peak cumulative issuance at 3.51 billion USD in 2007.

Aside from indemnity, industry loss and parametric trigger types, there are no significant trigger type growths in peak issuance. Based on the analysis of the cumulative dollar issuance from 1996 to present, the indemnity, industry loss and parametric trigger types are the most widely represented across the market.

4.3.4 Yearly Location Growth

Figure 11 below charts the cumulative dollar issuance of cat bonds based on the location of risk coverage. As discussed in section 4.2.2, North America represents the vast majority of cat bond coverage. Figure 11 illustrates how the cat bond market in North America has dominated the market since 1997. While cat bond risk coverage in North America has seen growth and stagnation, it has remained the top continental area for risk coverage since the inception of the market.

Figure 11: Yearly Location Growth by Dollar Issuance



Europe has primarily been the second most represented area for risk coverage, followed by Asia. Europe reached its peak cumulative dollar issuance in 2007 with 1.47 billion USD. However, in 2007, this still did not come close to North American coverage, which reached 4.29 billion USD. Asia reached its peak cumulative issuance in 2006 at 1.31 billion USD. However, once again this did not reach North American coverage, which was at 3.59 billion USD in 2006.

4.4 Summary of Results

This chapter has presented the results of pivot tables conducted on data from the Artemis deal directory based on specific issuance and development factors. Overall, significant details have been found through this analysis. The priority of this analysis was to identify key actors and processes in the cat bond market. This quantitative analysis has exposed the most commonly used determinants in developing and issuing cat bonds by arranging various determinants by dollar value and bond issuance. It has also identified emerging trends in the cat bond market by analyzing yearly data.

Through this analysis, key actors in the development and distribution of cat bonds have been identified. This includes the top five sponsors/issuers of cat bonds, the risk modelling companies used to identify risk and value the bonds, and the top five placement/structuring agents involved in facilitating cat bond transactions. These key actors have been identified through each of their respective bond issuances and cumulative dollar issuances. Other key factors in the cat bond market were also disclosed through this analysis. The areas that are provided risk coverage by cat bonds were identified and disclosed based on continent. The types of risks most commonly covered through cat bond issuance were also disclosed through this analysis. The various trigger types used to generate a cat bond payout and the representative usage of each type was also explained through the data analysis. Finally, cat bond investment ratings were also discussed and explored through the pivot table analysis.

In the next chapter, these results will be discussed in more detail by identifying initial interpretations of the quantitative results as well as using qualitative results for further interpretation.

5. Discussion

5.1 Analysis through Framework

To begin a discussion of the quantitative and qualitative results, the framework of analysis will be reintroduced. As mentioned in section 2.2.4, the conceptual framework that is being used for this thesis is based on the three mechanisms of financialization developed by Castree (2003) and demonstrated by Knox-Hayes (2013). This framework identifies the three main steps taken in the process of financialization. These three mechanisms are: privatization through ownership, individuation through commensuration, and displacement through mobilization. By exemplifying how each step of this process is used in the development and distribution of catastrophe bonds, they will be exposed as a form of financialization.

The discussion and analysis section below breaks up the process of developing and distributing cat bonds based on which mechanism each factor falls under. The quantitative and qualitative results will be presented and discussed based on their role within the three mechanisms of financialization. Each factor of analysis that was researched will be placed under one of the three mechanisms of financialization and discussed in this context. Each of the three mechanisms of financialization represents a specific step toward the financialization of a particular resource. By analyzing cat bonds through each of these mechanisms, the actors and procedures involved in creating and selling cat bonds will be broken down while exposing them as a form of financialization enabling compression processes.

5.2 Privatization through Ownership

Catastrophe bonds exemplify this mechanism of financialization as they are first defined by ownership. As catastrophe bonds represent risk coverage, the ownership aspect refers to the owners of the natural catastrophe risk, which in this case are the sponsors. The sponsors privatize the risks that are defined for coverage through a claim of ownership. This section of the discussion will analyze the sponsors, location of risk coverage, and the risks that are defined for coverage as they fall under the mechanism of privatization through ownership.

5.2.1 Sponsor

The first stage of developing a cat bond involves a company or institution identifying natural catastrophe risks they are exposed to and want coverage for. The first actor involved in the development of a cat bond is the sponsor. When asked about the process of developing a cat bond, participant 101 replied, "*It really begins back when an insurer, reinsurer, or even corporation begins to look at its risk transfer."* The process of developing a cat bond begins with the sponsor reviewing their risk transfer solutions and recognizing risks that need further coverage. The sponsor has to claim ownership over a particular natural catastrophe risk in order to begin the process of developing a cat bond.

The Artemis data results revealed the top sponsors of cat bonds. The top seven sponsors when analyzed by total dollar issuance and total bond issuance were Swiss Re, USAA, Munich Re, State Farm, Citizens Property, SCOR and Everest Re. Table 4 demonstrated the decreasing number of sponsors despite the increasing market size. This findings serves to illustrate the concentration of actors in the cat bond market. Participant 101 identified the majority of cat bond sponsors as insurers and reinsurers,

> "*When the market began, there was a lot of reinsurance companies because they were really the biggest and they were the ones who had the resources to test out the market. And they understood it and they could do a lot with it themselves and make it easier. But now, really, primary insurers are the main issuers. They probably make up somewhere around 40 percent of the total issuance, actually maybe even 50. And then reinsurers would be 30 and then the other 20 is a mixture of corporate government agencies and things like that."*

Participant 103 echoed a similar opinion, noting, "*It used to be only large insurers which used this product, now smaller insurers are using it."* Participants made it clear that the majority of the cat bond market is still sponsored by insurers and reinsurers. Therefore, it is insurers and reinsurers that are the prevalent actors in the first mechanism of financialization by privatizing these risks through a claim of ownership.

5.2.2 Location

Another important aspect in evaluating the privatization through ownership mechanism inherent in the development of cat bonds is the actual risks and locations that are being privatized through this process. The natural catastrophe risks that are being privatized are tied to a real spatial and temporal landscape. In the quantitative results section of this paper, the risk coverage was analyzed by location and risk. The location of specific risks helps to emphasize which areas of the world are receiving capital risk coverage through privatization and which other areas of the world have not received ownership claims over their catastrophe risks.

In the quantitative results section, Table 5 identified cat bond risk coverage by continent. Between 57 and 59 percent of all cat bond issuance provided coverage for natural catastrophe risks in North America. Europe represented between 14 and 16 percent of coverage and Asia represented 10 to 12 percent of coverage. No bonds had been issued for risk coverage in Africa and between 3 and 4 percent provided coverage to

South America. Mexico received the majority of coverage from bonds issued for risk coverage in South America. Although Asia represented a somewhat significant portion of risk coverage, the only countries that were represented in the market were China, Japan and Taiwan. Based on these observations, it is clear that the cat bond market is centralized in the developed, wealthy world and provides little to no coverage to the less affluent, developing world. While the bonds first developed in North America, based on the results, the coverage seems to be spreading to other affluent, developed countries and has not yet been significantly used in an effort to help developing countries deal with natural catastrophe risks.

Findings from the literature review revealed that some academics argued for the use of cat bonds based on their ability to help the developing world manage risk by accessing global funds to cover disasters. However, based on the quantitative findings, this has not been the case in the history of the cat bond market. Coverage is overwhelmingly centered in North America and the developing world. Based on these quantitative findings, participants were asked if they thought that cat bonds might result in insurance for the rich only, or if they believed that eventually the market could offer solutions to the developing world.

When asked why the majority of cat bond coverage was in North America, participant 102 explained the reason for the lack of coverage in the developing world,

> "*The reason why the rich are more dominant in the catastrophe bond market is simply because that's where the property concentration is, that's where the value is. Values are high on properties. Therefore, if there are reinsurance companies that are providing reinsurance protection, it becomes a concentration problem for them, and they charge more and more. Therefore, there is a need for reducing that cost, and that's where the capital market can come to play."*

Participant 102 continued by explaining that there is currently less of a need for cat bonds in the developing world,

> "*Emerging markets are actually a diversifier for reinsures, so they're able to provide that reinsurance protection very cost effectively, and there's less of a need for capital markets to step in. It's not that the capital market doesn't want to step in; it's just that there is less of a need and less of a reason to step in. It could, obviously as emerging markets become richer and richer, then additional need for buying protection and property values goes up, there is definitely a bigger role that capital markets can play."*

Based on participant 102's response, the developing world does not have a need for capital market solutions to risk transfer because they do not have any issues with risk transfer. One of the central reasons the cat bond market was created was based on the limited capacity of the reinsurance industry and an overabundance of insurance risks. However, if the developing world does not have this overabundance of risk and the reinsurance market in those countries has the capacity to handle insurance risks, is there a need for cat bonds in these markets? This line of thinking would contest climate change science, which has indicated that the developing world will suffer the majority of natural disasters and costs as a result of their geographical locations.

Participant 101 was asked the same question, and identified a slightly different reason for the lack of cat bonds in the developing world,

> "*If you look at the insurance markets in those parts of the world, even in India, where there's a very large insurance market, the insurance policies are very small- the overall size and amount of premiums is still quite small, it's growing fast, but it's not yet very big. They don't buy a great deal of reinsurance there. They also buy most of their reinsurance from within their own borders, from their companies within their own country, because their government mandates they shouldn't be sending too much money offshore. So these things hold back the development of cat bonds for the developing world."*

If the governments in developing nations want to keep capital within their own borders, they may be opposed to cat bonds, which would transfer capital to the global market. Participant 101 continued,

> "*That said- if you could make issuance cheaper, which in my opinion can be done because the World Bank can issue a cat bond through its own treasury which should be a much cheaper way to do it as possible, then there's absolutely no reason why you couldn't see national cat bonds for Cambodia, for all these other places, but someone has to pay the premium. And if the governments aren't going to pay the premiums, the insurance companies are too small, the premium levels aren't big enough, they're not using enough reinsurance, then it will just take time until those countries develop further I guess.*"

Participant 103 echoed a similar point,

> "*We talked about some of these World Bank initiatives and sometimes you have solutions in search of a problem. And I think that's what you kind of find in the Third World. There are a lot of people who are talking about providing these services or providing this catastrophe coverage, but there's not a lot of money able to pay for it because they are, unfortunately, addressing other economic concerns."*

All of the participants agreed that at the moment the developing world does not have an immediate need for cat bonds. The reinsurance market in those nations is not big enough to require capital market risk transfer solutions. Participants argued that once developing nations become more affluent and continue to grow economically, they might see cat bonds enter this market as a risk transfer solution. However, based on the quantitative and qualitative findings, the primary risks that are being privatized through ownership are in developed and affluent areas, primarily North America. Based on data and interview results, proponents of cat bonds utilizing the argument that they can offer developing world risk solutions should rethink the viability of this idea. If cat bonds are a solution to over-accumulation and capacity issues for the developed world, their use may make for a more efficient and stable risk management market. However, touting the opportunities cat

bonds pose for risk management in the developing world seems to be a problematic argument in need of further clarification.

The concentration of cat bonds in the developed world further implicates the financialization of these risks. There is a spatial link between cat bonds and where capital markets are most developed, which has resulted in the concentration of cat bonds in North America and other affluent areas. This raises the question of whether cat bonds provide risk coverage in those areas that need it or if they simply further concentrate wealth in the most developed capital markets and propel the agenda of financialization in accelerating the rates of profit accumulation.

5.2.3 Risks Covered

In evaluating privatization through ownership, a final and important aspect to discuss is the specific type of risks that are being privatized and claimed ownership of through this mechanism. These risks represent the top priorities for cat bond issuance and identify what areas of risk are receiving financial coverage through the bonds. In the quantitative results section of this paper, cat bonds were analyzed by which type of risk they provided coverage for. Table 6 identified the types of risks that receive coverage through the cat bond market.

Multi-peril coverage was identified as the leading type of cat bond risk coverage with between 42 and 46 percent of the market. Figure 9 illustrated how multi-peril coverage has seen continued growth in the market since 1998. The other top risks identified in the market were earthquakes, hurricanes and storms. Property catastrophe risk did not represent a high portion of dollar issuance in the cat bond market, but when evaluated by bond issuance, a significant portion of cat bonds had been issued with this

type of risk coverage. Participant 102 identified property catastrophe risk as a leading risk in the market, "*First and foremost, the underlying fundamental risk in catastrophe bonds is the property catastrophe- mostly- property catastrophe risk."* Participant 102 continued,

> *"The insurance industry operates to provide protection against property values and other things to their clients… for example, hurricanes in Florida, or on the east coast of the US, or earthquakes in California, cause an accumulation of risk and therefore, reinsurance companies want to take up protection."*

In this sense, most cat bonds do cover property catastrophe risks. All coverage that names multi-peril, earthquakes, hurricanes, etc., are essentially a form of property catastrophe risk in that property destruction and value loss is what is at risk with the occurrence of any of these disasters. If any cat bonds trigger based on most risk types, their payout would go toward covering property damages.

Participant 101 noted that cat bonds are beginning to be more expansive in their coverage,

> "*Cat bonds could be deemed to have slightly more restrictive cover because they are very strictly worded documentation. But, gradually, the terms- the terms aren't easing- but they are including more things in cat bonds, so you now get cat bonds that include a range of weather perils as well as catastrophe perils. So, a big insurer can cover more of the risks that they would have been buying coverage for through the reinsurance market, they can now get through the cat bond market.*"

In discussing risk coverage, participant 102 noted,

> "*You know, I think the overarching theme is that as the insurers and people become more aware of the concentration of peak risk that they have and as the property values appreciate, as the events happen, and people realize that they are exposed to it, there is a growing need for buying insurance protection, and disposing that risk. So risk management becomes important, and catastrophe bonds can play a risk model role from that perspective."*

Based on these participant responses coupled with the quantitative results, cat bonds are primarily used to cover property damages from possible near term natural catastrophes. The risk coverage continues to expand and grow, including more risks within a particular cat bond as indicated through the dominance of the multi-peril risk coverage in the market. However, as climate change threatens to increase the occurrence of natural catastrophes, an interesting question is whether cat bond sponsors and issuers view climate change risks as a top priority or a threat to their viability.

Participants were asked their opinions about the ability of cat bonds to address climate change risks in the present or the future. Participant 102 stated, "*One aspect of risk management is, you know, any climatic changes and how that potentially increases the risk and therefore, the need for risk protection. And catastrophe bonds can play a part in it".* Participant 103 agreed, noting that the industry understood the risks of climate change, but did not view them with immediacy,

> "*Climate change is certainly one factor. One of the nice things about our market is that our buyers, our customers- they're professional insurers. So they get it. They're actually feeling those exposures and they do recognize that it's a problem. But there's not a lot of immediacy to it. There's not a lot of immediate urgency, because it is down the road. And until we start seeing loss activity, you're not going to see an immediate reaction."*

Participant 102 made a similar point, arguing,

> "*I think a way to describe it is that global warming and associated climatological issues that you are referring to is a long-term trend line. But along that long-term trend line you have short-term fluctuations. You know, some years are bad- some years are good. There is a lot of noise around it. That noise also has a number of climatological factors associated with it, like what I mentioned about Atlantic multi-decadal oscillation and El Nino, La Nina cycles and many other factors like that. And those things have a bigger role to play in the short term."*

Participant 102 continued, *"It is not going to manifest itself over the next 2 to 3 years, but it will show up eventually. And catastrophe bonds will definitely play an important role on an ongoing basis"*.

Participants 102 and 103 both made clear that climate change issues are not viewed as an issue of immediacy in the cat bond industry. They viewed short-term climate trends as a more pressing issue and saw climate change as a long-term trend that would not affect the cat bond market in the near future. While they indicated that the insurance and reinsurance industry does view climate change as a concern for the industry, they are not acting on it as of yet in any significant way.

Participant 101 argued that the insurance industry recognizes that climate change is a risk and factors it in to risk coverage as much as possible, noting,

> "*Yes, it is factored in- in as much as it can be. The one thing I will say is the insurance and reinsurance industry- that includes cat bonds and ILS and all of the other areas- does a heck of a lot more than the banking industry does in terms of looking at climate risk on the assets that they hold."*

Participant 101 saw adaptation and resilience efforts as a possibility for the cat bond market in the future, but argued that different tools could be better suited,

> "*If it's just that a government wants to enhance its resilience to catastrophe risk, then it can go to the capital markets and buy insurance essentially. So that's good for them… But I think specifically, on the sort of resilience and adaptation side of things, I think we will see something come out of those efforts, but I think it will be some time and I think it will look very different to a cat bond. And the investors who actually end up backing that will probably be quite different as well, or if they are the same, it will be going into a different portfolio. Because one of the main reasons investors like cat bonds is that they don't have any financial market risk attached to them. Um- so as soon as you throw infrastructure risk or something tied to a government into that bond, um, you've kind of destroyed the low correlation argument that cat bonds have always had.*"

Based on the qualitative results, participants seem to view climate change risks as substantial, but not immediate. They see these risks as long-term and view cat bonds as

addressing short-term concerns. Cat bonds are not widely viewed as a means of adaptation to climate change, but rather, as a short-term risk transfer solution. In this regard, the cat bond market will not likely view climate change with any immediacy until the market starts to see loss activity as a result.

Climate change may increase the possibility of the risks covered by cat bonds meeting their trigger events. These interviews have demonstrated that climate change can and has been financialized by privatizing ownership and definitions of risk. While climate change risks are not viewed with immediacy, the risks that are covered by cat bonds can be affected by climate change and global warming. As climate change risks continue to grow, the privatization of these risks through claims of ownership will continue the process of financialization by using market mechanisms to offer financial coverage for these risks.

5.3 Individuation through Commensuration

Catastrophe bonds exemplify this mechanism of financialization through their transformation of catastrophic risks into credits. The process of transforming catastrophic risks into dollar amounts and creating the bonds represents the individuation through commensuration stage of financialization. Catastrophic risks are valued based on market factors and risk modelling. This section of the discussion will analyze the drivers of cat bond pricing as well as the research findings on risk modelling, trigger types and ratings as they fall under the mechanism of individuation through commensuration.

5.3.1 Drivers of Catastrophe Bond Pricing

An important step in the process of the financialization of natural catastrophe risks involves evaluating the risks and putting a price on them. There are many factors that impact the pricing of cat bonds. The risk modelling process is an important aspect of pricing that will be discussed in the section below. However, to discuss some of the drivers of cat bond pricing, this section will draw solely on interview results, as it is more descriptive and quantitative data analysis does not inform this section.

Participants were asked to describe the process of determining the value of a cat bond to explain what factors and conditions can drive pricing. Participant 101 explained, "*For the valuation of the bond- if it's a 100 million deal- that means it provides 100 million of cover. So in the same way that a 100 million reinsurance arrangement is defined by the amount of limit or coverage that's involved*". Participant 101 continued,

> *"The payment that the investor gets a hold in the risk, is pretty much akin to a reinsurance premium. So the premium payment goes to the investors instead of to the reinsurer. And then there are associated costs which are administrative, and sort of the structuring costs and things like that, I guess. So, from a value point of view, when a transaction is issued, typically a cat bond if it's a 100 million dollar cat bond, it will be split up into individual notes that are worth 250 thousand each. Those get issued at par, so at fixed cost, there are however many notes, all the transactions, and then once that goes into the market the value of those notes can fluctuate based on the time of year because of seasonality, as in what the risk of what a particular peril is, particularly if it's like windstorm or thunderstorm or something like that, changes and fluctuates throughout the year with the seasons. So that affects the secondary value."*

Participant 101 explained the process of pricing a bond. The explanation given was consistent with the findings from the literature review. The price of a cat bond is determined by how much coverage the sponsors are looking for based on a particular peril and their risk of loss. The price of the cat bond is directly linked to the price of the

coverage the cat bond will pay out. Seasonality can affect the pricing based on particular risks throughout the term of the cat bond.

Participant 102 explained some of the drivers of cat bond pricing and what can make the prices increase and decrease. The first point involved the state of the market from the insurer perspective,

> *"When there is abundance of capital available, clearly there is a pressure on the pricing. When there is a dearth of capital, which typically happens after some kind of an event, there is less capital available, and then there is demand for higher pricing. And the reason for that is obviously because the cost of capital goes up when there is dearth of capital. So one of the main factors is of course what is happening in the traditional reinsurance market, how much capital is available, supply demand dynamics in the market."*

The amount of investors and capital available for cat bond investment at a particular point in time can drive pricing. When there are a lot of investors and an abundance of capital in the market, cat bond pricing decreases. However, when there is limited capital and investors in the market, cat bond pricing increases. Participant 102 explained a second driver of pricing from the investors perspective,

> *"Secondly, from the investors perspective also, how does the catastrophe bond and other capital market investments compare with the other investments, other asset classes…So what is happening with the spreads on that side. There are different historic time periods where the spreads of catastrophe bonds reacted differently. So, for example, after Hurricane Katrina, where there was a depletion of capital, the spreads of catastrophe bonds went up. Simply because it went up, capital became expensive. So spreads on catastrophe bonds went up. Whereas, if you think about what happened after the financial crisis or during the financial crisis in 2008 and early 2009, catastrophe asset classes widened out significantly, the risk premium went up, high yield bond spreads went up, and catastrophe bond spreads also went up."*

Participant 102 is explaining how the pricing of bonds can go up based on the performance of other investments classes. As cat bonds have a low correlation to the rest of the capital market, their popularity could increase when other asset classes are

performing poorly, thus affecting pricing. However, as cat bonds are correlated with natural catastrophe risk, as weather risks increase, their popularity could decrease, also affecting pricing.

The results from the qualitative interviews describing the drivers of cat bond pricing were consistent with findings from the literature review. The pricing of cat bonds represents the individuation through commensuration mechanism of financialization through its conversion of natural catastrophe risks into exchangeable assets.

5.3.2 Risk Modellers

In discussing the process of identifying and pricing natural catastrophe risk, catastrophe risk modelling is a very important element. The risk modelling companies that perform an analysis of natural catastrophe risks for sponsors and investors have a significant amount of control over which risks are identified and their importance. Participant 102 explained,

> "*There are third party independent firms who have spent a lot of effort into developing statistical models to model those things. And those are probabilistic models, so they give you the probability of events happening. And they also look at the exposure data and calculate the potential losses that could happen. And there are a couple of well-known, well-established players in that market who perform this analysis."*

The quantitative data results identified the top players in the risk modelling market who conduct the majority of cat bond risk analysis. Table 7 identified the risk modelling companies by the amount of bonds issued which used their services as well as the total dollar amount issued using their services. AIR Worldwide was identified as the top risk modelling company, with 44 percent of total cat bond dollar issuance utilizing their risk modelling services. RMS was the second most popular service with 19 percent of total

cat bond dollar issuance utilizing their risk modelling services. The other risk modelling companies were all below 10 percent of total dollar issuance in the market. Discovering that two companies conducted the majority of risk modelling services was very surprising and warranted further inquiry.

Participants were asked if they had any concerns with the fact that the same two companies performed most of the risk analysis for cat bonds. They were also asked if they were aware of any challenges or data gaps in the risk modelling industry. Participant 102 answered,

> "*One of the good things about property catastrophe is that we have plenty of historical data for some key perils… For many peril zones, the analysis is, you know, robust. There is wide availability of these tools, and of course you have to pay for it and all that. But they are available, and one can use them. But then there are other perils where the credible models either don't exist, or if the model exists, there are gaps in it. So for those things, underwriters actually use actuarial techniques to do the analysis. And it's not all that different from what reinsurance companies have been doing for years. So, underwriters who are in reinsurance companies are able to do that analysis very effectively."*

Participant 102 argued that current risk analysis techniques were robust and did not show concern about the dominance of the market by two companies. Participant 101 expressed a bit more concern over this market dominance, but argued that most investors utilize more than one service,

> *"I see reasons why a complete reliance on three companies view of risk is not always the best thing in the world. Especially when you look at the differences between the model outputs. So, you could see one model telling you that the same risk is nearly twice as risky as another model tells you. That makes it very, very difficult for insurers and reinsurers. But, I don't know anybody who relies only on those models, I really don't. I don't know any investors who only rely on those models, pretty much everybody is taking a model, looking at it as an indicative baseline and then they're laying on top of it their own assumptions and their own view of risk. Some people create their own models as well. Most of the funds that invest in cat bonds will run at least two of those models, plus their own models, and they look at everything multiple ways with their own fine tuning on each of the models as well."*

Participant 101 seemed confident that investors did not rely on only one company's view of risk. Although they may identify one company as the primary risk modeller, participant 101 argued that they also utilized the services of many other modellers, some even creating their own models of risk. Participant 101 continued,

> *"The problem is there is no- I mean these are uncertain events. For example, an earthquake, while you might think it's a one in a hundred year event, you could have six of them in a row in two days, nobody knows. And nobody can really predict that. So they can only look at the available data I guess, and come up with a view of risk that they're comfortable with, based on sort of using their own expertise as well. But yeah, I mean, it's a problem that there is no clear standard for viewing these risks. But at the same time it's not possible because when are you ever going to have consensus on that sort of thing."*

Participant 101 identified that it was problematic to not have a clear standard for risk modelling, however, argued that this would be impossible. Views of future risk will always be varied and it is impossible to have everyone agree on one prediction. Participant 101 was fairly consistent with participant 102, both confident that the risk modelling was robust.

An area of interest was whether risk modellers factored climate change into their risk analysis. Participants were asked their opinions on if- and how- risk-modelling techniques factored climate change risks into their analysis. Participant 103 noted two different approaches to risk modelling: long-term and short-term. The participant noted that short-term modelling is more relevant to day-to-day underwriting and pricing, saying, "*It's long-term planning over day trading. Neither is wrong."* Participant 102 also identified short-term risks as more important to risk modelling than long-term climate risks,

> *"There are some other climatic factors that come into play when we do the evaluation of catastrophe bonds and those are things like El Nino, La Nina, Atlantic multi-decadal oscillation and things of that nature, that on the shorter term, have a bigger impact on the potential for losses than the long-term climate factors that you are referring to. If you think about it, the catastrophe bonds that we are evaluating, we are buying, issuing etc., are typically, you know 2 years, 3 years, 4 years. The climatic factors that you are referring to are actually long-term phenomenon. So yes, eventually they will have an impact, but over the next 2-3 years, the analysis is pretty solid based on the historical data and on the stochastic model that we have available."*

Participant 103 echoed a similar sentiment, noting,

> *"You can't draw a direct correlation to any individual event to climate change. But if the trends are real, you better be planning for it. Really, all insurance companies do that; they're all recognizing it. But there are other trends in aggregation of values in these exposed zones. So to the point you made at the beginning with Hurricane Andrew, you've gone from 15 billion of exposure to 150 billion of exposure. That's much more short-term and it dwarfs the climate change in whatever analysis you're given. Like, that has a very real effect. You've already factored that in and it's a bold increase of exposure if the exact same thing happens, so that's explicit. The climate change isn't a problem of that event happening today. At this juncture, there's certainly some re-evaluation of probability, but I wouldn't say explicitly, driven by climate change. I think it's just more driven by observations and trends and all that. I think it's definitely there; it's just not a large driver today."*

Both participant 102 and 103 believed that short-term risks were more relevant to the cat bond market and should have more of an effect on risk analysis and pricing. Incorporating climate change into risk modelling was viewed as a long-term strategy that was not of immediate necessity.

Participant 101 argued that climate change was incorporated into risk modelling as much as possible. When asked the same question, the participant said climate change was factored into risk analysis "*As much as it can be".* The participant continued,

> *"The investors tend to get the data and the view of risk with just the standard model output, and then with a stressed sensitivity test from the models, which simulates things like warm sea surface temperatures… Air temperatures and things like that, and then the general warming of the climate, I mean, as I said, they look at warm sea surface temperature scenarios, which covers a lot of that.*

But to be honest with you, I mean these are risk models and climate models. They do allow you to make changes based on that and people do look at that. But, I don't know of a modelling platform that provides a definitive view of what the climate is going to be like in 20-30 years time. All you can do is apply factors of maybe its two degrees warmer, maybe the sea levels two feet higher. And see how that affects your scenario models and then how that affects the covered portfolio. And people do that all the time, that's kind of what their job is in the modelling department."

Generally, the participants believed that risk modelling techniques were robust and as accurate as possible. They saw short-term, immediate risks as more relevant to risk modelling. They agreed that there is not one right way to view risk and there is not a standard model of risk. The risk modelling companies provide various simulations and possibilities depending on what the climate may be like in the future. However, a lack of a standard agreement on to what degree climate change factors should be included in risk modelling seems problematic. If risk modellers are presenting standard model outputs as well as stressed sensitivity tests with various predictions for the future climate, how is the level of risk decided? The process of risk modelling does not seem dangerous or problematic if we assume that climate risks are being estimated and accounted for accurately. However, based on the lack of standardization, it is impossible to account for this. If risks are being underestimated in the modelling process, the significance and pricing of risks could be incorrect and lead to economic and adaptive challenges.

The modelling of natural catastrophe risks represents an important step in the individuation through commensuration mechanism of financialization. This process of risk modelling identifies risk, converting it to a particular level based on their models. This process is key in converting natural catastrophe risks into exchangeable assets by placing boundaries on these disasters based on their possible effects and agreeing upon a transferable value based on this model of risk. The concentration of modelling companies

also signifies the commensuration stage of financialization. The concentration of the risk modelling on specific companies demonstrates the similar metrics of evaluation and material boundaries used to covert environmental risks into assets and commensurate risks.

5.3.3 Trigger Types

An important aspect of the individuation through commensuration mechanism of financialization involves defining a metric of evaluation and putting legal and material boundaries around a specific asset in order to define a standard and make the asset transferable. Identifying a trigger type for a cat bond is a definitive example of simplifying the variables and defining a clear metric to simplify the transferability of catastrophic risk. Trigger types are conditions that identify the exact circumstances for pay out of a cat bond.

The quantitative data results identified the top trigger types used in the cat bond market. Table 8 identified each trigger type based on bond issuance and dollar issuance. The indemnity trigger type was identified as the most dominant trigger type in the market with between 47 and 39 percent of bonds using this trigger type. Industry loss was the second most dominant, with between 24 and 25 percent of the market. Parametric was the third most dominant, with between 16 and 11 percent of the market. Figure 10 illustrated how different trigger types have dominated the market through its history. The indemnity trigger has been the most dominant since 2010. However, prior to that, the parametric trigger was the most dominant from 2001 to 2008. The industry loss trigger was the most dominant in 1999 and 2006.

Based on their expertise, participants were asked to explain why they thought the indemnity trigger has become the most dominant trigger type on the market. Participant 101 identified two reasons for the dominance of the indemnity trigger on the market,

> "*I think the reason it dominated was two-fold. One, the insurers and reinsurers who want protection, that's what they're used to, that's how they're used to buying protection. And the insurance and reinsurance industry is notoriously slow at embracing new ways of doing things. The second reason is that brokers have really pushed the market in that direction as well. The brokers have been very keen to be able to offer a cat bond as a comparable product. Now if you talked to some of the biggest investors in the space, they will all tell you that they would much rather have a portfolio of parametric cat bonds. Because for them, that makes life so much easier. But the insurance and reinsurance industry really is not yet capable of stepping away from the indemnity paradigm and looking at how to buy protection in a more parametric manner*."

Participant 101 explained that the insurance and reinsurance industry prefers the indemnity trigger, while investors have a preference for the parametric trigger. Participant 102 and 103 gave answers that were consistent with this opinion, but explained the reasons for the insurer and investors preference. Participant 102 explained,

> *"In the past the parametric triggers were you know, a little more prevalent. And the advantage from the investor's perspective, there is better transparency with the parametric trigger. Indemnity trigger is basically, the investor has to be comfortable with the underwriting of the reinsurer, not just with the frequency and severity of the event, but that's one thing. From the reinsurer or from the insurer perspective, the advantage of the indemnity trigger is that it minimizes the basis risk. With the parametric trigger, they would incur a certain amount of losses, but then from the investors place, the losses are not going to be exactly the same, they will be more or they will be less. And the recovery they get from a catastrophe bond therefore, may be sufficient or it may be more than sufficient. So basis risk is involved in using the parametric trigger. On the other end for indemnity trigger, whatever losses the insurer support, that's what they collect, providing the terms and conditions are met from the catastrophe bond insurance. So there is minimizing of basis risk, and that's one of the reasons why it's a better fit for the insurers. And investors have become more comfortable around doing this thing, partly because they have hired sophisticated underwriters to do the investment management, to do the analysis."*

Participant 102 continued,

> "*Parametric is super-efficient, but it also poses a problem for the insurer, that recoveries are not going to be equivalent to the loss that they take and it reaches the basis risk. And as investors become more sophisticated in understanding the underwriting of what's insured, most parties have come to the conclusion, you know, that indemnity makes sense for better functioning of the market and for the market to grow.*"

Participant 103 provided a similar answer, agreeing that investors would prefer the parametric trigger, as it is more straightforward and simple for them,

> *"This is oversimplified, but the only reason bonds were structured on a parametric trigger originally was to keep it simple for the investors. So if there's a hurricane, let's say that's the parameter, you know what that is, you don't really care whether the insurance company issued the policy. You just say, this event occurs, I pay."*

Participant 103 gave an example of how the parametric trigger can result in a mismatch of funds, where too much or too little coverage can be provided even when the parametric circumstances are met,

> *"There was a bond in Mexico, that had- not a full recovery- but a partial recovery. And it was intended to cover emergency services if there's an earthquake in Mexico. So they said, "oh this is a really good mechanism because when there's an emergency, we want a quick recovery. So we want it to be parametric, we get the money and we're able to deploy immediately". It made all the sense in the world. The problem, when the events occurred, parametrically, there wasn't actually an emergency. It wasn't a big populated area, and so they got the recovery but they didn't really need it. So in a way, there was absolutely a mismatch. For all of those reasons, the market's moving more towards indemnity, so there's going to be less of a mismatch, you know, so I think the market is actually addressing that problem by shifting from the parametric to the indemnity."*

While the parametric trigger may seem more straightforward for investors as they know exactly when to pay out and by how much, examples like the one given by participant 103 indicate that indemnity may be a better fit for the market as it eliminates basis risk and ensures that sponsors will receive what is needed to cover damages.

The qualitative and quantitative research results were consistent in analyzing trigger types. The interviews helped to add insight and clarity into why particular trigger types prevailed. By utilizing particular trigger types and centering the market around one or two particular triggers, the liquidity and transferability of natural catastrophe risk is simplified. These trigger types are a clear example of defining specific metrics and boundaries to an asset in order to simplify the exchange process. Defining a trigger type is an important example of the individuation through commensuration mechanism of financialization as it relates to the liquidity process of cat bonds.

5.3.4 Ratings

As mentioned in section 4.2.6, around 45 percent of all cat bond data that was analyzed did not provide any rating information. This rating data is included in the discussion for personal interest, but should be given limited bearing based on the significant portion of data that was not rated. Between 34 and 31 percent of cat bonds were given a substantial credit risk rating. Between 19 and 17 percent of cat bonds were given a high credit risk rating. The rating of a bond is an important step in the liquidity process as it provides investors with important information and allows them to categorize different assets through an established metric of evaluation. These ratings can help investors to make important decisions about adding particular assets to their portfolios and evaluating risk.

Participant 101 was asked to comment on why cat bonds were given substantial or high credit risk in their ratings,

> "*The reason they're rated not very highly is because… the rating was based on the lowest of the counterparty credit risk and the catastrophe risk. And it's always the catastrophe risk. And that is the major risk in there. And that's what the credit rating is based on. So it's not really- I don't know- nobody rates cat bonds anymore. I haven't seen a cat bond rated, or actually there's been one tranche of*

> *a cat bond that's been rated so far this year, out of 60 or 70 tranches. Nobody bothers anymore because the investors don't want them because they know they're not really reflective of the risk that they're really worried about. A cat bond is a pure catastrophe risk, there's not real counterparty risk, because the collateral is held in trust accounts in as good as cash. There's no default risk apart from the catastrophe happening really. So, yeah, I don't know, I wouldn't read too much into the ratings the rating agencies give them."*

Participant 101 explained that the ratings are particularly low because of the high catastrophic risk inherent in cat bonds. Typically, low ratings represent things such as high counterparty credit risk or default risk. However, as cat bonds are virtually uncorrelated to the wider financial market and have little to no counterparty credit risk, their low ratings are a result of another risk. The risk of the natural catastrophe occurring and the bond triggering is the reason for the low credit ratings that cat bonds are given.

Investors that are in the cat bond market are assumed to be aware of the natural catastrophe risk they are taking on when investing in a cat bond. Depending on one's view of risk, natural catastrophe risk could be deemed more substantial than typical asset investment risks, such as default or counterparty credit risk. However, if investors are accustomed to viewing ratings based on typical asset investment risks and are aware of the substantial or high catastrophe risk they are taking when investing in cat bonds, the ratings may not be important or indicate anything substantial. Although, it may be helpful to remind investors of the high risk involved in investing in cat bonds through the rating system. The rating system supports the commensuration stage of financialization by using clear metrics of evaluation in order to make assets transferable. These ratings can be viewed as boundaries or standards used in order to simplify the process of transforming assets into cash and given transferable valuations.

5.4 Displacement through Mobilization

Catastrophe bonds exemplify this mechanism of financialization through their complex market trading infrastructures and investments. While catastrophe bonds represent risks that are embedded in a particular time and space, by transforming risks into financial figures and selling them to investors, the risk is displaced and mobilized from the real temporal and spatial aspects. This section of the discussion will analyze the process of exchange in the cat bond market by evaluating the placement/structuring agents, investors and market growth.

5.4.1 Placement/Structuring Agents

In evaluating the displacement through mobilization mechanism of financialization as it relates to cat bonds, an important aspect are the actors involved in mobilizing the transfer of the assets and facilitating trades. The placement/structuring agents are directly involved in the market infrastructure which facilitates the process of exchange and investor participation. These agents mobilize the assets by structuring a deal between sponsors and investors and further displacing natural catastrophes from their real spatial and temporal aspects.

The quantitative results section of this paper identified the top five placement/structuring agents by total cat bond dollar issuance and bond issuance. Table 10 and 11 identified the top placement/structuring agents in the cat bond market as Goldman Sachs, Swiss Re, Aon Benfield Securities, GC Securities and Willis Capital Markets. These agents are large corporations providing reinsurance, advisory services, securities and investment management and banking services. These corporations are responsible for structuring deals, dividing up bond profiles, marketing the bonds to

investors and facilitating transactions. Participant 101 explained the role of brokers and structuring agents in the cat bond market,

> "*They'll* [the sponsors] *engage sort of a broker/dealer type, capital markets unit, who will look at different possible structures and tranching the transaction and things like that. And then, I would say it's probably a 4 month process still for a full blown cat bond from the initial modelling beginning through to actually sort of running the book and marketing it to investors. The bit that's really sped up in recent years is the investor allocations to it. So, going back 10 years, deals could be marketed 3 months and then they have a round of meetings around the world with investors and things, now a days that usually happens in about 2 weeks. So that's really sped up a little bit.*"

The role of these agents is vital to the mobilization of natural catastrophe risks through cat bonds. Financialization seeks to constantly mobilize assets more quickly and easily. As explained by participant 101, this process of structuring and tranching the transaction, marketing the bond and facilitating a trade has sped up recently. The role of third party agents in facilitating these transactions represents how assets are displaced in space and time through market infrastructures designed to mobilize assets as quickly as possible.

5.4.2 Investors

The key actors involved in the mobilization of natural catastrophe risks are the investors that invest in cat bonds and offer capital to cover these risks. The types of investors involved in the cat bond market and their role in the displacement of natural catastrophe risks from spatial and temporal aspects is key to understanding the displacement through mobilization mechanism of financialization. In discussing investors in the cat bond market, this section will draw solely on interview results. There is no available data on investors in the space as there is no requirement to disclose investor information. The participants are very knowledgeable about the types of investors in the market based on their own experience with cat bonds and relationships with investors.

Participant 101 explained the types of investors that are typically involved in the cat bond market based on sponsor expectations,

> "*The insurers and reinsurers who issue cat bonds want to see institutional money on the back end of it because that's one of the things that gives them comfort, that the moneys always going be there, and that these are people that are going help them grow this market into sort of a more meaningful piece of their reinsurance as well. Cause that's really important to the sponsors, they want to know that this is not just investors who are here to bet, and try and make a quick sort of buck out of this market. They want people who are going to be there year after year after year after year, so that their reinsurance program they can make use of the capital markets increasingly. So they want to see the big pension funds of the world, the big investment banks and things like that, backing these things."*

Participant 102 echoed this sentiment, indicating concern from sponsors about the types of investors in the space. Sponsors want to ensure that these investors will stick around and continue to provide capital after disasters,

> *"There is always this question in the mind of insurers in general, if there is a large event, would the capital market investors be around after the event, and continue to provide them the coverage? You know, historically we have had a few events and the capital market has just continued to grow and the cat bond market has continued to grow. So, it's very encouraging to see that."*

Sponsors want to keep large scale institutional investors in the cat bond market in order to ensure that they are able to provide continued capital funds to cover their reinsurance needs. Participant 101 argued that more investors are continually being drawn to the cat bond market as it becomes more familiar to them,

> "*The returns that investors are willing to accept continue to come down as more and more investors become familiar with the asset class. So there are more and more investors now looking to enter the asset class who've spent, in some cases, I know people who spent 8 to 10 years analyzing the space before they actually deployed any capital into it. And as they come online, some of the investors are quite big, and they have quite a lot of money to deploy*."

Participant 102 explained that investors are becoming more comfortable with the market, "*Investors have become more sophisticated. They have developed or acquired tools for*

doing the analysis. They've hired the right people to do the analysis, and it develops and becomes very specialized". Participant 102 continued, explaining why the cat bond market was so compelling to investors,

> *"For investors, investing into catastrophe bonds provides a very compelling- there is a compelling argument for that. Based on that the underlying fundamental drivers of losses in catastrophe bonds are completely uncorrelated with macroeconomic factors…Moreover, even within the catastrophe bond, different perils have virtually zero correlation… So it serves a very important purpose from that perspective in a portfolio of an investor. The catch is though, catastrophe risk is by nature something that is a tail risk and unstable by nature. So investors need to be very sophisticated in understanding and taking this risk. To the extent that what I laid out, that they have a complete understanding and can do a complete analysis, it serves a really good purpose and moves your efficient frontier in the portfolio in the right direction, improving your risk tolerance profile."*

Participant 103 explained that the market is continually getting more complex for investors as they become more comfortable with the market risks,

> *"It's getting more complex. You're not talking about very simple clean risks anymore. You're talking about much more complicated exposures being assumed by the market. And that's simply because as the market gets comfortable with this, they're willing to take up more and more. So it used to be that the cat bond market was 1 percent risk paying 8 percent spreads and it was all either parametric or index based. Now, you're seeing a wide range of loss expectations, a wide range of yields, you're seeing all sorts of exposures being transferred into the capital market. So it's just a much more complicated market than it was in the past."*

As investors become more comfortable with taking on catastrophe risks and the market becomes more complicated and complex, there are concerns that the cat bond market could pose systemic risk to the financial system. As discussed in the literature review, scholars have criticized the cat bond market for underpricing catastrophic risk and risking large sums of money being lost when the bonds eventually trigger. Participants were asked whether they thought that cat bonds could pose systemic risk to the financial market. The participants did not agree with this argument, noting that the cat bond market

is much too small to cause any systemic damage to the broader financial market.

Participant 102 argued,

> *"I will put it this way, the catastrophe bond market- or I'll go beyond that and say if you look at the entire property catastrophe reinsurance market, and say if you look at that versus the size of the capital market, it's apples and oranges. I mean, the capital market is multiple times the size of the catastrophe bond market. In any investor's portfolio, typically cat bonds would be 1 to 2 percent and sometimes even less than 1 percent of the portfolio. How can that cause significant disruption to that particular investors portfolio if something goes wrong?"*

Participant 101 echoed this point, arguing, "*It's a 28 billion dollar market at the moment. It's really quite tiny compared to the sort of market that would cause a systemic default risk anywhere in the world"*. Despite participants' beliefs that the market was too small to cause systemic risk, they each pointed out the importance of investors being aware of the risks before entering the market. Participant 102 said,

> "*It is very important for investors to be able to analyze this risk properly because it's not a typical risk that you see in other asset classes. Because at the end of the day, you are providing tail protection, you are providing catastrophe protection. It needs to be understood very well by the investors and that becomes very important. And so far we have seen it has been that investors engage specialized managers, you know investment managers to do that analysis, or hired very sophisticated underwriters in their own organization to do the underwriting and analysis and things like that. So that's very encouraging.*"

Participant 103 made a similar point, noting,

> "*That was kind of a binary scary, like all good or all bad. What we're really seeing is market-pricing adjusting…There's some supply and demand of capital out there, and it's a good compliment to portfolios, but it's certainly not a solution. It certainly shouldn't replace the totality of anyone's investment portfolio. It should be a component. And as long as people are handling it that way, it's definitely not going to expose the financial market to systemic risk. You still have to be very careful, individual participants, if you're going to be in this market, you've got to know what you're getting in to. But yeah, I don't see systemic risk, and even more so, if there were to be a big event that were to wipe out a lot of the capital, I believe there's a lot of money on the sidelines that would actually come in, recognizing that there's probably going to be a rate increase that they can take advantage of. So I think it's a pretty sustainable market at this*

> *juncture. I don't see a lot of things derailing it. So, I think it's a healthy component, not a disruptive component."*

All of the participants dismissed the possibility of systemic risk based on the size of the market and the calibre of investor. Each participant explained the importance of investors understanding the market risks before entering the market. Participant 101 also noted the importance of investors being fully aware before entering the market. The participant argued that the investors in the market are responsible and aware,

> "*It's like any financial market. You have investors who potentially might get into it who don't understand what the market is. But, I mean the investors I know in this space are not betting that there isn't going to be a catastrophe. They are willing to take on the risk that there is a catastrophe because they feel the return is worth having. They feel that's a risk worth taking, compared to the risk of other asset classes. So if you think of what else they could put their money in, they could put it in infrastructure, they could put it in environmental bonds, green bonds, they could put it in mortgage bonds, whatever it happens to be. The risk-return kind of toss up between one asset class and another makes cat bonds seem quite attractive to the investors. So they aren't- these aren't people who believe there's not going to be a hurricane for another 10 years in Florida, these are people who accept that there will be a hurricane at some point and they will lose a lot of money at that point, but they feel the return they get is worth having*."

While all of the participants agreed that the cat bond market did not seem to pose any significant systemic risk, participant 102 noted that it could potentially cause crisis for the insurance industry,

> "*If for any reason capital markets become the dominant provider of reinsurance protection in property catastrophe and something like a large event takes place and suddenly investors become sour on it, then the insurance industry might actually see crisis go up for their protection. So I don't think it is actually going to disrupt the capital market, but it could disrupt the insurance industry. Although I personally believe that is unlikely given that the investors so far have shown clear understanding of the risks they're taking and investors have understood what the risks are.*"

The participants did not show concern over systemic risk from the cat bond market. They expressed the importance of investor diligence before entering the market, but seemed

confident that investors in the market were prepared and aware of the risks. The market is arguably too small to cause any significant systemic risk to the financial system.

While the cat bond market may currently be too small to cause any concern over systemic risk, participants also discussed the continual and expanding growth witnessed in the history of the market. Although cat bond investment may currently represent an insignificant risk to the financial market based on its limited size, the increasing growth of the market may be a cause for future concern. If we assume that investors entering the cat bond market are diligent and aware of the risks, the market may not pose any significant danger for underestimating catastrophic risks. However, as participants noted, more investors are entering the market and taking on more complex and substantial risks. If these investors continue to become more and more comfortable with these types of catastrophic risks, and coverage continues to become more and more complex, how can we ensure that investors are not under evaluating these risks? As the cat bond market continues to grow and catastrophic risks are continually transformed into assets and mobilized through investors, can we be confident that investors are accurately analyzing risks? As discussed in section 5.3.2, there are many different views of risk and climate change. If climate change risks are underestimated through this process of mobilization and displacement, there is cause for economic and adaptive concerns.

5.4.3 Market Growth

In order to demonstrate the effective financialization of natural catastrophes through displacement and mobilization, the market growth of cat bonds provides an effectual example. The quantitative results illustrated in Figure 8 showed the steady and cumulative growth the cat bond market has seen since inception. In the most recent six

months, from December 2016 to June 2017, there has been an increase of 8.3 billion USD in cumulative growth.

All of the participants responses were consistent with the quantitative findings, in that each of them argued that the market was continually growing by more substantial amounts every year. Participant 101 noted,

> "*There has been more transactions in the last month or so then we've ever seen at this time of year. This is always the busiest time of year but this year is the busiest by far. The issuance for 2017 is already past seven billion, which is ahead of the full year issuance in 2016. The market has just hit another record, it's just passed 28 billion, the outstanding size of it, which is the third time this year it's reached a record*."

Participant 102 argued that the market would continue to grow as a result of society becoming wealthier and property values continuing to increase,

> *"In general, if you think about it, as people become, for lack of a better word, more affluent, the society becomes more affluent, the property values go up, there is more disposable income available, there is need for better protection anyway, so we expect this market to continue to grow."*

The cat bond market has a cumulative issuance of approximately 88 billion USD and an outstanding issuance of approximately 28 billion USD. While the market is still relatively small, it has continued to grow consistently since its inception. As climate change risks may create more need for property protection, the cat bond market could see even more significant growth in the coming years.

5.5 Financialization and Implications for Spatial and Temporal Compression

The analysis and discussion of the quantitative and qualitative methods and results for this paper have attempted to expose catastrophe bonds as a form of financialization enabling spatial and temporal compression. This section will analyze how the results have successfully exposed cat bonds as a form of financialization through the three mechanisms of financialization framework analysis. Then the implications of this analysis for the spatial and temporal compression of natural catastrophes will be discussed.

The actors and processes involved in developing and distributing cat bonds were identified within each mechanism of financialization. By exposing cat bonds as utilizing each mechanism of financialization through the framework analysis, they are exposed as a form of financialization. The steps involved in developing and distributing a cat bond are the same steps involved in the financialization of any asset. Catastrophe bonds exemplified each mechanism of financialization through the process of ownership, commensuration and mobilization. Catastrophe bonds turn natural catastrophes into assets by privatizing the risks through the sponsor's claim of ownership. This ownership is further privatized through the increasing concentration of actors. Then, these natural catastrophe risks are given a monetary value and specific metrics and boundaries through risk modelling, pricing, trigger types and investment ratings. The assets are then mobilized through an established market infrastructure of structuring agents and brokers who facilitate this displacement and sell these risks to investors.

Returning to the original concept of financialization used for the purposes of this thesis by Knox-Hayes' (2013), cat bonds can now be exposed as a form of financialization. As discussed in the literature review, financialization diminishes the

importance of use value over exchange value through a distortion of material values. Commodities are abstracted from their real space and time, and future use value is treated as present value. Catastrophe bonds remove natural catastrophe risk from real space and time and reduce risks to financial exchange values. The future costs of these risks are treated as present costs to be bought and exchanged in the market. In this sense, catastrophe bonds are a clear example of the financialization of natural resources and material values.

Cat bonds transform material risks into exchange values through a process of financialization, thus, converting physical space and time into social space and time. Natural catastrophe risks are removed from their spatial and temporal materiality and treated as abstract exchangeable values through their mobilization in the market. As the exchange values of these catastrophic risks become more abstracted from the use value and the real spatial and temporal materiality of these natural systems, they can become devalued. Catastrophe bonds divorce financial value from the material context they seek to represent. This process of converting environmental risk into exchange value creates distortions in the representation of climate change risk and value and could lead to undervaluation and mismanagement of environmental risks.

5.6 Final Observations

Although catastrophe bonds are an effective way to transfer risk through the capital market, they could result in an undervaluation of risk. While the insurance and reinsurance industry cannot be blamed for engaging in financialization as a solution to risk management, these tools should be used with caution and diligence. Cat bonds are not widely viewed as a means of adaptation to climate change, but rather, as a short-term risk transfer solution. In this regard, the cat bond market will not likely view climate change with any immediacy until the market starts to see loss activity as a result. This view is not problematic if we assume that climate change risks are long-term, predictable, and will emerge in years to come. We would also need to assume that if climate change events appear abundantly and loss activity increases, the cat bond market and actors within the industry will respond with immediacy. If climate change risks are short-term and occur in a shorter time frame than the industry predicts, when will a sense of urgency or immediacy kick in? If climate change risks are rapid, unpredictable and occur in the short-term, who will claim ownership of these risks? Will actors in the cat bond market react to climate change events in time? Will there ever be a sense of immediacy in responding to climate change?

If climate change risks materialize sooner than predicted, the market may experience dangerous losses. As the cat bond market continues to see increasing growth and investment, investors need to be diligent and aware of the risks they are taking. However, as the future climate is unpredictable, is it possible for these investors to be fully aware of the risks? The catastrophe bond market provides short-term risk coverage to insurers and short-term economic gains for investors, however, the long-term

consequences that could arise based on the rapid and unpredictable nature of climate change should cause some hesitation and concern over the future of this market.

6. Conclusion, Contributions and Recommendations

6.1 Introduction

As the catastrophe bond market continues to see increasing growth and becomes a more prominent way of dealing with climate change disaster risk, the ability for cat bonds to adequately address environmental risks comes into question. There is a propensity for environmental risks or problems to be represented through financial figures and addressed through the marketplace. Catastrophe bonds are indicative of this trend as they transform environmental risks into financial figures and trade these risks through the market. This thesis sought to investigate how catastrophe bonds represent a form of financialization that enables time-space compression.

Through an explanatory sequential mixed methods approach to the study, this question was effectively answered. By utilizing quantitative data analysis and qualitative semi-structured interview results, cat bonds were proven to exemplify the three mechanisms of financialization. This analysis exposed cat bonds as a form of financialization. The process of financialization and the implications of the separation of natural catastrophes from their spatial and temporal materiality were discussed.

Through a utilization of both quantitative and qualitative results, cat bonds were analyzed based on the actors and processes involved in their development and distribution. Each actor and process fit into a specific mechanism inherent in the financialization of assets. Through this analysis, cat bonds were exposed as a form of financialization. The implications of the financialization of environmental risks were discussed and cat bonds were demonstrated to enable the temporal and spatial compression of natural catastrophes.

6.2 Contributions of this Thesis: Research and Practice

This thesis provides contributions to academic researchers and practitioners. There are three primary contributions this thesis makes to research. The first is an extension of the critical literature on catastrophe bonds. Research on cat bonds to date has primarily focused on their structure, development, popularity, and what their usage means for the insurance and investment industry. While there has been some significant critical literature on cat bonds, this thesis has extended these critiques. It has provided a clear map of the infrastructure and networks of catastrophe bonds and laid this map on the foundation of a process of financialization. This thesis has exposed cat bonds as a form of financialization enabling temporal and spatial compression of natural catastrophes. The research can contribute to critical literature of cat bonds through its exposure of this method of insurance risk management as a potentially dangerous tool for addressing environmental risks.

The second contribution to academic literature that this thesis provides is a connection between financialization, time-space compression, and insurance risk management. While research on each of the three topics individually is widespread, there has been limited research connecting these concepts, particularly regarding the explosive cat bond market. This thesis research filled a gap in analyzing cat bonds from a critical financialization lens. This thesis connected the theories of financialization and time-space compression with climate change risk management in the insurance industry through an in-depth analysis of cat bonds. It exposed cat bonds as a form of financialization through their decoupling of the spatial and temporal aspects of natural catastrophes and connected the two theoretical concepts to develop a critique.

The third contribution that this thesis provides to academic literature is a broader critique of the ability for market mechanisms to address environmental problems. Cat bonds are representative of the broader inclination for environmental problems to be addressed through market mechanisms and financialization. By exposing the process of turning environmental risks into financial values, the limits of financialization as a method of addressing environmental problems were revealed. Therefore, this research is representative and informative of other forms of financialization of environmental problems such as carbon permit trading or weather derivatives. A significant contribution of this research is its exposure of the broader issues involved in the transformation of material problems into market values and how this can result in an undervaluation of natural systems.

This thesis also provides contributions to practitioners in the field of cat bonds. This research can reveal insights to both investors and sponsors involved in the cat bond market. The thesis has exposed critiques of cat bonds and the importance of investor awareness and diligence prior to entering the market. It has also highlighted the dangers that insurance companies can encounter if they rely fully on cat bonds for their risk management needs. Most importantly, this thesis addressed some of the assumptions made by practitioners in the cat bond market about the relevance and immediacy of climate change risks. It highlighted the potential economic and adaptive dangers the industry could face if they do not address climate change risks in the modelling, underwriting and investing process.

6.3 Recommendations for Future Research

Through the discussion section of this thesis, a number of questions were posed that could be relevant and of interest for future research in the catastrophe bond market. The first involves the inclusion of the developing world in the cat bond market. An interesting area of research would be to analyze whether the developing world would reap benefits or disadvantages if cat bonds were used as a form of risk management in the Third World. The touted opportunities that cat bonds pose for risk management in the developing world would be an interesting area of inquiry to study and analyze.

Another interesting area for future research would be an in-depth analysis of the catastrophe modelling performed by risk modelling companies. While there is currently no standardized models or views of risk, it would be interesting to analyze the type of models being used to identify future risks and how seriously these models take climate change threats. In addition, the actions of investors and sponsors in the cat bond market in regards to climate change risks would also be an interesting avenue for study. An analysis of the long or short-term approaches to climate change risks in the industry would be a worthy area for future research.

A final recommendation for future research in this field would be a study of the investor and financial risks cat bonds could pose for the financial market. While the information was unavailable for the purposes of this study, it would be interesting to research the types of investors that are involved in cat bond trading and what their view of the market is.

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Appendix A: Semi-Structured Interview Questions

1. What actors are typically involved in the development and distribution of cat bonds?
2. What are some of the benefits of cat bonds to the insurance and reinsurance industry?
3. What processes are involved in determining the value of a cat bond? What factors and conditions can drive pricing?
4. What challenges, if any, do you think risk analysis techniques pose? (In terms of data gaps or the domination of the market by 2-3 companies)
5. Can you think of any disadvantages of cat bonds for the insurance or reinsurance industry?
6. The indemnity trigger seems to me the most popular in the market right now. Do you have any comments about the benefits or disadvantages of this trigger type and why you think it has dominated the market?
7. How would you say that the effects of a changing climate are factored into cat bond pricing and risk analysis?
8. What is your personal opinion of cat bonds as a means of addressing insurance risk?
9. Climate change and warming temperatures are widely believed to result in an increase in natural disasters. What role do you think cat bonds can play in adapting to climate change, if at all?
10. One argument put forward by academics for the use of cat bonds is that they can help the developing world manage risk by accessing global funds to cover disasters. However, right now the bond market is overwhelmingly centred in the US. Do you think that cat bonds could result in insurance for the rich only? What is your opinion of this argument?
11. Some scholars have argued that catastrophe bonds can pose systemic risk for the financial market through a collective underpricing of catastrophic risk leading to large financial losses. What do you think of this argument?
12. Are there any recent changes or trends that you are aware of now in the ILS marketplace?