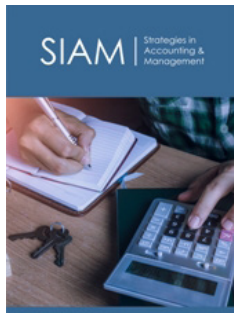


The Low-Probability Puzzle: Emotions Override Rationality for Rare Disasters

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Annette Hofmann*

Director, Lindner Center for Insurance and Risk Management, Lindner College of Business, University of Cincinnati, Ohio, USA

Abstract

Human emotions frequently supersede rationality, and the comprehension of probabilities is a cognitive challenge for individuals. Within the realm of insurance decision-making, our choices often deviate from optimality. Notably, the comparison between a low-probability-high-consequence risk, such as the threat of a flood, and a high-probability-low-consequence risk, like bicycle theft, reveals an irrational tendency to prefer insuring against the latter over the former. Surprisingly, individuals exhibit a proclivity to opt for coverage against high-probability-low-consequence risks, such as bicycle theft, even when confronted with the alternative of insuring against low-probability-high-consequence risks, like flooding. Additionally, there is a common inclination to augment homeowner's insurance policies with add-on coverage for bicycle theft, neglecting the consideration of coverage for the more severe risk of loss due to flooding.

***Corresponding author:** Annette Hofmann, Director, Lindner Center for Insurance and Risk Management, Lindner College of Business, University of Cincinnati, Ohio, USA

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Introduction

When confronted with low-probability yet high-consequence events, there is a tendency for individuals to experience intense emotional reactions, thereby diminishing the significance of the actual likelihood of the event occurring in their decision-making processes. This phenomenon is particularly prominent in the context of events categorized as Low-Risk-High-Consequence (LRHC), exemplified by scenarios with slim probabilities but substantial implications, such as winning a sizable lottery or accessing a lucrative new market. When managing rare events that elicit strong emotional responses, individuals in managerial roles are prone to either excessive or insufficient allocation of their firm's resources. Specifically, when dealing with exceedingly small probabilities, there is a propensity for managers to overestimate these probabilities, leading to irrational responses.

Furthermore, individuals who derive satisfaction from their existing environment are disinclined to disrupt it in pursuit of potential gains. This inclination stems from the recognition that losses typically evoke greater emotional distress than gains of equivalent magnitude generate emotional well-being. While adopting a risk-averse approach may instill stability in a manager's firm, it concurrently imposes constraints on entrepreneurial initiatives and their attendant prospects for substantial economic profits.

The Catastrophe Insurance Market Puzzle

In light of the tendency for individuals to overestimate low and extremely low probabilities, an intriguing question arises: why do people exhibit a higher inclination to insure against high-probability events as opposed to low-probability events? Although addressing this phenomenon is complex, this chapter endeavors to delineate its primary drivers and proposes strategies for addressing it. The common Expected Utility model posits that a rational individual would opt for insurance against high-consequence risks. However, empirical evidence contradicts this expectation, revealing that only a minority of the insured population seeks coverage against natural disasters, even in scenarios where catastrophe insurance is generously subsidized. Analogous patterns emerge in the domains of long-term care insurance

and agricultural insurance markets, as noted in the works of Gollier [1], Volkman-Wise [2], and Brown [3]. Another dimension of irrationality manifests in instances where individuals tend to overinsure certain risks, a phenomenon observed in homeowners and auto insurance markets. The EU model struggles to account for this behavior without attributing unrealistically high degrees of risk aversion to individuals, as observed in studies by Sydnor [4] and Barseghyan [5].

The insurance industry, despite these anomalies, plays a pivotal role in enhancing societal welfare. Insurers serve as conduits for transferring risk from risk-averse individuals to more risk-tolerant investors, fostering the diversification of risks across society. This not only directly benefits risk-averse individuals but also stimulates risk-averse entrepreneurs to engage in more venturesome activities, thereby amplifying growth and employment. However, the increase in catastrophic events globally, exacerbated by climate change, underscores a surprising shortfall in insurance coverage against low-probability, high-impact events. Hurricane Katrina in 2005 serves as an illustrative example, where only 40% of individuals in the flood-prone New Orleans parish were insured against flood events, highlighting a broader trend outlined by recent data from Swiss Re Institute indicating substantial portions of losses from catastrophic events remain uninsured. The dearth of demand for catastrophe insurance results in notable inefficiencies in managing risk-bearing aspects. Entrepreneurs, faced with larger risks within their investments than optimal conditions would dictate, may experience consequential reductions in investment, employment, and overall growth. Individuals and companies, compelled to shoulder significant economic risks, are required to provide the requisite equity. Consequently, the suboptimal allocation of catastrophe risks carries the potential for severe adverse welfare effects on the entire economy, as emphasized by Gollier [1].

The consistent missing demand for catastrophe insurance and other low-probability-high-consequence risks is often referred to as the catastrophe insurance puzzle. People show reluctance to insure low-probability events, and this behavior is particularly pronounced for some disasters. Individuals rather prefer to insure against high-probability losses. According to Kunreuther [6], one driver for that behavior could be that people think of insurance as an investment. Indeed, it may seem that insuring against hazards which do not occur in most cases might be a bad investment most of the time. Kunreuther [6], state that “there is evidence that people do not voluntarily insure themselves against natural disasters even when the rates are highly subsidized. The reasons for failure of insurance markets need to be understood, as they have important implications for policy.”

Certainly, following each significant disaster, there is a recurring inquiry in the media regarding why homeowners fail to sufficiently insure themselves against catastrophic losses. Economic theory posits that the optimal degree of insurance coverage for catastrophe risks exceeds the observed levels in practice, even when considering liquidity constraints. The conventional economic model of risk exchange contends that, in an ideal scenario, all non-systematic

risks should be diversified across the entire economy. However, empirical evidence contradicts this theoretical expectation, revealing a notable lack of demand for insurance against events such as earthquakes, floods, and other natural damages.

Transaction costs

The practical limits of insurability encompass a crucial consideration, with a significant factor being the presence of transition costs. While transaction costs in financial markets generally do not exceed 2 or 3%, they are notably higher for insurance products. In the German Property and Casualty (P&C) Insurance sector, the average expense ratio reached approximately 21% in 2018. For household and residential building insurance lines, including elementary insurance, the costs are even higher, averaging 26.4% and 33.8%, respectively. In the United States, homeowners insurance costs amounted to 27% in 2018, covering damages to both household items and buildings, depending on the contract.

From a theoretical perspective, transaction costs are considered in insurance market models. Mossin [7] demonstrated that full insurance coverage is never optimal when a proportional premium loading is charged, taking into account transaction costs. Similarly, Raviv [8] incorporated transaction costs in his analysis, concluding that the Pareto optimal insurance contract includes a deductible and co-insurance of losses. Consequently, transaction costs may contribute to the partial uninsurability of certain risks. The breakdown of a large risk into parts can render the sum of all parts insurable when assumed by risk carriers, even if the risk as a whole would be deemed uninsurable. However, practical limitations arise as administrative and brokerage costs impose a constraint on further risk atomization. There exists a threshold at which the negative cost impact offsets the positive effect of additional risk segmentation. These observations suggest that a portfolio consisting of numerous small risks is relatively cost-intensive, contrary to real-life observations. This cost-intensive nature is particularly pronounced in catastrophe insurance, where high transaction costs are evident. Catastrophic risks, such as natural disasters, impact a large number of policyholders simultaneously, leading insurance companies to contend with substantial waves of claims. Due to the nature of disaster events, claim treatments are not uniformly distributed over time in catastrophe insurance, amplifying auditing costs per customer compared to other insurance lines. When the number of claims surpasses the auditing capacity of insurance companies, a situation may arise where randomizing audits becomes necessary. This introduces an incentive for policyholders to report inflated losses, seeking higher indemnity payments and, in turn, compelling insurers to either increase auditing costs to scrutinize more claims or raise indemnity payments. In either scenario, the collective bears the additional cost, leading to an increase in insurance premiums for subsequent years. The substantial transaction costs associated with catastrophe insurance may dissuade consumers from purchasing coverage. Catastrophe insurance policies often feature a low net premium due to the low probability of loss, with the premium loading (comprising transaction costs and risk

loading) constituting a significant portion of the gross premium. This perceived high premium can discourage individuals from opting for insurance.

Empirical studies, such as Browne [9] and Ganderton [10], highlight the negative correlation between insurance demand and the cost of insurance products, emphasizing that high costs significantly lower demand. The research by Kunreuther [11] further supports this, indicating that consumers often perceive premiums for disaster insurance as inappropriately high, deterring their interest. Additionally, high search costs for information on these insurance products serve as a limiting factor in insurance demand. Several potential solutions to mitigate high transaction costs include implementing high deductibles, which could reduce claim waves and contribute to more affordable premiums. Another approach is to link indemnity payments to an index, such as catastrophe bonds, introducing a basis risk for policyholders. Digitalization emerges as a transformative driver to decrease transaction costs, with examples including partially automated processing of indemnity payment claims and digital customer service solutions like chatbots or insurance administration apps. The entry of Insurtech's and major technology players like Google and Amazon into the insurance market could further accelerate these advancements.

Inefficient financial markets

In the realm of financial markets, where the distribution of risks among investors is inherent, catastrophe risks can also be shared and traded. Two prevalent methods for engaging in risk-sharing activities through financial markets are evident. The first involves the straightforward acquisition of shares in a reinsurance company. By doing so, investors obtain ownership stakes in the company, consequently assuming a share of the risks it undertakes. Another avenue for participating in insurance risk-sharing within financial markets is through the issuance or purchase of Catastrophe Bonds (CAT bonds). CAT bonds, categorized as insurance-linked securities, made their debut in 1992 and have since gained prominence. In 2019, CAT bonds with a cumulative value of 11.1 billion USD were issued. Reinsurance companies or governments have the capability to transfer portions of the risks associated with a specific event, such as a natural catastrophe in a designated region, to other market participants through CAT bonds. This process securitizes the risk, allowing it to be shared with potential investors. Similar to other bonds, CAT bonds provide coupon payments to buyers and return the notional value upon maturity. However, in the event of the specified disaster occurring, investors may incur a partial or complete loss of their investment. Investing in CAT bonds can offer investors a measure of diversification in their portfolios, as these instruments exhibit low correlations with other securities traded on capital markets.

Asymmetric information

Rothschild [12] were pioneers in highlighting the impact of population heterogeneity and information asymmetry on the efficiency of insurance markets. In the context of natural

catastrophe insurance, variations in risk among individuals are evident. For instance, homeowners in California face a significantly higher likelihood of earthquake-related losses compared to those residing in New York City. However, the potential loss amount might be higher in New York if the property value is greater than a similar house in the California countryside. Insurers could adopt an approach of charging average prices for all agents with the same observable risk attributes, giving rise to an adverse selection problem. If individual risks within a group of agents are not observable or are prohibitively costly to observe, and the insurer applies a uniform price for the entire group, those with lower risks than the average are likely to abstain from purchasing the product. Recognizing that the price is not suitable based on their accurate risk assessment, they may choose not to transfer the risk to the insurer or opt for a policy from another insurer with risk-based pricing. Consequently, the average risk, and thus the average price, of the group rises as individuals with the lowest risks exit. This cycle continues, resulting in adverse selection, where the remaining group seeking insurance consists mainly of those with the highest risks, ultimately reaching the maximum individual price of the original group.

Ethically, questions arise about the fairness of every citizen paying an individual risk-based price for an insurance product. Moreover, concerns emerge when considering scenarios where the riskier group is on average economically disadvantaged compared to the less risky group. For example, how could individuals with pre-existing conditions like cancer afford health insurance when prices are based on individual risk? These ethical dilemmas have sparked intense discussions surrounding price discrimination for insurance products. Gollier [1] proposes two potential solutions to address the adverse selection problem and associated ethical concerns. The first approach advocates making catastrophe insurance compulsory, similar to car liability insurance, and incorporating non-discrimination regulations, as seen in the French system. In 1982, the French government implemented this system for natural catastrophes and insurance against damages from war, nuclear catastrophes, and terrorist attacks. They impose an additional premium on every Property and Casualty (P&C) insurance policy covering natural catastrophes, with the amount determined by the government and reinsured by the public, state-owned reinsurer CCR (Caisse Centrale de Réassurance). The second approach suggests using the tax system to redistribute wealth between low- and high-risk citizens, such as levying taxes on cars or properties in Germany based on their value.

Limited liability

Firms and individuals have the capacity to generate environmental risks that are ultimately borne by third parties rather than by the entities responsible for the risks. For example, a manufacturer situated near a river, utilizing the river's water for cooling machinery, may unintentionally pollute the river, adversely affecting others. Similarly, in the event of a nuclear power plant accident, the local population may suffer significant damages to their property and health. In such instances, the originator of the

risk typically has limited liability and is obligated to compensate the third parties harmed by the realized risk. However, the extent of this liability is constrained by the financial resources available to the risk originator. Entities with limited liability often exhibit a tendency to undertake additional risks. Consider a scenario involving a lottery with a potential win of \$40 and a 50% probability, coupled with a potential loss of \$50. Risk-averse individuals, equipped with sufficient financial resources to bear the \$50 loss, would abstain from participating, given the negative expected value of the lottery. However, if these individuals lack the financial means to cover the additional \$50, they may choose to participate, as they stand to gain from the risk without incurring a loss. This example illustrates that entities, whether firms or individuals, are more inclined to embrace additional risks when they are not directly responsible for the losses. They benefit from increased risk-taking, adopting a risk-prone stance, even if they are inherently risk-averse. Therefore, risk aversion is only effective when entities are adequately capitalized.

The concept of limited liability has implications for the efficacy of corporate environmental liability insurance markets. When firms have limited resources, their exposure to losses is restricted, leading them to see limited value in investing their finite resources in insurance policies priced based on the full potential loss. Gollier [1] presents two approaches to address this inefficiency. First, states could mandate compulsory insurance for environmental risks to ensure proper indemnification for victims in case of an incident. However, in practice, such policies were often non-discriminatory and lacked incentive structures, resulting in low investments in risk prevention. The second approach involves holding banks, closely involved in managing a firm's activities, liable for damages caused by the firm, establishing a "deep pocket" principle. In this scenario, banks would heavily invest in monitoring firms and adjust loan interests for risky entities, thereby internalizing the risk. However, the monitoring process is often costly. For example, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulates toxic waste disposal in the United States.

Diversification in time

The concept of diversifying risks through time via credit markets presents an alternative to traditional insurance. In this approach, individuals save money over time and resort to taking credits (or depleting their own reserves) in the event of a catastrophe. Scholars have debated the effectiveness of this strategy, considering factors such as infinite life and independent risks through time. Time diversification appears viable under the assumption of infinite life and independent risks through time. However, when finite life and borrowing and liquidity constraints are considered, especially in the case of an early occurrence of a catastrophe, time diversification may not be a suitable substitute for traditional insurance. In situations where individuals face short-term borrowing constraints and need to transfer risk promptly, relying solely on time diversification becomes impractical. It is more likely that individuals would seek to transfer risk to insurers in the short term, even if they plan to build financial reserves in the long run.

To support the strategy of capital accumulation, governments could potentially subsidize loans to prevent borrowing constraints. This idea extends to insurers and their approach to capital accumulation and reinsurance. A nascent insurance company may initially need to reinsure a significant portion of its business but could gradually reduce this reliance as it accumulates capital. However, the practical implementation of this strategy might deviate from theoretical assumptions. Managers in insurers with high capital efficiency might not necessarily accumulate capital and time diversify, as expected. In contrast, those in firms with low reserves may have a different approach. In such scenarios, the state can intervene to time diversify and assume the role of a reinsurer. The government, with its considerable creditworthiness and long-time horizon, can step in to provide support in managing risks over time.

Regret aversion

Studies on insurance demand indicate that individuals tend to either ignore or undervalue low-probability events. In the case of rare but high-impact events, insurance often lacks attractiveness. One possible explanation for this phenomenon is that individuals may only pay attention to risks when the probability of the event surpasses a certain threshold. Some research argues that the limited demand for insurance against low-probability events may be attributed to individuals consciously deciding against insuring such events, potentially due to regret aversion. Numerous experiments and field surveys reveal a consistent pattern where individuals opt for insurance only when the probability of loss exceeds a certain threshold, even when insurance is heavily subsidized (e.g., Kunreuther [6]). Another contributing factor to low demand could be the incomplete understanding of the probability of disasters by consumers. Catastrophe insurance is more frequently purchased immediately after a major disaster occurs, as individuals then perceive the probability of the event more vividly ("it does happen!"). This reasoning is rooted in the salience bias, where individuals tend to focus on notable items or information while overlooking less attention-grabbing ones. A second reason might be the high deductible problem, where individuals feel that insurance may offer limited coverage after a disaster. Additionally, a preference for policies with a rebate, ensuring that individuals do not feel deceived in the absence of a catastrophe, or even probability neglect, could contribute to the observed low demand.

There are various potential reasons why people may not participate in catastrophe insurance. Market failure, including adverse selection, moral hazard, correlated risks, and time consistency, is one set of factors. Another set of reasons involves government failure, including the reliance on government relief in the case of a major catastrophe (Samaritan's Dilemma). While some of these factors, such as high underwriting costs and limited supply, as well as the anticipation of government relief programs, may contribute to the low demand for extreme-event insurance, they may not fully explain the low take-up rates of federally subsidized flood insurance. In addition to these factors, a study by Browne [13] suggests that individual preferences play a role in insurance decisions. The study, which analyzes data from an insurer covering

both a low-probability-high-consequence risk (flood peril) and a high-probability-low-consequence risk (bicycle theft), finds evidence consistent with a preference for insurance against high-probability-low-consequence risks. More policyholders purchase add-on coverage for bicycle theft than for the risk of loss due to flooding.

Regret aversion is proposed as a potential explanation for this behavior. In catastrophe insurance markets, where the probability of suffering a loss is low, individuals may experience high regret aversion, anticipating significant regret when they do not receive any benefit from their insurance policy. This anticipation of high regret may reduce the demand for insurance against rare events. On the contrary, the desire to avoid regret may explain the relatively high demand for insuring high-probability-low-consequence risks, leading to the growth of markets for low-value policies like cellphone insurance. Despite the usually low consequence of losing a cellphone, the global mobile phone insurance market has seen substantial growth, reaching a valuation of approximately USD 18 billion in 2018. Mobile phone insurance helps individuals mitigate high replacement costs in case of loss or breakdown, covering physical damage, internal component failure, theft and loss protection, and sometimes supporting data protection.

Concluding Remarks

Human decision-making in the realm of insurance is often influenced by emotions overriding rationality, and humans typically struggle with assessing probabilities accurately. In the context of insurance decisions, choices tend to deviate from optimality. Notably, the comparison between a low-probability-high-consequence risk, such as the threat of a flood, and a high-probability-low-consequence risk, like bicycle theft, reveals an irrational inclination towards insuring against the latter over the former. Surprisingly, individuals exhibit a tendency to opt for coverage against high-probability-low-consequence risks, such as bicycle theft, even when presented with the alternative of insuring against low-probability-high-consequence risks, like flooding.

Additionally, there is a common tendency to augment homeowner's insurance policies with add-on coverage for bicycle theft, neglecting the consideration of coverage for the more severe risk of loss due to flooding.

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