Effects of Risk Attitudes and Information Friction on Willingness to Pay for Precautionary Building Standards

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Abstract

We use a field experiment to estimate effects of higher order risk attitudes and information friction on willingness to pay (WTP) for precautionary building standards with insurance discounts. To elicit risk attitudes and WTP, we employ 50-50 model-free risk apportionment lotteries and WTP experiments. Results reveal significant effects of second, third, and fourth order risk attitudes and information friction on homeowners' WTP for precautions. We find that risk-lovers are also prudent and intemperate (mixed risk-loving), and exhibit dichotomous behaviors with mixed risk-averters. Overall, mixed risk-averters are willing to pay more than mixed risk-lovers for higher levels of precaution. Mixed risk-averter's WTP increases with decreases in information friction about the performance of precaution while that of mixed risk-lovers decreases. Risk-loving, prudent, and intemperate homeowners exhibit the highest WTP.

Keywords: Risk attitudes, Information friction, Homeowners insurance, Willingness to pay, Field experiment, Natural Disasters

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1 Introduction

Extensive economic theory links agents' propensity for precautionary actions with risk attitudes. However, most findings are model-specific and focus on risk aversion, a second order risk attitude, even though higher order risk attitudes (HORA) also play a key role in individuals' decision making under risk. Kimball (1990) provides early evidence. He finds that individuals who are third degree risk averse, whom he terms "prudent," save more when faced with an uncertain stream of future income. In a subsequent study, Kimball (1993) finds that when faced with an unavoidable risk, fourth degree risk-averse agents, whom he calls "temperate," seek to reduce the exposure to another risk even if both risks are statistically independent.[1] Equivalently, a prudent agent prefers a loss distribution with less positive skewness, and a temperate agent prefers a loss distribution with less positive kurtosis. Subsequent studies reveal salient effects of prudence and temperance on the propensity to take actions that reduce probabilities of hazards (Eeckhoudt and Gollier, 2005), insurance demand (Fei and Schlesinger, 2008), precautionary bidding in auctions (Eso and White, 2004), and other behaviors under risk (White, 2008; Treich, 2010; Gomes and Michaelides, 2005; Snow and Warren, 2005).

While there is a growing body of literature relating HORA to demand for precautions, attention is largely focused on risk averters, despite the appearance of risk-seeking behavior in empirical results, and ambiguous perceptions of the role of risk seekers in society (Crainich et al., 2013; Jindapon, 2013; Noussair et al., 2014). A few recent studies reveal distinct patterns of prudence and temperance among risk lovers and risk averters with potential implications on the demand for precautionary actions. Leaning on expected utility theory (EUT) and Eeckhoudt et al.'s (2009) characterization of HORA, while assuming that risk lovers prefer to combine "good with good" and "bad with bad," Crainich et al. (2013) theoretically show that risk lovers are both prudent and intemperate. Deck and Schlesinger (2014) generalize and test theoretical findings up to the sixth order using experiments on students finding similar results. Generally, they also find risk averters and risk lovers behave similarly with odd-order risk attitudes (e.g., prudence) and differently with even-order risk attitudes (e.g., temperance). Similarly, using a price list experiment defined on risk compensation, Ebert and Wiesen (2014) find that both risk averters and risk lovers are prudent. They also find that risk averters are more temperate than risk lovers. These studies and others (Maier and Rüger, 2011; Deck and Schlesinger, 2010; Ebert and Wiesen, 2014) rely on lab experiments using students to investigate the prevalence and (to a limited extent) effects of HORA on decision making.[2] None of these studies examines the effects of HORA beyond the setting of precautionary savings.

In addition, recent and growing empirical evidence suggests that demand frictions such as cognitive ability (Fang et al., 2008), inertia (Handel, 2013), risk perception bias (Cutler and Zeckhauser, 2004; Abaluck and Gruber, 2011), and information friction (Handel and Kolstad, 2015; Spinnewijn, 2017) also explains considerable variation in demand for insurance. Using unique survey and claims data on health insurance plans for a large employer in the U.S, Handel and Kolstad (2015) show that not accounting for information friction leads to upward bias in risk aversion estimates. Whether or not information friction on the attributes of precautionary building standards exist, and the extent to which it affects WTP remain open questions, especially given existing ambiguous relations between risk attitudes and the demand for prevention and insurance. The scarcity of empirical applications jointly linking explicit measures of HORA and information friction to decisions made by economic agents in the field, and the lack of literature that studies these relationships within the framework of precautionary building standards, motivate our efforts.

[1] We use the terms prudent (temperate) and third order risk averse (fourth order risk averse) interchangeably.

[2] Only Noussair et al. (2014) studies the impact of HORA on precautionary savings using both student and non-student samples with mixed results.

In this study, we use theory and empirical analysis to investigate the effects of HORA and information friction on real economic agents' demand for precautionary building standards. Specifically, we theoretically predict and empirically estimate the effects of HORA and information friction on homeowners' WTP for windstorm-resistant loss-prevention features with corresponding insurance discounts. The setting of our field experiment is the coastal area of Alabama, where homeowners are highly vulnerable to hurricane risk. First, we revisit and extend the theory on WTP for prevention. We examine comparative statics up to the fourth order risk attitude, paying attention to both risk averters and risk lovers.[3] To keep the model tractable, we do not introduce information friction at this stage. Instead, we disentangle and separately identify its causal effects on WTP (from HORA) experimentally. To achieve this, we randomly treat half of our sample with credible information (a video) revealing the performance of precautionary and conventional building standards side-by-side under hurricane-like winds prior to their participation in the WTP experiment. Empirically, this enables us to isolate the causal effect of information friction and test the predicted relationships between HORA and WTP for precautionary building standards. The WTP experiment is designed with actual levels of protection and insurance discounts currently available to the subjects in our sample. Thus, it mimics the decisions faced by homeowners in managing hurricane risk.

We consider precautionary building standards that are characterized by two levels (Bronze and Silver) of the FORTIFIED Home^{TM} program (henceforth *Fortified*), and are potentially both self-insuring and self-protecting.[4] *Fortified* is a set of engineering and building standards based on research by the Insurance Institute for Business and Home Safety (IBHS).[5] The standards are designed to strengthen new and existing homes through system-specific upgrades to minimum building code requirements that will reduce damage from specific natural hazards. The *Fortified* hurricane program enables existing single-family homes to be retrofitted to mitigate high winds and wind-driven water damage.

There are three incremental *Fortified* levels (Bronze, Silver, and Gold) designed to improve the roof, reduce water intrusion through the attic ventilation systems, strengthen gable end construction (Bronze), protect openings (Silver), and strengthen critical elements of the continuous load path from the roof to the foundation (Gold). A trained and certified inspector must inspect the house at several specific points in the building process for a house to receive a *Fortified* designation. Because it is not practical to retrofit an existing house to the *Fortified* Gold standard, we only consider Bronze and Silver designations.

Alabama's coastal region is an ideal setting for our experiment because it includes more than 75 percent of all *Fortified* houses.[6] In addition, Alabama regulators enforce a benchmark insurance discount for each level of *Fortified* designation as a percentage of the wind portion of homeowners insurance premiums.

Even though *Fortified* houses sell for a premium that exceeds the cost of retrofitting to the standard, and several public information campaigns have educated homeowners and contractors in the region about *Fortified* construction and wind-insurance discounts, current take-up of *Fortified* relative to conventional standards is disappointingly low.[7] Such low take-up could be explained by other salient factors which affect

[3] Existing analysis of the joint effects of HORA, up to the fourth order, with attention to risk-seeking behaviors are lacking even though significant correlation exists among HORA. For example see Dachraoui et al. (2004), Eeckhoudt and Gollier (2005), Dionne and Li (2011), Meyer and Meyer (2011), and Jindapon (2013).

[4] For actions taken to reduce the severity of loss, self-insurance theory generally predicts a more risk-averse agent will demand more self-insurance than a less risk-averse agent. However, in the case of actions that reduce the probability of loss, self-protection, and severity of loss, self-insurance-cum-protection, a more risk-averse agent does not necessarily take more protection.

[5] See www.disastersafety.org for additional information on *Fortified* programs.

[6] At the time of our survey, there were about 4,000 *Fortified* houses in Alabama. The *Fortified* program is available in several other states, but it has gained the most traction in Alabama.

[7] It costs three percent to five percent of a house's value to retrofit a conventional house to the *Fortified* standard and *Fortified* houses sell at a seven-percent premium on average (Awondo et al., 2019). Thus, the *Fortified* designation is a sound economic investment, even without accounting for other direct and indirect benefits.

WTP such as homeowners' lack of complete information on the attributes and performance of *Fortified* to enable the distinction from conventional building standards.

We elicit homeowners' first four order risk attitudes and WTP using two experiments. The first is a series of 50-50 model-free risk apportionment lotteries (Eeckhoudt and Schlesinger, 2006). The second is a repeated WTP payment cards experiment (Cameron and Huppert, 1989; Cameron et al., 2002). The WTP experiment is elicited with 2 actual attribute levels of precaution (*Fortified* Bronze and *Fortified* Silver) and 3 actual attribute levels of homeowners insurance discounts (20-percent, 35-percent, and 45-percent), and 2 attribute levels of payment card WTP range (low and high). The insurance premium discounts are based on loss-reduction estimates associated with the uptake of corresponding levels of *Fortified*. Discounts are derived using commercial catastrophe models. The payment card attributes allow us to test for ending-point bias in payment card methods. As a final but crucial design attribute, we randomly assigned half of our sample to watch a video demonstrating the performance of a *Fortified* and conventional building standard side-by-side under hurricane-like winds just before they answered the WTP experiment questions. The video was not presented to the other half of the sample. This treatment allows us to isolate the effect of information friction about the performance of *Fortified* relative to conventional building standards, on WTP.

Our research design and data allow us to empirically disentangle and test theoretical predictions on the relationship between WTP for precautionary actions and HORA, thus extending the literature on several fronts. Specifically, we (1) develop propositions for the total effects of risk aversion, prudence, and temperance on optimal demand for precautions by risk lovers and risk averters; (2) establish and quantify the extent to which second, third, and fourth degree risk attitudes, information friction, and risk perception affect homeowners WTP for increasing levels of precautionary building standards with a range of benefits; (3) test for mixed risk attitudes (lovers and averters) and differences in WTP; and (4) evaluate theoretical predictions of precautionary demand under stochastic dominance. Tests for stochastic dominance indicate whether homeowners who are n^{th} degree risk averse and satisfy n^{th}-degree stochastic dominance preference relations have higher WTP than agents who are $(n-1)^{th}$ or less degree risk-averse and also preserve $(n-1)^{th}$ or less degree stochastic dominance preference relations. Our study also paves the way for comparison and generalization of findings across settings.

To properly estimate the heterogenous treatment effects while minimizing type I error, we employ both multiple hypothesis testing (MHT) and multivariate regression methods in our analysis.[8] In the former, we use multiplicity adjustment methods proposed by List et al. (2016) and compare the results with Bonferroni and Holm adjustments. In the latter, we estimate a series of panel-level random-effects Tobit regression models that also control for socio-demographic variables (including income), housing characteristics, and HORA. Finally, we predict average WTP for different levels of precautionary building standards and insurance discounts for the whole sample, as well as subsamples of second and third order risk lovers and risk averters at low, median, and high household income levels.

Results show strong effects of HORA and information friction on WTP for precautionary building standards with insurance discounts. Consistent with findings reported by Crainich et al. (2013) and Deck and Schlesinger (2014), we find that risk lovers are also prudent and intemperate, thus exhibiting mixed risk-loving behavior, and further reveal interesting new dichotomy between mixed risk-averters and mixed risk-lovers. First, unlike mixed risk-averters who are willing to pay more for higher level of precaution (*Fortified* Silver), mixed risk-lovers are willing to pay more for a lower level of precaution (*Fortified* Bronze). Surprisingly and contrary to mixed risk-averters, mixed risk-loving homeowners who watched the video, demonstrating the performance of *Fortified* and conventional houses side-by-side under hurricane-like winds, are

[8]Recent literature (Maniadis et al., 2014; List et al., 2016) highlights increased likelihood of false positives in experimental studies involving multiple treatments and subgroups.

willing to pay (significantly) less than those who did not watch the video. Thus suggesting that mixed risk-averter's WTP increases with decrease in information friction about the performance of *Fortified*, as expected, while WTP for mixed risk-lovers decreases with decrease in information friction.

Comparing predicted WTP estimates amongst mixed risk-lovers and mixed risk-averters generally reveals that risk-loving, prudent, and intemperate homeowners exhibit the highest WTP ($1347 to $7424) for *Fortified* building standards while risk-loving, imprudent, and temperate homeowners exhibit the least WTP (-$8331 and -$1731). Overall, risk-averse, prudent, and temperate homeowners are willing to pay more than risk-loving, prudent, and temperate homeowners are for similar level of precautions and benefits. Similarly, risk-averse, imprudent, and intemperate homeowners are willing to pay more than risk-loving, imprudent, and intemperate homeowners for similar level of precautions and benefits.

Our results do not support the hypothesis that individuals who exhibit n^{th}-degree stochastic dominance preferences are willing to pay more than those with lower-degree stochastic dominance preferences. While the difference across groups is nominally positive, it is not statistically significant at the 10-percent level, thus lending little support to theory. Similar to previous studies revealing starting-point bias, we find a statistically significant presence of ending-point bias in the payment card WTP analysis.

Besides marginally closing the gap between theory and practice, our results also have significant policy implications on the promotion of precautionary building standards in particular, and the disaster risk management and economic resilience agenda in general. From 1997-2017, hurricanes and tropical storms caused over $220 billion in insured losses, accounting for 38 percent of all insured losses in the U.S (Insurance Information Institute, 2017), and resulting in substantial increases in homeowners insurance premiums in coastal areas.[9]

Today, there is a broad consensus among researchers, insurers, and some policymakers that adoption and enforcement of stronger building codes is critical to disaster risk management and to building resilient communities. Five states, including Alabama, now have policies mandating that insurers offer wind insurance discounts for *Fortified* houses. In addition, the state of Alabama recently launched the Strengthen Alabama Homes program offering subsidies to help homeowners retrofit existing homes to meet *Fortified* standards. Results from this study can be used to calibrate a set of loss-prevention discounts and subsidies to achieve desired results based on observed prevalence of HORA, WTP, and construction costs.

The remainder of our study is organized as follows. In Section 2, we revisit and extend the theory on WTP for loss-prevention up to the fourth order (kurtosis) risk and conduct comparative statics analysis. Section 3 discusses the payment card WTP experimental design and the 50-50 model-free risk apportionment lotteries used to elicit homeowners WTP and HORA, respectively. This section also presents survey sampling and administration strategy details. Next, we present a summary of the data collected and multiple hypothesis tests in Section 4. Section 5 presents and discusses regression results. Section 6 concludes.

2 Theoretical framework

2.1 Willingness to pay for self-protection

We develop and examine the total effects of second, third, and fourth order risk attitudes on risk lovers' and risk averters' marginal WTP for prevention under expected utility theory. We build on model frameworks proposed by Dionne and Li (2011), Eeckhoudt and Gollier (2005), Meyer and Meyer (2011) and Jindapon

[9] Insured losses from 1997-2016 are $161 ($ 2016) billion. Recent estimates of insured losses from hurricanes Harvey and Irma in 2017 are close to $60 billion (https://www.iii.org/fact-statistic/hurricanes.

(2013). To keep the analysis tractable, we do not introduce information friction and instead opt to separately identify its causal effects on WTP experimentally.

Consider an agent with initial wealth w_0 facing potential future loss $L \leq w_0$ with probability p, and no loss with probability $1-p$, $p \in [0,1]$. The agent has the option to spend c to reduce the probability and severity of a loss. In the absence of market insurance, the agent's decision problem can be represented as

$$\underset{c}{\textit{Maximize}} \quad U(c) = p(c)u(w_0 - L(c) - c) + (1-p(c))u(w_0 - c), \tag{1}$$

where the utility function, u, is at least four-times differentiable. We assume $p^{'}(c) < 0$ and $L^{'}(c) < 0$. The first order condition derived from equation (1) is

$$\Gamma^{'}(c^*) = \frac{p(c^*)u^{'}(w_0 - L(c^*) - c^*) + (1-p(c^*))u^{'}(w_0 - c^*)}{u(w_0 - L(c^*) - c^*) - u(w_0 - c^*)}, \tag{2}$$

where c^* is the optimal level of protection, $\Gamma^{'}(c^*) = \frac{p^{'}(c^*)}{L^{'}(c^*)+1}$ approximates the ratio of marginal willingness to pay to reduce the probability of loss, $p^{'}(c^*)$, to the marginal willingness to pay to reduce the amount of wealth loss. To examine comparative statics of second, third, and fourth order risk attitudes on the marginal WTP, we begin by rewriting equation (2) as

$$\Gamma^{'}(c^*) = \frac{p(c^*)u^{'}(w_0 - L(c^*) - c^*) + (1-p(c^*))u^{'}(w_0 - c^*)}{\int_{w_0 - L(c) - c^*}^{w_0 - c^*} u'(x)dx}. \tag{3}$$

Taking the support of wealth as $[w_0 - L(c^*) - c^*, w_0 - c^*]$ and its midpoint $\bar{x} \equiv w_0 - \frac{L(c^*)}{2} - c^*$, and expanding $u'(x)$ using Taylor's second-degree approximation around $\bar{x}$ gives

$$f(x) = u^{'}(\bar{x}) + u^{''}(\bar{x})(x - \bar{x}) + \frac{u^{'''}(\bar{x})}{2}(x-\bar{x})^2 + \frac{u^{''''}(\bar{x})}{6}(x-\bar{x})^3. \tag{4}$$

Equation (4) implies $p(c^*)u^{'}(w_0 - L(c^*) - c^*) + (1-p(c^*))u^{'}(w_0 - c^*) = p(c^*)f(\bar{x} - \frac{L(c^*)}{2}) + (1 - p(c^*))f(\bar{x} + \frac{L(c^*)}{2})$, and $\int_{w_0 - L(c^*) - c^*}^{w_0 - c^*} u'(x)dx = \int_{\bar{x} - \frac{L(c)}{2}}^{\bar{x} + \frac{L(c)}{2}} f(x)dx$. With further simplification, we can rewrite equation (2) as

$$\Gamma^{'}(c^*) \approx \frac{\frac{1}{L(c^*)} + (p(c^*) - \frac{1}{2})R(\bar{x}) + \frac{D(\bar{x})L(c^*)}{8} + (p(c^*) - \frac{1}{2})\frac{K(\bar{x})L(c^*)^2}{24}}{1 + \frac{D(\bar{x})L(c^*)^2}{24}}, \tag{5}$$

where $R(\bar{x}) = -\frac{u^{''}(\bar{x})}{u^{'}(\bar{x})}$ is the Arrow-Pratt measure of absolute risk aversion, $D(\bar{x}) = \frac{u^{'''}(\bar{x})}{u^{'}(\bar{x})}$ is the measure of local downside risk aversion introduced by Modica and Scarsini (2005) and Crainich and Eeckhoudt (2008), and $K(\bar{x}) = -\frac{u^{''''}(\bar{x})}{u^{'}(\bar{x})}$ is a measure of local kurtosis risk aversion. Using equation (5), we derive the partial effects of $R(\bar{x})$, $D(\bar{x})$, and $K(\bar{x})$ as follows:

$$\frac{\partial \Gamma^{'}(c^*)}{\partial R(\bar{x})} = \frac{p(c^*) - \frac{1}{2}}{1 + \frac{D(\bar{x})L(c^*)^2}{24}} \tag{6}$$

$$\frac{\partial \Gamma'(c^*)}{\partial D(\bar{x})} = \frac{\left[2 - (p(c^*) - \frac{1}{2})R(\bar{x})L(c^*) - (p(c^*) - \frac{1}{2})K(\bar{x})\frac{L(c^*)^3}{24}\right] L(c^*)}{24\left[1 + \frac{D(\bar{x})L(c^*)^2}{24}\right]^2} \tag{7}$$

$$\frac{\partial \Gamma'(c^*)}{\partial K(\bar{x})} = \frac{(p(c^*) - \frac{1}{2})\frac{L(c^*)^2}{24}}{1 + \frac{D(\bar{x})L(c^*)^2}{24}} \tag{8}$$

Equations (6), (7), and (8) reveal that the partial effects depend on the values of $p(c^*)$, $R(\bar{x})$, $D(\bar{x})$, and $K(\bar{x})$. Specifically, equation (8) reveals that if $p(c^*) < (>)\frac{1}{2}$ and an agent is prudent, an increase in kurtosis risk aversion will increase (decrease) the level of effort (c^*). Similarly, equation (6) reveals that if $p(c^*) < (>)\frac{1}{2}$ and an agent is prudent, an increase in risk aversion will increase (decrease) the level of effort (c^*). Thus indicating that risk aversion and kurtosis risk aversion affect WTP for prevention in a similar manner. Equation (7) reveals that an increase in downside risk aversion may increase or decrease the optimal level of effort depending on the value of $p(c^*)$, $R(\bar{x})$ and $K(\bar{x})$. More importantly, if kurtosis risk aversion ($K(\bar{x})$) is incorrectly omitted, the effects of downside risk aversion on optimal effort will be over estimated.

Because higher order risk attitudes are correlated, a change in $R(\bar{x})$ is likely to affect $D(\bar{x})$, $K(\bar{x})$ or both. Therefore, to examine the effects of one measure of risk attitude on the marginal WTP for prevention, we need to simultaneously evaluate all three partial effects. Proposition 1.1 summarizes the total effects of changes in risk aversion, downside risk aversion, and kurtosis risk aversion on the optimal prevention decisions of risk lovers and risk averters. This extends and complements propositions in Dachraoui et al. (2004), Eeckhoudt and Gollier (2005), Dionne and Li (2011), Meyer and Meyer (2011) and Jindapon (2013), which are limited to risk-averters and/or downside risk averters.[10]

Proposition 1.1

(i) When $p(c^*) = \frac{1}{2}$, a decision maker exerts more effort with decrease in downside risk aversion.

(ii) When $p(c^*) < (>)\frac{1}{2}$, a prudent risk averter (lover) or a prudent kurtosis risk averter (lover) exerts more effort with increase (decrease) in risk aversion or kurtosis risk aversion and a decrease in downside risk aversion.

(iii) When $p(c^*) < (>)\frac{1}{2}$ and $|R(\bar{x})|L(c^*) + |K(\bar{x})|\frac{L(c^*)^3}{24} < 4$, a prudent risk averter (lover) or a prudent kurtosis risk averter exerts more effort with a decrease (increase) in risk aversion or kurtosis risk aversion and a decrease in downside risk aversion.

Note that equations (6)-(8) can also be viewed as the partial effects on marginal willingness to pay to reduce probability of loss, holding marginal willingness to pay for reduction of loss constant. Conversely, the results from inverting equations (6), (7), and (8) can be interpreted as the partial effects on marginal willingness to pay for reduction of loss while holding marginal willingness to pay to reduce probability of loss constant. In the latter, the total effects are slightly different, and are summarized in proposition 1.2.

Proposition 1.2

(i) When $p(c^*) = \frac{1}{2}$ and $L(c^*) > 12$, a decision maker exerts more effort with decrease in downside risk aversion.

(ii) When $p(c^*) < (>)\frac{1}{2}$, a prudent risk averter (lover) or a prudent kurtosis risk averter (lover) exerts more effort with increase (decrease) in risk aversion or kurtosis risk aversion and a decrease in downside

[10] This assumes infinitesimal loss, and the maximum (minimum) probability of loss, p_n, condition under which a risk lover exerts less (more) effort than a risk-neutral agent, set forth by Dionne and Li (2011), that is $p(w_0 - y) \leq (\geq)\frac{1-2p_n}{p_n}\frac{1}{y}$, for all $y \in [0, L]$.

risk aversion.

(iii) When $p(c^*) < (>) \frac{1}{2}$ *and* $|R(\bar{x})|L(c^*) + |K(\bar{x})|\frac{L(c^*)^3}{24} < \frac{L(c^*)-12}{2}$*, a prudent risk averter (lover) or a prudent kurtosis risk averter exerts more effort with a decrease (increase) in risk aversion or kurtosis risk aversion and a decrease in downside risk aversion.*

Similar conditions can be derived by examining agents' decisions in the presence of market insurance with premiums , $\pi(c)$, dependent on level of effort (c). Assuming $\pi^{'}(c) < 0$ and a fixed deductible ψ, the agent maximizes

$$\underset{c}{\textit{Maximize}} \quad U(c) = p(c)u(w_0 - \psi L(c) - c - \pi(c)) + (1 - p(c))u(w_0 - c - \pi(c)), \tag{9}$$

with first order conditions

$$\Gamma^{'}(c^*) = \frac{p(c^*)u^{'}(w_0 - \psi L(c^*) - c^* - \pi(c^*)) + (1 - p(c^*))u^{'}(w_0 - c^*)}{u(w_0 - \psi L(c^*) - c^* - \pi(c^*)) - u(w_0 - c^*)}, \tag{10}$$

where the new ratio of marginal willingness to pay, $\Gamma^{'}(c^*) = \frac{p^{'}(c^*)}{\psi L^{'}(c^*) + \pi^{'}(c^*) + 1}$. Taking $[w_0 - \psi L(c^*) - c^* - \pi(c^*), w_0 - c^*]$ as the domain of wealth and $\bar{x} \equiv w_0 - \frac{(\psi L(c^*) + \pi(c^*))}{2} - c^*$ its midpoint, and following similar steps above produces similar partial and total effects, albeit bounded within a smaller domain of wealth.

While we can confidently assume the probability of loss $p(c^*) < \frac{1}{2}$ in our study, it is clear that the degree to which higher order risk attitudes (and therefore information friction) effect WTP for precautionary building standards, separately and jointly, is best addressed as an empirical question. Our study seeks to unbundle and empirically test these relationships by eliciting risk attitudes, causal effect of information friction reduction, and WTP for precautionary building standards, using actual levels of precautions (*Fortified* home designations) and premium discounts, and administered to coastal homeowners in a field experiment.

2.2 Risk apportionment

Eeckhoudt and Schlesinger (2006) and Eeckhoudt et al. (2009) describe risk attitudes based on principles of risk apportionment. Let $M > 0$, $z_1 > 0$, and $z_2 > 0$ be strictly positive monetary outcomes. Consider two lotteries $A = [M, M - z_1 - z_2]$ and $B = [M - z_1, M - z_2]$, each with equally likely outcomes. A risk-averse individual will prefer B over A for all possible values of M, satisfying mean-preserving spreads (Rothschild and Stiglitz, 1970) and a concave utility within EUT.

Eeckhoudt and Schlesinger (2006) relate the preference for B over A as a preference for "disaggregating the harms" and term it risk apportionment of order two. In this case z_1 and z_2 represent the "harms." Prudence is characterized as a preference for disaggregating a zero-mean risk v and a sure loss of wealth z_2, across two equally likely states of nature. To elicit prudence with lotteries A and B, the authors replace one of the harms of a sure loss with v resulting in $A = [M, M + v - z_2]$ and $B = [M + v, M - z_2]$. A preference for lottery B over A for all values of M, $z_2 > 0$, and v defines prudence and satisfies a convex marginal utility under EUT and a decrease in downside risk (Menezes et al., 1980). Intuitively, this means prudent individuals prefer adding a zero-mean risk to a higher wealth level than to a lower wealth level. Similarly, they characterize temperance as a preference for disaggregating two independent zero-mean risks (v and u). A temperate individual will prefer $B = [M + v, M + u]$ over $A = [M, M + v + u]$. These choices will be consistent with any model of preference, e.g., EU with increasing, concave, and continuously differentiable utility function that preserves nth-order stochastic dominance (Zilcha and Chew, 1990; Eeckhoudt et al., 2009).

In general, models based on stochastic dominance of one choice over another are consistent with models of preferences that preserve a preference for n^{th}-order stochastic dominance. Preference relations based on the principles of risk apportionment preserve preferences for n^{th}-order stochastic dominance when the utility function is n^{th}-order differentiable and concave such that the sign of $u^n(.) = (-1)^{(n+1)}$ for $n = 1, ..., N$. These restrictions produce results consistent under EUT and $non-EUT$ models. Eeckhoudt and Schlesinger (2006) show that risk-apportionment of order n exists for agents under EUT if this restriction on the sign of utility derivation holds. This implies, under the alternating pattern of signs of successive derivations of u, risk-averse agents will also be prudent and temperate, with a preference for combining "good with bad."

Using a similar theorem, Deck and Schlesinger (2014) posit that mixed risk lovers – with preferences for combining "good with good," and "bad with bad" – satisfy risk apportionment of order n when n is odd, but dislike risk apportionment when n is even. As such, risk averters and risk lovers are predicted to demonstrate similar preferences when n is odd and dissimilar preferences when n is even. Based on this theorem, risk lovers are expected to be prudent but intemperate. Whether or not risk averters are indeed mixed risk averters and risk lovers are mixed risk lovers in practice is an empirical question our study seeks to answer. Because the uptake of precautionary building standards for hurricane-related losses reveals aversion to downside risk, or prudence, we expect both risk-lovers and risk-averters to have a positive association between prudence and level of precaution.

In the above cases, a preference for lottery $B = [M - z_1, M - z_2]$ over lottery $A = [M, M - z_1 - z_2]$ is equivalent to saying that B dominates A via second-order stochastic dominance ($BSSDA$) or in the spirit of Ekern (1980), A has more second degree risk than B for all u such that the sign of $u^n(.) = (-1)^{(n+1)}$ for $n = 1, ..., N$. Similarly, $B = [M + v, M - z_2]$ dominates $A = [M, M + v - z_2]$ via third-order stochastic dominance ($B\ TSD\ A$) or A has more third degree risk than B, and $B = [M + v, M + u]$ dominates $A = [M, M + v + u]$ via fourth order stochastic dominance ($B\ FSD\ A$). Therefore, we expect homeowners who exhibit n^{th} degree risk attitudes to take-up more precautionary building standards than those who exhibit $(n - 1)^{th}$ or lower degree risk attitudes.

Alternatively and more intuitively, homeowners with time-separable preferences faced with two random housing (wealth) values, B in time period one and A in time period two such that B dominates A via n^{th} order stochastic dominance ($B\ NSD\ A$), will invest in loss mitigation whenever preferences satisfy $(n - 1)^{th}$ degree stochastic dominance preference.

For our study, it is reasonable to assume that the probability of hurricane-related loss is far less than 50 percent. Thus, we expect homeowners who exhibit more n^{th}-degree risk preference, to have higher WTP than those who exhibit lower-degree risk preference, for similar levels of precaution and insurance discount.

To the best of our knowledge, these relationships have not been tested empirically, and our study seeks to fill this gap in the literature. More importantly, WTP estimates are commonly used to guide public policy. Promoting stronger building codes is key to disaster risk management and economic resilience. Determining specific codes to promote in specific risk environments needs to also account for homeowners' WTP. The latter could vary significantly depending on exposure as well as risk attitudes. Gaining insight on the prevalence of HORA and their relationship with homeowners' WTP could help guide the selection and promotion of an optimal portfolio of loss mitigation features and subsidies for targeted segments of the population.

3 Experimental design

3.1 Higher Order Risk Attitude experiment

This study employs a series of 50 - 50 model-free risk apportionment lotteries (Eeckhoudt and Schlesinger, 2006) to measure the first four orders of homeowners' risk preferences in two coastal counties in the U.S.[11] Subjects were presented with 14 lottery pairs (Table 1) and were asked to choose the preferred option.[12] Two tasks seek to measure the principle that "more money is preferred to less." Four tasks each measure second, third, and fourth order risk preferences as well as verifying their consistency. In each case, if option B is chosen over A, it implies the individual prefers more money to less (first order), is risk averse (second order), prudent (third order), and temperate (fourth order). This design sufficiently varies in the lotteries pairs within each category, enabling us to elicited 2^{nd}, 3^{rd}, and 4^{th} risk attitudes with reasonable confidence. Following Deck and Schlesinger (2014), we presented each choice task as a lottery with equally likely payoffs depicted as cash amounts in association with other lotteries to ease understanding and to enable respondents to see it as combining "good with bad" or combining "good with good." In addition to written descriptions and instructions (Online Resource 1) made available to respondents, we created and uploaded short video clips describing in detail (using a visual example) the risk preference choice tasks. Participants were required to watch the clips and confirm their understanding before engaging in the choice tasks. The tasks were presented to survey participants in random order.

Table 1: Choice tasks

Task	Order	Option A	Option B
1	1	$20	$20 + $10
2	1	[$2+[$10,$20],$20]	[$25,$27+[$-1,$1]]
3	2	[$5, $10+$5]	[$5+$5, $10]
4	2	[$2, $4+$8]	[$2+$8, $4]
5	2	[$2, $4+$3]	[$2+$3, $4]
6	2	[$20, $40+$30]	[$20+$30, $40]
7	3	[$5+[$-2,$2],$10]	[$5,$10+[$-2,$2]]
8	3	[$10+[$-4,$4],$20]	[$10,$20+[$-4,$4]]
9	3	[$8+[$2,$-2],$10]	[$8,$10+[$2,$-2]]
10	3	[$12+[$1,$-1],$14]	[$12,$14+[$1,$-1]]
11	4	[[$14,$20]+[$14,$20],[$10,$24]+[$10,$24]]	[[$10,$24]+[$14,$20],[$14,$20]+[$10,$24]]
12	4	[[$7,$10]+[$7,$10],[$5,$12]+[$5,$12]]	[[$5,$12]+[$7,$10],[$7,$10]+[$5,$12]]
13	4	[$14+8A, $24+8B]	[$14+8B,$24+8A]
14	4	[$7+7A,$12+7B]	[$7+7B,$12+7A]

Source: Adapted from Deck and Schlesinger (2014)

Each participant was paid $40 for taking part in the survey and earned a bonus of $0 to $60 depending on outcomes of randomly selected lotteries and ability to solve the expected value of a simple lottery. To

[11] We also elicited homeowners risk attitudes using a price-list experiment à la Tanaka et al. (2010), except that we do not enforce monotonicity. The lotteries are also specified in the gain domain in terms of loss reductions from retrofitting a house. We analyze and compare results from the two experiments in a separate paper that addresses issues beyond the scope of this study, and also for brevity sake.

[12] These lotteries are adapted from those used in the experiment by Deck and Schlesinger (2014). The full lottery design used by the authors was intended to broadly investigate consistency in risk attitudes, an objective we do not intend to pursue in this study.

calculate the bonus, one lottery each was randomly drawn from the risk apportionment lotteries and the price-list lotteries defined as loss reduction from retrofitting a house. A weighted sum of the two lotteries outcomes was calculated to ensure similar contribution from each experiment while capping the bonus at $60. Details on the bonus calculation (See online appendix 1) with examples were made available to all respondents. Participant had to solve the expected value of a simple lottery (depicted in online appendix 1) correctly to earn the bonus. This final hurdle was introduced to comply with The University of Alabama Institutional Review Board per Alabama State law.[13] Total compensation earned by each survey participant ranges from $40 to $100, which is substantial compared to compensation offered in other studies, as well as the median hourly wage in the counties where we implemented the survey.

3.2 Willingness to Pay (WTP) Experiment

We elicit homeowners' WTP for *Fortified* using a payment card method. Our experimental design involves four attributes, each with two or three levels. The main attributes, *Fortified* designation and premium discount, have two (*Fortified* Bronze and *Fortified* Silver) and three (20-percent, 35-percent and 45-percent) attribute levels, respectively. The premium discounts capture the reduction in loss and/or probability of loss due to *Fortified* home standards, and are based on estimates from commercial catastrophic models derived in collaboration with insurers. Note that current Alabama law mandates insurance premium discounts on the wind portion of premium[14] by 20 percent and 35 percent for *Fortified* Bronze and 35 percent and 45 percent for *Fortified* Silver, depending on the age of the roof.[15]

Past studies show that WTP estimates vary with the range of payment values offered to survey participants. Estimates tend to be positively correlated with the level of the lower-bound, resulting in a starting-point bias. To account for this potential drawback in our research design, we introduce payment card WTP range as an attribute and consider two payment card ranges. The first has a low upper bound, ranging from $0 to $25,000 ($0, $2,500, $5,000, $7,500, $10,000, $12,500, $15,000, $17,500, $20,000, $\geq$ $25,000) henceforth "$WTP_{LUB}$." The second has a high upper bound, ranging from $0 to $35,000 ($0, $2,500, $5,000, $7,500, $10,000, $12,500, $15,000, $17,500, $20,000, $25,000, $30,000, $\geq$ $35,000) henceforth "$WTP_{HUB}$." This design attribute allows us to test for ending-point bias in payment card WTP estimates.[16]

As a final attribute of our survey design, we randomly assign half of the survey respondents to watch a video from the IBHS lab demonstrating the performance of *Fortified* and conventional homes side-by-side in the face of hurricane-speed winds.[17] In this video, the conventional home quickly collapses; while the *Fortified* home remains standing. This treatment allows us to gauge the effect of information friction on the performance of *Fortified* versus conventional home construction on homeowners' WTP. We hypothesize that seeing the video will reduce information friction and increase confidence in the attributes and performance of *Fortified*, resulting in higher WTP for precautionary standards. Table 2 summarizes the attributes and attribute levels in our design.

The full factorial experimental design based on the four attributes and attribute levels includes 24 unique combinations. By implementation, we indirectly block the full factorial into four treatment blocks based

[13]Alabama State law prohibit the usage of gambles, lotteries or raffles as a form of compensation.

[14]The wind portion of homeowners insurance premiums ranges from 60% to 80% of total premium in our sample region.

[15]The smaller discount applies if a roof is more than five years old.

[16]Data collected by Alabama State Insurance Commissioner under the Strengthen Alabama Home Program in the area of study from 2016 to 2019 show that the average (standard deviation) cost to retrofit a convention house to a *Fortified* Bronze and *Fortified* Silver designation is $14200 ($4900) and $13000 ($8600), respectively. Our WTP ranges are reasonably inclusive if we consider that the support of the cost distribution lies within 3 standard deviation of the mean.

[17]Watch the video at https://vimeo.com/17764719.

Table 2: Attributes and Attribute levels of WTP experiment

Attributes	Attribute levels
Fortified designation	Bronze, Silver
Insurance premium discount	20%, 35%, 45%
Payment card WTP range	WTP_{LUB} (\$0 $\geq$ \$25,000), WTP_{HUB} (\$0 $\geq$ \$35,000)
Information on performance of *Fortified*	watched video, no video

on whether or not the watched the video and the payment card WTP range seen. These blocks include (i) no video, WTP_{LUB} (ii) watched video, WTP_{LUB} (iii) no video, WTP_{HUB} and (iv) watched video, WTP_{HUB}. Each block has all possible combinations of *Fortified* designation and insurance discount attribute levels but different combinations of payment card WTP range and information on the performance of *Fortified* versus conventional construction. Each homeowner is randomly assigned to one block and thus responds to six WTP questions elicited with combinations of the four attribute levels. A sample of the six questions presented to each respondent appears in Appendix A.

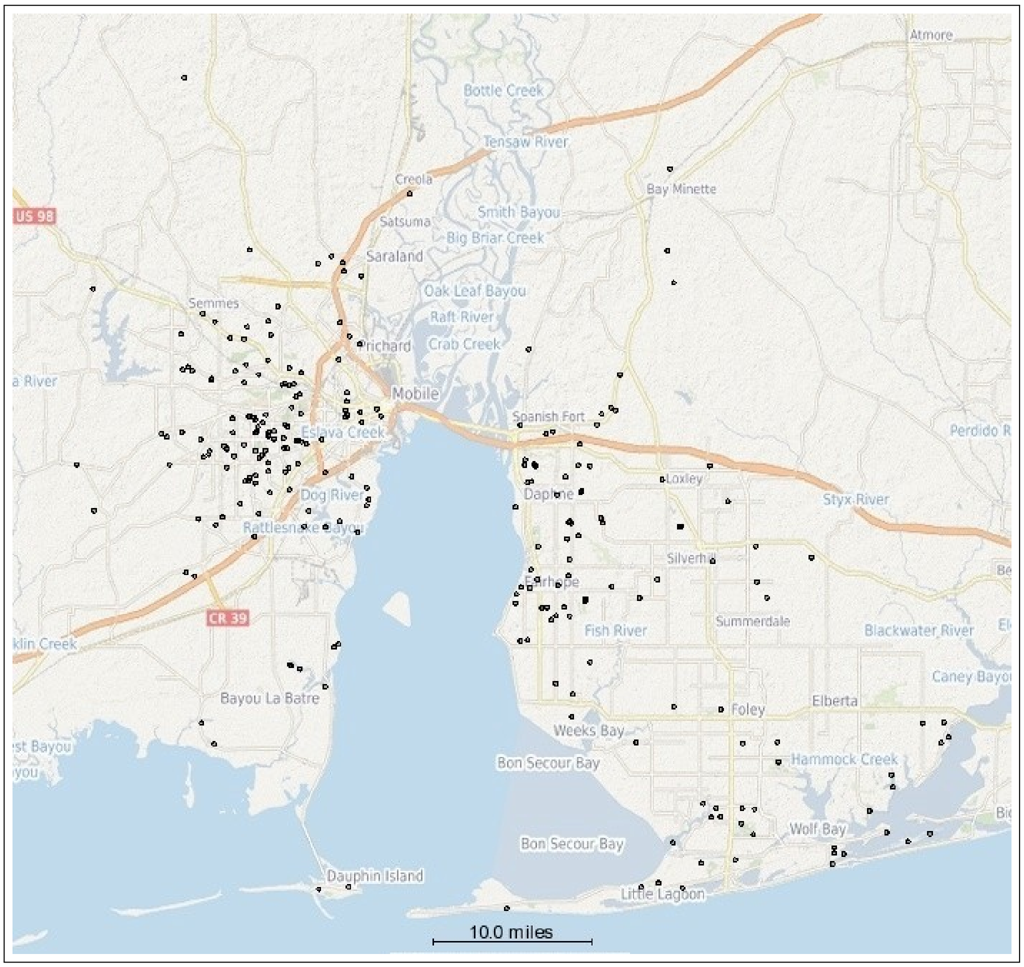
Our experimental design and data enables us to empirically test for causal relationship between information friction, payment card WTP range and WTP for precautions. Specifically, *Hypothesis 1:* For given risk attitudes, level of *Fortified* designation, insurance premium discount, and payment card WTP range, homeowners (exposed to the video demonstrating the performance of fortified side-by-side with a conventional house) with lower information friction on *Fortified* will be willing to pay more than homeowners (who did not watch the video) with higher information friction.
Hypothesis 2: Homeowners assigned to WTP_{HUB} will be willing to pay more than homeowners assigned to WTP_{LUB} for given risk attitudes, level of *Fortified* designation, and insurance premium discount.

Additionally, our experiment also enable us to empirically resolve and compare the relationships put forth in propositions 1 relating mixed risk-lovers, mixed risk-averters, and WTP for precautions. Specifically, we cleanly identify and test for correlation between mixed HORA subgroups and the WTP for different combinations *Fortified* designation, insurance premium discount and ultimately make comparison between WTP for mixed risk-lovers and mixed risk-averters. Note that we are unable to predict in advance the magnitude and direction of the joint increase in second, third, or fourth order risk attitudes on WTP any HORA subgroup.

The WTP experiment was implemented as part of an online survey of homeowners insurance in Mobile and Baldwin counties in Alabama. Homeowners' risk preferences up to the fourth order are also elicited using 50-50 risk apportionment lotteries (Deck and Schlesinger, 2014). In addition, the survey collects information about precautionary home investments against windstorm risk, risk perception, socio-demographic information, and housing data. We pretested the initial version of the survey in face-to-face interviews with a total of 16 participants in three successive sessions. We updated the survey after each session to ensure the questions are unambiguous. Results from the final round of pretesting show that participants generally understand the survey content. Using 2015 property tax data from Mobile and Baldwin counties as the population, we obtain a random sample of 6,500 homeowners. To increase the chances of obtaining a representative sample, we block the survey design by county, wind speed zone, flood risk zone, and property value. We conduct random sampling at the block-level, allocating sample size across blocks by population. The survey was administered to the random sample of homeowners during summer of 2016.

We solicit participants by mail using a cover letter including the survey link and password, as well as an RSVP card with five options for indicating a recipient's intention of participating in the survey, and whether or not they need assistance (via telephone, online, or in-person) in taking the survey. We follow up with the target sample through two waves of reminders mailed out every fourth night following the initial solicitation, in addition to phone calls and emails to those who RSVP. To access and complete the online survey, individuals must be at least 18 years old, current resident of either Mobile or Baldwin County, and a homeowner in an owner-occupied property. Homeowners who have not yet adopted any level of *Fortified* designation are identified using preliminary questions and directed to participate in the WTP section of the survey. Homeowners indicated that lack of information on *Fortified* and initial cost of investment are the top reasons they have not adopted *Fortified* designation, thus leading more support to our underlined research questions. In the end, we receive 213 WTP survey responses. Figure 1 shows the locations of survey respondents. Our sample includes diverse respondents with respect to neighborhood value and distance from the coast.

Figure 1: Location of survey respondents



4 Data summary and multiple hypothesis tests

Table 3 reports summary statistics of the variables in our analysis. Monotonic choices are the number of times option B lottery is chosen over option A out of two choice tasks (showing that "more money is preferred to less"). Safe choices are the number of times option B lottery (indicating homeowner is risk averse) is chosen over option A out of four choice tasks. Similarly, prudent and temperate choices are the number of times option B lottery (indicating homeowner is downside risk-averse and kurtosis risk-averse, respectively) is chosen over option A out of four choice tasks. Option B is chosen more than half of the times in each category of choices (see Table 3) indicating that, on average, homeowners prefer more money to less, are risk averse, prudent, and temperate.

A two-sided Wilcoxon sign rank test and t-tests comparing the observed counts to a randomly-generated sample reject the null hypothesis (that the counts from both samples are equal) at the 1-percent level. We classify individuals into categories of second, third, and fourth order risk subgroups based on choice counts. We classify homeowners who chose option B zero or one time out of four choice tasks used to elicit second-degree risk attitudes as risk lovers. Those who chose option B two times out of the four choice tasks are risk-neutral, and those who choose B three or four times are risk-averse.

Table 3: Data summary

Variable	Count	Mean	Std. Dev.	Min.	Max
Monotonic choices	191	1.7	0.6	0	2.0
Safe choices	191	2.6	1.4	0	4.0
Prudent choices	191	2.7	1.4	0	4.0
Temperate choices	191	2.3	1.1	0	4.0
WTP: Bronze with 20-percent premium discount	211	1,955	2,673	0	15,000
WTP: Bronze with 35-percent premium discount	212	2,618	3,432	0	25,000
WTP: Bronze with 45-percent premium discount	209	3,313	4,050	0	25,000
WTP: Silver with 20-percent premium discount	213	2,078	2,924	0	17,500
WTP: Silver with 35-percent premium discount	213	2,664	3,171	0	17,500
WTP: Silver with 45-percent premium discount	213	3,509	4,061	0	20,000
WTP: Watched video	107	2,778	3,523	0	25,000
WTP: No video	105	2,599	3,407	0	25,000
WTP: Low Upper Bound, No video	49	2,262	2,738	0	15,000
WTP: Low Upper Bound, Watched video	59	2,175	3,324	0	17,500
WTP: High Upper Bound, No video	57	2,892	3,878	0	25,000
WTP: High Upper Bound, Watched video	48	3,526	3,624	0	25,000
Hurricane risk perception	213	2.9	1.8	0	6.0
Income	199	76,533	54,591	10,000	275,000
Female	213	0.5	0.5	0	1.0
House age	212	33.4	21.8	1.2	156.2
Roof age	213	9.6	5.8	1.0	27.5
House size	213	2,140	803	800	5,600

Note: Monotonic choices is the number of choices (out of two) indicating the respondent prefers more to less. Safe/Prudent/Temperate choices is the number of choices (out of four) indicating respondent is risk averse/prudent/temperate. The variables beginning with WTP are willingness-to-pay responses for the six combinations of precaution and premium discount. Hurricane risk perception is the number of category three hurricanes the respondent expects will affect her community in the next 50 years. Income is household income. Female is a dummy variable equal to one if respondent is female. House age is the number of years since a house was built. Roof age is the number of years since the roof of a house was built or replaced. House size is square feet of living space. Count varies when respondents choose not to answer a question.

Similarly, we classify homeowners as imprudent/downside risk-lovers, prudence-neutral/downside risk-neutral, and prudent/downside risk-averse if they have zero or one count, two counts, and three or four counts, respectively. Additionally, we classify homeowners as intemperate/kurtosis risk-lovers, temperance-neutral/kurtosis risk-neutral, and temperate/kurtosis risk-averse if they have zero or one count, two counts, and three or four counts, respectively, out of the four fourth-degree risk attitudes choice tasks. Table 4 reports the frequency distribution of second, third, and fourth-degree risk attitudes by sub-risk categories. Results reveal high prevalence of second, third, and fourth-degree risk-averse homeowners.

Table 4: Frequency distribution of Higher Order Risk Attitude (N=191)

	Risk-loving	Risk-neutral	Risk-averse
Second-degree	52	26	113
Third-degree	42	21	128
Fourth-degree	43	60	88

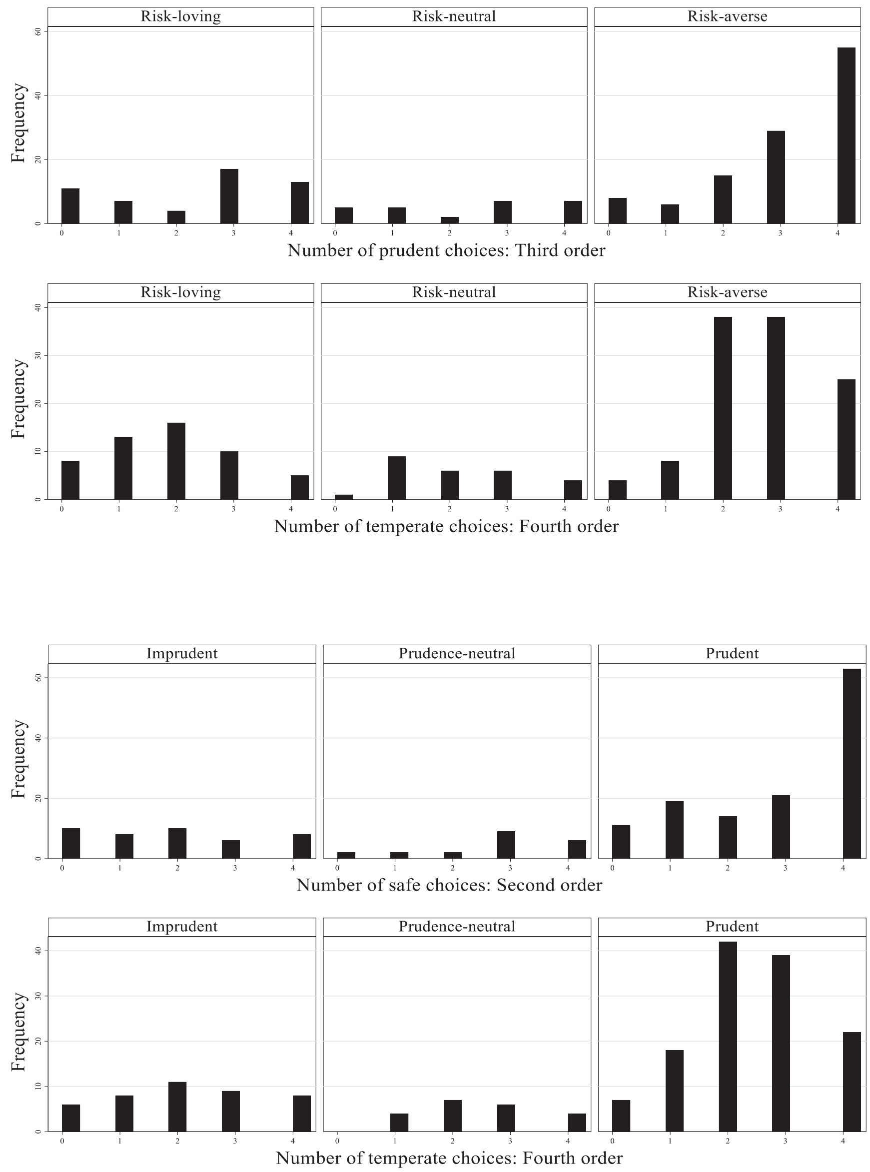
Figure 2 depicts frequency distributions of homeowners risk attitudes by second and third order risk classification. Panel 1 depicts the frequency distribution of third and fourth order risk attitudes by risk lovers, risk-neutral agents, and risk averters. Panel 2 depicts the distribution of second and fourth order risk attitudes by third-order risk classification. The figures suggest that homeowners are most likely to exhibit combinations of risk aversion and prudence, risk aversion and temperance, and prudence and temperance.

In Table 3, Bronze/Silver and 20-percent/35-percent /45-percent are the WTP for each combination of precaution level and insurance-premium discount percentage. "Watched video" and "no video" are the WTP for homeowners who watched and did not watched the video illustrating the performance of *Fortified* relative to conventional homes prior to responding to the WTP questions, respectively. WTP low/high upper bound and watched/no video are the WTP for each treatment block based on whether or not the respondent watched the video, and the payment card WTP range seen. Hurricane risk perception is the number of category-three hurricanes (wind speed $>$110 mph) a homeowner anticipates affecting her community in the next 50 years. Income is household income, calculated using the midpoints of income ranges selected by survey participants.[18] We use the natural logarithm of income in subsequent multivariate tests. Female is a dummy variable equal to one if the survey respondent is female. The last four variables describe the respondent's house. House age is the number of years since the house was built. Roof age is the number of years since the roof was replaced. House size is square feet of living area in the house. Older houses, larger houses, and newer roofs increase the cost of retrofitting a house to *Fortified* standards.

Observed WTP ranges from $0 to $17,500 and $0 to $25,000 for homeowners who were assigned to the WTP payment card with low upper bound (WTP_{LUB}) and high upper bound (WTP_{HUB}), respectively, indicating that our data are only left-censored. Results reported in Table 4 show that homeowners are willing to pay more for stronger building standards and corresponding homeowners insurance premium discounts. The average WTP ranges from $1,955 for *Fortified* Bronze with 20-percent premium discount to $3,509 for *Fortified* Silver with 45-percent premium discount. The average WTP for homeowners who watched the video demonstrating the performance of *Fortified* relative to conventional houses before stating their WTP is slightly higher than those who did not watch the video. The average WTP in the four design treatment blocks ranges from $2,175 for homeowners who watched the video and were assigned WTP_{LUB} to $3,526 for

[18]The maximum income category is "greater than $250,000 per year." We insert the income value $275,000 for the handful of respondents that selected this range. While this is in part a judgment call, $275,000 is approximately two standard deviations from the mean income if we exclude the highest category. Results and conclusions are not sensitive to alternative choices for highest income level. Note we use percentiles of income, rather than the mean, when predicting WTP later in the article

Figure 2: Frequency distribution of homeowners risk attitudes by 2^{nd} and 3^{rd} order risk classification



those who watched the video and were assigned WTP_{HUB}. On average, homeowners who were assigned WTP_{HUB} have higher WTP than those assigned WTP_{LUB}. However, watching the video, on average, increased the WTP among those assigned WTP_{HUB} but moderately decreases the WTP amongst those assigned WTP_{LUB}.

We conduct Multiple Hypothesis Testing (MHT) to test for heterogeneous treatment effects among experimental blocks and risk attitude subgroups. In MHT, a cluster of hypotheses is tested simultaneously, while properly adjusting for the likelihood of committing type I errors and reaching false positives. List et al. (2016) develop two methods to adjust standard errors for multiplicity, and compare them to existing methods proposed by Bonferroni (1935) and Holm (1979).

Table 5 presents results of MHT comparing the four treatment blocks. Except for differences in mean WTP between the "WTP_{LUB} & no video" and "WTP_{LUB} & watched video" treatment blocks, results reveal significant differences in mean WTP between every treatment block combination at the 10 percent level or less, based on 3 or all 4 multiplicity adjustment methods. Therefore, based on findings in Table 3, the results suggest that homeowners who were assigned the high upper bound payment card exhibited significantly higher WTP for *Fortified* than those who answered the low upper bound payment card, irrespective of their exposure to the video, indicating ending-point bias in WTP payment card design. Additionally, homeowners who were exposed to the video and were assigned the high upper bound payment card WTP had significantly higher WTP than those who saw the same payment card but were not exposed to the video, suggesting the presence and negative effect of information friction on WTP.

Table 5: MHT: Comparing treatment blocks

Treatment block 1	Treatment block 2	Diff.	Unadj	LXS1	LXS2	Bonf	Holm
WTP_{LUB} / no video	WTP_{LUB} / watched video	86.76	0.708	0.708	0.708	1	0.708
WTP_{LUB} / no video	WTP_{HUB} / no video	630.11	0.014	0.037	0.014	0.084	0.042
WTP_{LUB} / no video	WTP_{HUB} / watched video	1264.41	0.000	0.000	0.000	0.002	0.002
WTP_{LUB} / watched video	WTP_{HUB} / no video	716.87	0.012	0.040	0.032	0.074	0.049
WTP_{LUB} / watched video	WTP_{HUB} / watched video	1351.17	0.000	0.000	0.000	0.002	0.002
WTP_{HUB} / no video	WTP_{HUB} / watched video	634.30	0.037	0.072	0.037	0.222	0.074

Note: MHT abbreviates Multiple Hypothesis Testing. Diff. is the difference between means for treatment block 1 and treatment block 2. Unadj is the unadjusted p-value. LXS1 and LXS2 are p-values obtained by applying correction procedures proposed by List et al (2015) to Unadj. Bonf and Holm are p-values obtained by applying Bonferroni adjustment and Holm adjustment, respectively to Unadj.

Next, we measure the information friction (video) treatment effect within risk attitude subgroups. Results of the MHT method appear in Table 6. We find a statistically significant difference in mean WTP (at the 6 percent level or less) within three of the four mixed risk-loving subgroups (risk loving-prudent-temperate, risk loving-imprudent-temperate, and risk loving-imprudent-intemperate) and none within mixed risk-averse subgroups. These results suggest that mixed risk-lovers exhibit high information friction about the performance of *Fortified* relative to conventional building standards resulting to lower WTP, and exposure to the video reduces the friction. The effects of information friction is highest among risk loving-prudent-temperate homeowners resulting to a decrease in WTP of $3,103 on average. The results also reveal the multiplicity problem in the risk-loving, prudent, and intemperate subgroup whose statistical significance at the 5 percent level disappears after adjusting the p-values.

Table 7 depicts MHT results for pairwise comparisons of multiple treatment blocks and a baseline treatment block (WTP_{LUB} & no video) within risk attitude subgroups.

Results based on Bonferroni and Holm adjustments reveal that among homeowners who are risk-loving, imprudent, and temperate, the mean WTP for homeowners who watched the video and later assigned either

Table 6: MHT: Comparing information friction treatment effect within risk attitude subgroups

Risk attitude subgroup	Diff.	Unadj	LXS1	LXS2	Bonf	Holm
Risk-loving/imprudent/intemperate	2,014	0.000	0.002	0.002	0.002	0.002
Risk-loving/imprudent/temperate	1,250	0.008	0.044	0.044	0.058	0.042
Risk-loving/prudent/intemperate	2,778	0.045	0.172	0.172	0.317	0.181
Risk-loving/prudent/temperate	3,103	0.000	0.000	0.000	0.002	0.002
Risk-averse/imprudent/temperate	111	0.879	0.879	0.879	1	0.879
Risk-averse/prudent/intemperate	139	0.869	0.983	0.983	1	1
Risk-averse/prudent/temperate	142	0.698	0.969	0.969	1	1

Note: MHT abbreviates Multiple Hypothesis Testing. Diff. is the difference between means for participants who watched the IBHS video and those who did not watch the video. Unadj is the unadjusted p-value. LXS1 and LXS2 are p-values obtained by applying correction procedures proposed by List et. al (2015) to Unadj. Bonf and Holm are p-values obtained by applying Bonferroni adjustment and Holm adjustment, respectively to Unadj.

Table 7: MHT: Pairwise comparison of multiple treatment blocks and a baseline treatment block within risk attitudes subgroups

Risk attitude subgroups	Treatment block 2	Diff.	Unadj	LXS1	LXS2	Bonf	Holm
Risk-loving, imprudent, & temperate	WTP_{LUB} & watched video	2,500	0.000	1	1	0.007	0.006
Risk-loving, imprudent, & temperate	WTP_{HUB} & no video	1,875	0.151	0.642	0.642	1	1
Risk-loving, imprudent, & temperate	WTP_{HUB} & watched video	2,500	0.000	1	1	0.007	0.007
Risk-loving, prudent, & intemperate	WTP_{LUB} & watched video	938	0.505	0.900	0.900	1	1
Risk-loving, prudent, & intemperate	WTP_{HUB} & no video	6,458	0.029	0.214	0.214	0.609	0.29
Risk-loving, prudent, & intemperate	WTP_{HUB} & watched video	313	0.819	0.965	0.965	1	1
Risk-loving, prudent, & temperate	WTP_{LUB} & watched video	5,556	0.020	0.166	0.166	0.413	0.216
Risk-loving, prudent, & temperate	WTP_{HUB} & no video	2,761	0.008	0.059	0.059	0.161	0.107
Risk-loving, prudent, & temperate	WTP_{HUB} & watched video	3,889	0.001	0.007	0.007	0.021	0.016
Risk-averse, imprudent, & temperate	WTP_{LUB} & watched video	417	0.520	0.885	0.885	1	1
Risk-averse, imprudent, & temperate	WTP_{HUB} & no video	2,917	0.066	0.349	0.349	1	0.525
Risk-averse, imprudent, & temperate	WTP_{HUB} & watched video	1,250	0.210	0.712	0.712	1	1
Risk-averse, prudent, & intemperate	WTP_{LUB} & watched video	1,667	0.018	0.156	0.156	0.385	0.22
Risk-averse, prudent, & intemperate	WTP_{HUB} & no video	1,250	0.322	0.808	0.808	1	1
Risk-averse, prudent, & intemperate	WTP_{HUB} & watched video	2,639	0.005	0.036	0.036	0.098	0.07
Risk-averse, prudent, & temperate	WTP_{LUB} & watched video	759	0.033	0.214	0.214	0.693	0.297
Risk-averse, prudent, & temperate	WTP_{HUB} & no video	43	0.917	0.917	0.917	1	0.917
Risk-averse, prudent, & temperate	WTP_{HUB} & watched video	1,574	0.008	0.053	0.053	0.161	0.099

Note: Diff. is the difference between means for treatment block 1 (WTP_{LUB} & no video) and other treatments block 2. Unadj is the unadjusted p-value. LXS1 and LXS2 are p-values obtained by applying correction procedures proposed by List et. al (2015) to Unadj. Bonf and Holm are p-values obtained by applying Bonferroni adjustment and Holm adjustment, respectively to Unadj.

high or low upper bound payment card range is statistically different (at the 1 percent level) from the mean WTP for those who did not watch the video and saw the low upper bound payment card range. Similarly, 2 or all 4 multiplicity adjustment tests reveal that among homeowners who are risk-loving, prudent, and temperate, the mean WTP for those who either watched or did not watch the video and were later assigned the high upper bound payment card range is statistically different from the mean WTP for those who did not watch the video and saw the low upper bound payment card range. Additionally, among homeowners who are either risk-averse, prudent, and intemperate or risk-averse, prudent, and temperate, the mean WTP for those who watched the video and were assigned high upper bound payment card range is statistically different from the mean WTP for those who did not watch the video and saw the low upper bound payment card range, based on at least three MHT methods. These results suggest that differences in mean WTP for risk-averse, prudent, temperate, and intemperate homeowners is likely driven by the high payment card WTP range, rather than information friction on the performance of *Fortified* as is the case with risk-loving, prudent, imprudent, temperate, and intemperate homeowners.

Comparing the magnitude of the differences in WTP among the (6) risk attitude subgroups and treatment blocks that are statistically significant reveals that, strongest treatment effect compared to the baseline treatment is the video and high WTP payment card range treatment among risk loving-prudent-temperate homeowners ($3889) followed by the no video and high WTP payment card range treatment ($2761), the video and high WTP payment card range treatment among risk averse-prudent-intemperate homeowners ($2,639) while the video and high WTP payment card range treatment among risk averse-prudent-temperate homeowners is the least ($1,574). These results imply that (i) alleviating information friction among risk loving-prudent-temperate homeowners while controlling for WTP payment card range increases their WTP by $1,128 on average (ii) the range of WTP payment card has no effect among risk loving-imprudent-temperate homeowners. However alleviating information friction increases WTP among this HORA subgroup increases their WTP by $2,500, and (iii) risk-averse-prudent-intemperate homeowners are WTP $1,065 more than risk-averse-prudent-temperate homeowners.

Table 8 reports results for pairwise comparisons of all multiple block-treatment interactions with a baseline block-treatment interaction (WTP_{LUB} & no video, Fortified Bronze, 20-percent insurance discount).

Results show that the mean WTP for 6 (out-of 23) treatments (WTP_{HUB} & no video, *Fortified* Bronze, 45-percent insurance discount; WTP_{HUB} & watched video, *Fortified* Bronze, 45-percent insurance discount; WTP_{HUB} & watched video, *Fortified* Silver, 20-percent insurance discount; WTP_{HUB} & watched video, *Fortified* Silver, 35-percent insurance discount; WTP_{HUB} & no video, *Fortified* Silver, 45-percent insurance discount; WTP_{HUB} & watched video, *Fortified* Silver, 45-percent insurance discount) are significantly different from the mean WTP for the baseline treatment (WTP_{LUB} & no video, *Fortified* Bronze, 20-percent insurance discount) at the 10-percent level or less, based on two or more multiplicity adjustments methods. Overall, the results appears to suggest that higher levels of insurance discounts (and precautions to a lesser extent) increases WTP for *Fortified*.

Next, we conduct MHT to test for heterogeneous treatment effects among experimental blocks and hurricane risk perception subgroups. The latter is the number of category 3 hurricanes the homeowner expects to hit her community in the next 50 years.[19]

Results comparing the mean WTP (i) between risk perception subgroups, (ii) for information friction (video) treatment effect within hurricane risk perception subgroups and (iii) of multiple treatment blocks (WTP_{LUB} & video, WTP_{HUB} & no video, and WTP_{HUB} & video) with a baseline treatment block (WTP_{LUB} & no video) within hurricane risk perception subgroups are reported in Online Resource 2. Overall, they show a statistically significant difference in mean WTP between (i) the lowest (zero) hurricane risk perception subgroup and higher risk perception subgroups (ii) those who watched the video and those who did not among homeowners who expect 4 and 6 category 3 hurricanes in the next 50 years and (iii) a statistically significant difference in mean WTP between the baseline treatment block and every other treatment block among homeowners who expect 1, 2, 3, 4, and 6 category 3 hurricanes in the next 50 years. Thus, suggesting that homeowners with high hurricane risk perception are more likely to exhibit information

[19]Homeowners are most likely to expect 3 category 3 hurricanes within the next 50 years. The percentages of homeowners who expect 1, 2, 3, 4, 5, 6, and 7 number of category 3 hurricanes in the next 50 years are 9.9%, 13.2%, 23.0%, 17.4%, 12.7%, 14.1%, and 9.9%, respectively.

Table 8: MHT: comparing multiple block-treatment interactions with a baseline block-treatment

Block-Treatment 2	Diff.	Unadj	LXS1	LXS2	Bonf	Holm
WTP_{LUB} / Watched video / Bronze / 20%	79.56	0.864	0.864	0.864	1	0.864
WTP_{HUB} / No video / Bronze / 20%	478.32	0.320	0.732	0.732	1	1
WTP_{HUB} / Watched video / Bronze / 20%	1,235.35	0.022	0.227	0.227	0.498	0.325
WTP_{LUB} / No video / Bronze / 35%	561.22	0.221	0.700	0.700	1	1
WTP_{LUB} / Watched video / Bronze / 35%	715.15	0.168	0.690	0.690	1	1
WTP_{HUB} / No video / Bronze / 35%	1,326.53	0.036	0.275	0.275	0.828	0.396
WTP_{HUB} / Watched video / Bronze / 35%	1,802.72	0.022	0.217	0.217	0.506	0.308
WTP_{LUB} / No video / Bronze / 45%	1,479.59	0.017	0.189	0.189	0.383	0.267
WTP_{LUB} / Watched video / Bronze / 45%	969.39	0.091	0.516	0.516	1	0.907
WTP_{HUB} / No video / Bronze / 45%	2,060.30	0.007	0.093	0.093	0.153	0.120
WTP_{HUB} / Watched video / Bronze / 45%	2,817.21	0.000	0.000	0.000	0.008	0.008
WTP_{LUB} / No video / Silver / 20%	255.10	0.580	0.909	0.909	1	1
WTP_{LUB} / Watched video / Silver / 20%	121.93	0.829	0.971	0.971	1	1
WTP_{HUB} / No video / Silver / 20%	530.79	0.278	0.741	0.741	1	1
WTP_{HUB} / Watched video / Silver / 20%	1,386.05	0.006	0.091	0.091	0.146	0.120
WTP_{LUB} / No video / Silver / 35%	714.29	0.123	0.587	0.587	1	1
WTP_{LUB} / Watched video / Silver / 35%	672.78	0.204	0.717	0.717	1	1
WTP_{HUB} / No video / Silver / 35%	1,232.55	0.024	0.219	0.219	0.544	0.308
WTP_{HUB} / Watched video / Silver / 35%	2,011.05	0.001	0.007	0.007	0.015	0.014
WTP_{LUB} / No video / Silver / 45%	1,377.55	0.014	0.168	0.168	0.322	0.238
WTP_{LUB} / Watched video / Silver / 45%	1,308.37	0.024	0.211	0.211	0.552	0.288
WTP_{HUB} / No video / Silver / 45%	2,548.33	0.002	0.031	0.031	0.046	0.040
WTP_{HUB} / Watched video / Silver / 45%	2,740.22	0.000	0.000	0.000	0.008	0.007

Note: MHT abbreviates Multiple Hypothesis Testing. Block treatments are described by the payment card upper bound (WTP_{HUB} or WTP_{LUB}), if the participant watched a video, textitFortified level (Bronze or Silver), and the level of insurance discount (20%, 35%, or 45%). The baseline block treatment is WTP_{LUB} / No video / Bronze / 20%. Diff. is the difference between means for a baseline block-treatment and block-treatments2. Unadj is the unadjusted p-value. LXS1 and LXS2 are p-values obtained by applying correction procedures proposed by List et. al (2015) to Unadj. Bonf and Holm are p-values obtained by applying Bonferroni adjustment and Holm adjustment, respectively to Unadj.

friction about the performance of *fortified* than those with low risk perception. However, results of the MHT based on hurricane risk perception subgroups show a less support for ending point and information friction biases compared to those derived with HORA subgroups.

Table 9 reports MHT results comparing second, third, and fourth order stochastic dominance preference relations. Results based on all (unadjusted and adjusted) methods show no significant differences in mean WTP between all (second and third, second and fourth and third and fourth) pairwise comparisons of n^{th} and $(n-1)^{th}$ order stochastic dominance preference.

5 Regression results and discussion

The regression analysis further assesses the heterogeneous treatment effects on WTP for precautionary building standards within risk attitude subgroups, allowing us to further evaluate the theoretical predictions stated in proposition 1. These analyses also enable us to control for other socio-demographic and housing variables to demonstrate the validity of our experimental design, and boost confidence in results above what can be

Table 9: MHT: comparing second, third, and fourth order stochastic dominance preference relations

Treatment 1	Treatment 2	Diff.	Unadj	LXS1	LXS2	Bonf	Holm
Second-degree stochastic dominance	Third-degree stochastic dominance	177.15	0.59	0.794	0.59	1	1
Second-degree stochastic dominance	Fourth-degree stochastic dominance	19.84	0.951	0.951	0.951	1	0.951
Third-degree stochastic dominance	Fourth-degree stochastic dominance	196.99	0.485	0.763	0.763	1	1

Note: MHT abbreviates Multiple Hypothesis Testing. Diff. is the difference between means for n^{th} order stochastic dominance preference relation and $(n-1)^{th}$ order stochastic dominance preference relation. Unadj is the unadjusted p-value. LXS1 and LXS2 are p-values obtained by applying correction procedures proposed by List et. al (2015) to Unadj. Bonf and Holm are p-values obtained by applying Bonferroni adjustment and Holm adjustment, respectively to Unadj.

gleaned from multiple hypothesis tests.

Homeowners could place negative values on investments in precaution, but the lowest WTP choice in our experiment is zero. Therefore, we estimate hurdle models with the full-sample and risk attitude subsamples to account for left-censored data. For additional robustness, we also estimate Cragg and Heckman selection models. These additional results are presented and discussed in Online Resource 4.

First, we estimate pooled and panel-level random-effects Tobit models. A likelihood ratio test between pooled and random-effects models rejects the null hypothesis that the variance of random-effects is zero, indicating that the random-effects model is a superior fit.[20] Table 10 presents results of five nested random-effects Tobit regression models with WTP as the dependent variable, left-censored at zero.

Model 1 is based on the attribute levels in the experimental design. Models 2, 3, 4, and 5 include additional controls for demographics (hurricane risk perception, income, and gender), housing characteristics (age of house, age of roof, and house size in square feet), and number of choices associated with each HORA (risk aversion, prudence, and temperance), to gauge the robustness of results from Model 1. In all models, indicator variables for *Fortified* bronze, 20-percent premium discount and WTP_{LUB} and no video are the baseline variables.

Results for all five models reported in Table 10 show that the coefficients on our experimental design attribute levels (Model 1) are robustly estimated. The signs and, for the most part, the magnitudes of coefficient estimates on the experimental design variables remain consistent, even after controlling for demographics, housing characteristics, and HORA. This indicates our design is nearly orthogonal with respect to the design attributes. Additionally, results reported in models 2, 3, 4, and 5 show that HORA, demographics, and housing characteristics also explain homeowners' WTP for precautionary building standards with insurance discounts. Based on the Bayesian Information Criterion (BIC), Model 5 provides the best fit for the full sample.

Table 11 reports results from estimating Model 5 on the full sample (same as Table 10) and the risk-loving, risk-averse, imprudent, and prudent subsamples. Detailed regression output on each of the subsamples appear in Online Resource 3. Results reported for the full sample show that homeowners are not willing to pay more for a *Fortified* Silver designation compared to Bronze. The coefficient estimate is nominally positive, but it is not statistically significant. The coefficient estimates for 35-percent and 45-percent complementary premium discounts are positive and statistically significant at the 1-percent level, indicating

[20]Note that the interpretation of WTP in the Tobit Model is based on the unobserved or latent variable (WTP^*). For $WTP \leq 0$ (left-censored), it is with respect to WTP^*, for $0 < WTP <= 25,000$, observed $WTP = WTP^*$ and for $WTP > 25,000$, the dependent variable is latent.

Table 10: Random-effects panel Tobit regression Models, full sample

	Model 1	Model 2	Model 3	Model 4	Model 5
Fortified Silver	190	183	183	206	200
	(126)	(128)	(128)	(126)	(128)
35% ins discount	1,162**	1,119**	1,119**	1,175**	1,128**
	(157)	(160)	(160)	(158)	(160)
45% ins discount	2,375**	2,353**	2,353**	2,329**	2,298**
	(157)	(159)	(159)	(157)	(159)
WTP_{LUB} / watched video	-404	-205	-36	-838	-1,007
	(1,235)	(1,099)	(1,091)	(1,065)	(965)
WTP_{HUB} / no video	1,068	1,032	1,054	496	119
	(1,250)	(1,134)	(1,122)	(1,019)	(944)
WTP_{HUB} / watched video	2,566*	2,341*	2,382*	2,131*	1,867^{+}
	(1,283)	(1,153)	(1,140)	(1,082)	(989)
Hurricane risk perception		407^{+}	393^{+}		
		(232)	(230)		
Female		-696	-608		
		(816)	(807)		
Income		1,949**	1,773**		1,512**
		(497)	(504)		(426)
House size			1,311^{+}	1,364^{+}	1,279^{+}
			(711)	(701)	(683)
Safe choice				467^{+}	340
				(281)	(254)
Prudent choice				726**	711**
				(278)	(257)
Temperate choice				-463	-504
				(346)	(324)
Constant	-1,801^{+}	-23,770**	-31,882**	-13,369*	-28,468**
	(937)	(5,561)	(7,126)	(5,416)	(6,333)
Panel-level variance (σ_u)	5,658**	5,136**	5,089**	4,687**	4,191**
Overall variance (σ_e)	1,811**	1,787**	1,787**	1,770**	1,740**
Observations	213	199	199	191	178

Note: Dependent variable is WTP for precautionary building standards. Model 1 is based on the attribute levels in the experimental design. Models 2, 3, 4 and 5 include additional controls and higher order risk attitudes. Hurricane risk perception is the number of category three hurricanes the respondent expects will affect her community in the next 50 years. Income is the natural log of household income. Female is a dummy variable equal to one if respondent is female. House size is the natural log of square feet of living space. Safe/Prudent/Temperate choices is the number of choices indicating respondent is risk averse/prudent/temperate. Number of observations varies when respondents choose not to answer questions. Standard errors in parentheses. $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

that, as expected, homeowners' WTP increases with the level of premium discount. Specifically, switching from a 20-percent discount to 35-percent (45-percent) discount, while holding all other variables constant, increases WTP by $1,128 ($2,298).

The coefficient on "WTP_{HUB} and watched video" is positive and statistically significant at the 10-percent level[21] while that of "WTP_{LUB} and watched video" is not statistically significant. This finding is consistent with ending point bias in our WTP payment card design. Specifically, homeowners who watched the video demonstrating the performance of *Fortified* and conventional houses side-by-side under hurricane-like winds, prior to selecting WTP level in the design with high upper bound, are willing to pay $1,867 more than those who did not watch the demonstration video and were assigned the design with low upper bound. In contrast, the coefficient on "WTP_{HUB} and no video" is not statistically significant at the 10-percent level, suggesting the effect of the demonstration video, if any, is entangled with the higher WTP range. The coefficients on income and house size for the full sample are also positive and significant, at least at the 10-percent level, indicating a positive effect for each variable on WTP for *Fortified* designations. Specifically, a 1-percent increase in Income (House size) increases the average WTP by $15 ($13).

Importantly, the coefficient on prudent choices using the full sample is positive and statistically significant at the 1-percent level, indicating that prudent homeowners are willing to pay more for *Fortified* building standards. Specifically, a unit increase in the number of prudent choices made by a homeowner increases WTP by $775.

Results based on the risk-loving sub-sample reveal a positive coefficient on prudent choices and a negative coefficient temperate choices. Specifically, a unit increase in prudence increases WTP by $1,718, and a unit increase in temperance decreases WTP by $1,531. Regarding the theoretical predictions stated in Proposition 1, the results indicate that risk-loving, prudent, and temperate homeowners will increase WTP for precautionary building standards with an increase in prudence and a decrease in temperance.

On the contrary, results based on the risk-averse sub-sample in Table 11 reveal that both third and fourth degree risk attitudes have no effect on the WTP for precautionary building standards for risk-averse homeowners. However, both risk-averse and prudent homeowners are willing to pay significantly more for higher levels of *Fortified* building standards and insurance premium discounts. Specifically, risk-averse agents are willing to pay $363 more for the Silver designation compared to the Bronze designation, and $1,345 ($2,555) more for a 35-percent (45-percent) premium discount compared to a 20-percent discount. Similarly, prudent homeowners are willing to pay $269 more for a Silver designation compared to a Bronze designation and $1,253 ($2,611) more for a 35-percent (45-percent) premium discount compared to a 20-percent discount. Notice that the effect of an additional unit of income on WTP is nominally higher for prudent ($1,608) than for risk-averse homeowners ($1,318). In addition, risk-averse agents who watched the demonstration video prior to stating their WTP, using the high upper bound payment design, have a significantly higher WTP ($2,960) than those who did not watch the demo video and were assigned a design with low upper bound. However, watching the demonstration video, and payment card WTP range have no effect on WTP for prudent homeowners. Note that the interpretation of the coefficients on prudent and temperate choice in Table 11 is applicable to imprudence and prudence and to intemperance and temperance, respectively, thus making it difficult to draw definitive comparisons between the subgroups.

To directly estimate and compare treatment effects on WTP for precautions by homeowners who are risk-loving, (im)prudent, and (in)temperate and those who are risk-averse, (im)prudent, and (in)temperate, we re-estimate regression models with the risk-loving and risk-averse sub-samples using dummy variables, instead of count variables, for the third (prudent and imprudent) and fourth (temperate and intemperate) order risk attitudes subgroups. In this case, the dummy for prudent (imprudent) equals 1 if the homeowner

[21] This result is significant at the 5-percent level in some model specifications. See Online Resource 3.

Table 11: Random-effects Tobit regression models, full sample and risk attitude subsamples

	Full sample	Risk-loving	Risk-averse	Imprudent	Prudent
Fortified Silver	200	-278	363*	-31	269^{+}
	(128)	(250)	(145)	(268)	(155)
35% ins discount	1,128**	706*	1,345**	599^{+}	1,253**
	(160)	(311)	(182)	(336)	(194)
45% ins discount	2,298**	1,961**	2,554**	1,411**	2,609**
	(159)	(310)	(181)	(333)	(194)
WTP_{LUB} / watched video	-1,007	-3,491^{+}	-694	1,826	-1,771
	(965)	(2,085)	(974)	(1,697)	(1,157)
WTP_{HUB} / no video	119	-1,801	1,302	2,468	-1,126
	(944)	(1,708)	(1,003)	(1,726)	(1,136)
WTP_{HUB} / watched video	1,867^{+}	-2,669	2,803**	2,319	1,401
	(989)	(1,928)	(1,040)	(1,555)	(1,208)
Income	1,512**	2,324*	1,131*	2,772**	1,779**
	(426)	(916)	(517)	(936)	(524)
House size	1,279^{+}	1,756	734	799	1,017
	(683)	(1,917)	(1,091)	(1,006)	(805)
Safe choice	340			1,001*	-85
	(254)			(435)	(302)
Prudent choice	711**	1,718**	127		
	(257)	(458)	(287)		
Temperate choice	-504	-1,531*	92	-324	-451
	(324)	(655)	(352)	(507)	(403)
Constant	-28,468**	-39,196**	-19,278**	-40,826**	-25,337**
	(6,333)	(13,872)	(7,346)	(10,721)	(8,149)
Panel-level variance (σ_u)	4,191**	4,200**	3,327**	3,001**	4,241**
Overall variance (σ_e)	1,740**	1,648**	1,600**	1,461**	1,813**
Observations	178	50	106	38	122

Dependent variable is WTP for precautionary building standards. The first six variables are dummy variables representing attribute levels in the experimental design. Income is the natural log of household income. House size is the natural log of square feet of living space. Safe/Prudent/Temperate choices is the number of choices (out of four) indicating respondent is risk averse/prudent/temperate. Standard errors in parentheses. BIC is the Bayesian Information Criterion. $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

is prudent (imprudent) and zero otherwise. Similarly, temperate (intemperate) equals 1 if homeowner is temperate (intemperate) and zero otherwise. Results based on this specification for the risk-loving and risk-averse sub-samples are reported in Table 12.

Model 1 includes dummy variables for prudent and temperate, and therefore jointly examines risk-loving (risk-averse), prudent, and temperate risk attitudes. Model 2 examines risk-loving (risk-averse), prudent, and intemperate risk attitudes. Model 3 captures the effects for risk-loving (risk-averse), imprudent, and temperate homeowners, and Model 4 does the same for risk-loving (risk-averse), imprudent, and intemperate risk attitudes. The additional analysis in Table 12 allows a cleaner comparison and provides a stronger conclusion. Each of the four models also provides an opportunity to test for mixed risk loving and mixed risk averse behavior. For example, Model 1 controls for prudent and temperate homeowners. If homeowners are mixed risk loving, we expect the coefficient estimate for prudent to be positive and that of temperate to be negative. Likewise, in Model 2, estimating WTP for prudent and intemperate homeowners, positive coefficients on prudent and intemperate would be consistent with mixed risk loving behavior.

Results for the risk-loving subsample reported in Table 12 indicate prudent and imprudent are statistically significant, each with expected opposite sign and similar magnitude, indicating that risk-lovers are prudent and not imprudent.

On the other hand, results in the same table reveal temperate and intemperate agents with opposite signs, but only intemperate is statistically significant. Thus indicating that some risk-lovers are prudent and intemperate, while others are imprudent and intemperate. On the contrary, none of the coefficients on (im)prudent and (in)temperate choices are statistically significant for models using the risk-averse subsample.

Table 12: Random-effects Tobit regression models, Risk-lovers and Risk-averters by 3^{rd} and 4^{th} degree risk

	Risk-loving				Risk-averse			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Fortified Silver	-278	-277	-278	-277	363*	363*	363*	363*
	(250)	(250)	(250)	(250)	(145)	(145)	(145)	(145)
35% ins discount	705*	706*	705*	706*	1,345**	1,345**	1,345**	1,345**
	(310)	(310)	(311)	(311)	(182)	(182)	(182)	(182)
45% ins discount	1,959**	1,958**	1,960**	1,959**	2,554**	2,554**	2,555**	2,554**
	(310)	(310)	(310)	(310)	(181)	(181)	(181)	(181)
WTP_{LUB} / watched video	-1,834	-5,202**	-1,557	-4,839*	-655	-668	-761	-770
	(1,924)	(1,871)	(1,992)	(1,952)	(971)	(970)	(976)	(975)
WTP_{HUB} / no video	-1,717	-2,404	-1,513	-2,236	1,367	1,358	1,207	1,200
	(1,747)	(1,481)	(1,803)	(1,563)	(995)	(993)	(1,009)	(1,007)
WTP_{HUB} / watched video	-1,482	-4,415*	-886	-3,699*	2,827**	2,807**	2,763**	2,744**
	(1,856)	(1,806)	(1,943)	(1,862)	(1,038)	(1,031)	(1,037)	(1,031)
Income	1,825^{+}	1,798*	2,033*	2,036*	1,177*	1,188*	1,189*	1,198*
	(938)	(823)	(945)	(858)	(511)	(511)	(504)	(503)
House size	1,161	1,175	2,223	2,322	712	750	690	732
	(2,001)	(1,723)	(2,018)	(1,782)	(1,103)	(1,088)	(1,092)	(1,079)
Prudent	4,991**	5,215**			112	93		
	(1,373)	(1,238)			(792)	(792)		
Temperate	-598		-610		-1		7	
	(1,473)		(1,528)		(712)		(709)	
Intemperate		5,862**		5,663**		438		412
		(1,387)		(1,425)		(1,092)		(1,086)
Imprudent			-4,747**	-4,752**			-872	-857
			(1,465)	(1,348)			(1,032)	(1,032)
Constant	-31,394*	-32,267**	-37,459*	-39,140**	-19,115**	-19,554**	-18,811*	-19,257**
	(14,231)	(12,125)	(14,564)	(12,724)	(7,413)	(7,378)	(7,361)	(7,334)
Panel-level variance (σ_u)	4,356**	3,528**	4,479**	3,751**	3,331**	3,327**	3,318**	3,315**
Overall variance (σ_e)	1,646**	1,646**	1,647**	1,647**	1,600**	1,600**	1,600**	1,600**
Observations	50	50	50	50	106	106	106	106

Note: Dependent variable is WTP for precautionary building standards. The first six variables represent attribute levels in the experimental design. Income is the natural log of household income. House size is the natural log of square feet of living space. Prudent/Imprudent/Temperate/Intemperate are dummy variables indicating the respondent's HORA classification.Number of observations varies by subsample and when respondents choose not to answer questions.

Therefore with regards to our theoretical predictions (Proposition 1), a risk-loving, prudent, and intemperate homeowner will increase WTP for precautions with an increase in prudence and intemperance (or a decrease in downside and kurtosis risk). Conversely, we expect a risk-loving, imprudent, and intemperate homeowner to increase WTP with decreases in imprudence and increases in intemperance. Empirically, the effect of various representations of third order risk on WTP for precautionary building standards is statistically larger than those of temperance in the risk-loving sub-sample. Therefore, considering only third and lower-degree risk attitudes, without the fourth, will significantly over-estimate the effect of risk attitudes on WTP for risk lovers who are imprudent and intemperate, and under-estimate the effects for those that are prudent and intemperate. Additionally, these results - that risk lovers are prudent and intemperate - indicate risk lovers are mixed risk lovers, consistent with the theoretical predictions of Crainich et al. (2013). They exhibit a preference for combing "good with good" and "bad with bad," unlike mixed risk-averters who prefer combining "good with bad."

More generally, results underscore the high relevance of third and fourth order risk attitudes on the WTP for precautionary building standards among risk-loving, but not for risk-averse homeowners.

5.1 Predicted Willingness to Pay for Precautionary Building Standards

Next, we analyze predicted WTP for *Fortified* building standards for the 24 block-treatments in our experiment by HORA subgroups and income levels.[22] Figure 3 includes charts of predicted average WTP with 95-percent confidence intervals for mixed risk-loving homeowners at the 25th, 50th, and 75th income percentile (based on models 1, 2, 3, and 4 in Table 12 under the risk-loving panel) holding house size at their sample means. Figure 4 depicts similar results for mixed risk averse homeowners based on models 1, 2, 3, and 4 in Table 12 under the risk averse panel.

Results in Figure 3 generally reveal that risk-loving, prudent, and intemperate homeowners have the highest WTP for *Fortified* building standards while risk-loving, imprudent, and temperate homeowners have the least WTP. Additionally, wealthy homeowners are willing to pay the most while poor homeowners are willing to pay the least. On average, WTP for mixed risk-lovers ranges from -\$8,928 for (20-percent discount, Silver, WTP_{LUB}, video, risk loving-imprudent-temperate, 25th percentile income) to \$10,164 for (45-percent discount, Bronze, WTP_{LUB}, no video, risk loving-prudent-intemperate, 75th percentile income). Overall, mixed risk-lovers are more willing to pay for *Fortified* Bronze than *Fortified* Silver with similar discount levels. In addition, mixed risk-lovers WTP for Bronze increases with increase in discount from 20-percent to 45-percent (but not 35-percent) while WTP for Silver decreases with increase in discount from 20-percent to 35/45-percent. Overall, WTP decreases with increases in both discount and level of precautionary efforts from *Fortified* Bronze with 20-percent discount to *Fortified* Silver with 35/45-percent discount.

Surprisingly, mixed risk-loving homeowners who watched the video exhibit a lower WTP for *Fortified* with a given insurance discount than those who did not. This suggests that an attempt to reduce information friction on the performance of *Fortified* relative to conventional houses may adversely affect WTP for mixed risk-lovers. Additionally, WTP for *Fortified* increases with level of precautions and payment range for a given insurance discount.

Results in Figure 4 also reveal that risk-averse, prudent, and intemperate wealthy homeowners have the highest WTP for *Fortified* building standards while risk-averse, imprudent, and temperate poor homeowners have the least WTP. On average, WTP for mixed risk-averse homeowners range from -\$4,205 for (20-percent discount, Bronze, WTP_{HUB}, video, risk averse-imprudent-temperate, 25th percentile income) to \$5,920 for

[22]Considering WTP across income levels is useful in estimating means-tested subsidies required to increase take-up.

(45-percent discount, Silver, WTP_{HUB}, video, risk averse-prudent-intemperate, 75th percentile income). Unlike the case for mixed risk-lovers, the WTP for mixed risk-averse homeowners increases monotonically with increases in *Fortified* building standards, insurance discounts, and payment card range. As expected, homeowners who watched the video comparing the performance of *Fortified* to conventional house are willing to pay more than those who did not watch the video. Thus indicating that the WTP for *Fortified* increases with decrease in information friction about the performance of *Fortified* as expected. Additionally, mixed risk-averters' WTP for *Fortified* Bronze increases with increases in discount, while their WTP for *Fortified* Silver only increases when discount is increased from 20-percent or 35-percent to 45-percent. Overall, WTP increases with increases in both discount and level of precautionary efforts from *Fortified* Bronze with 20-percent discount to *Fortified* Silver with 35-percent or 45-percent discount.

Figure 3: Predicted average WTP for mixed risk-loving by (25^{th} and 75^{th}) percentile of household income

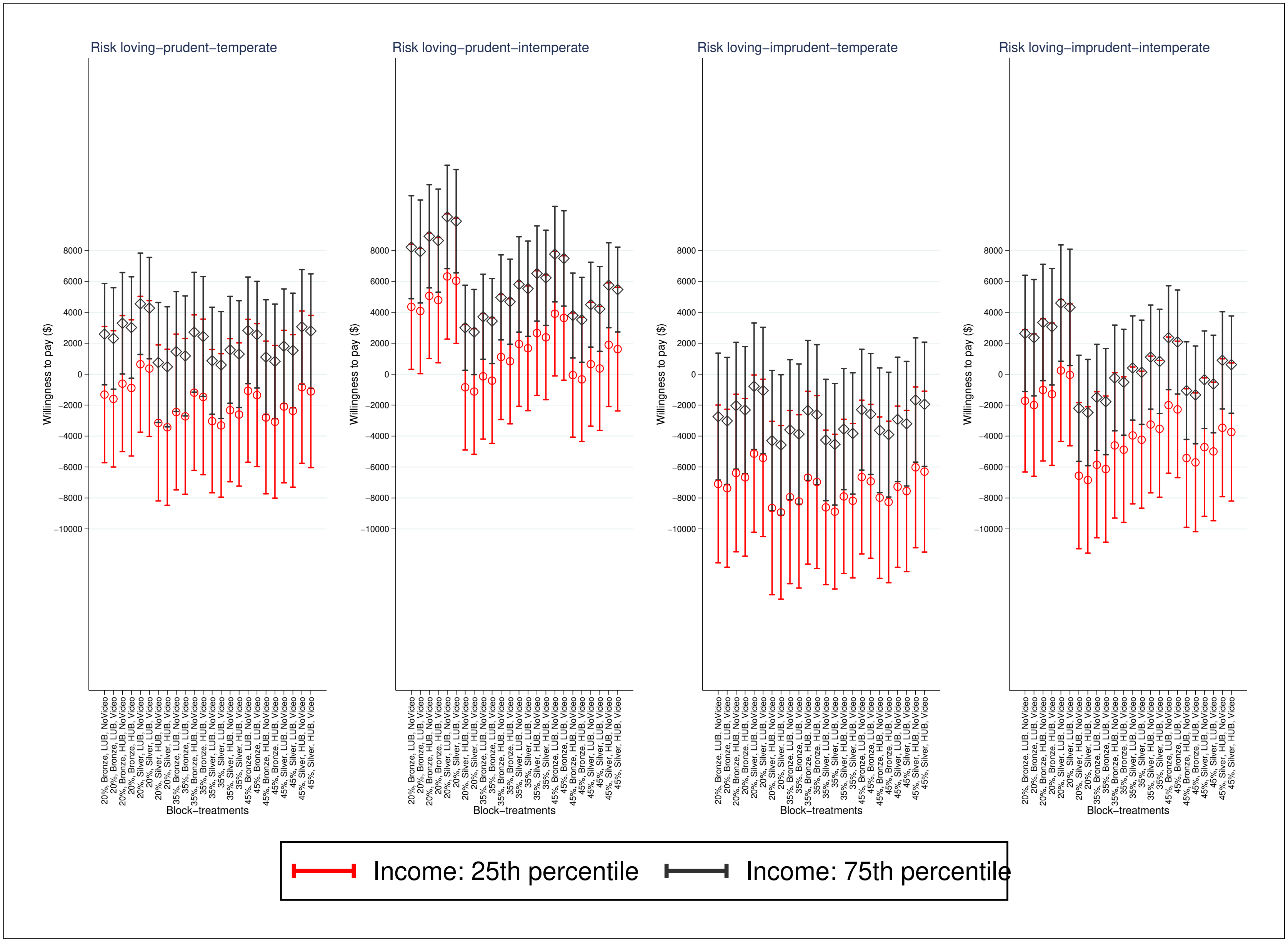
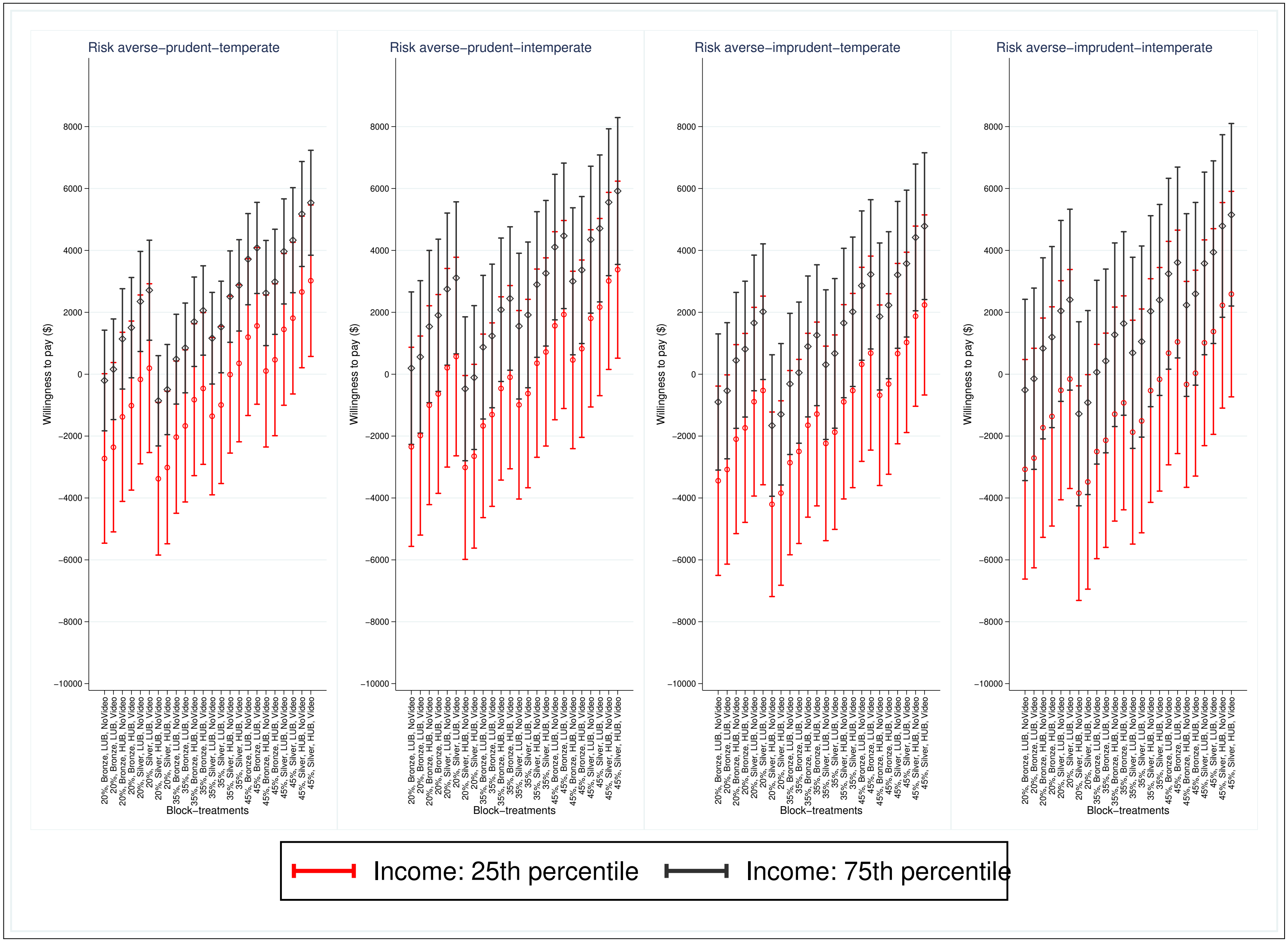


Figure 4: Predicted average WTP for mixed risk-averse by (25^{th} and 75^{th}) percentile of household income

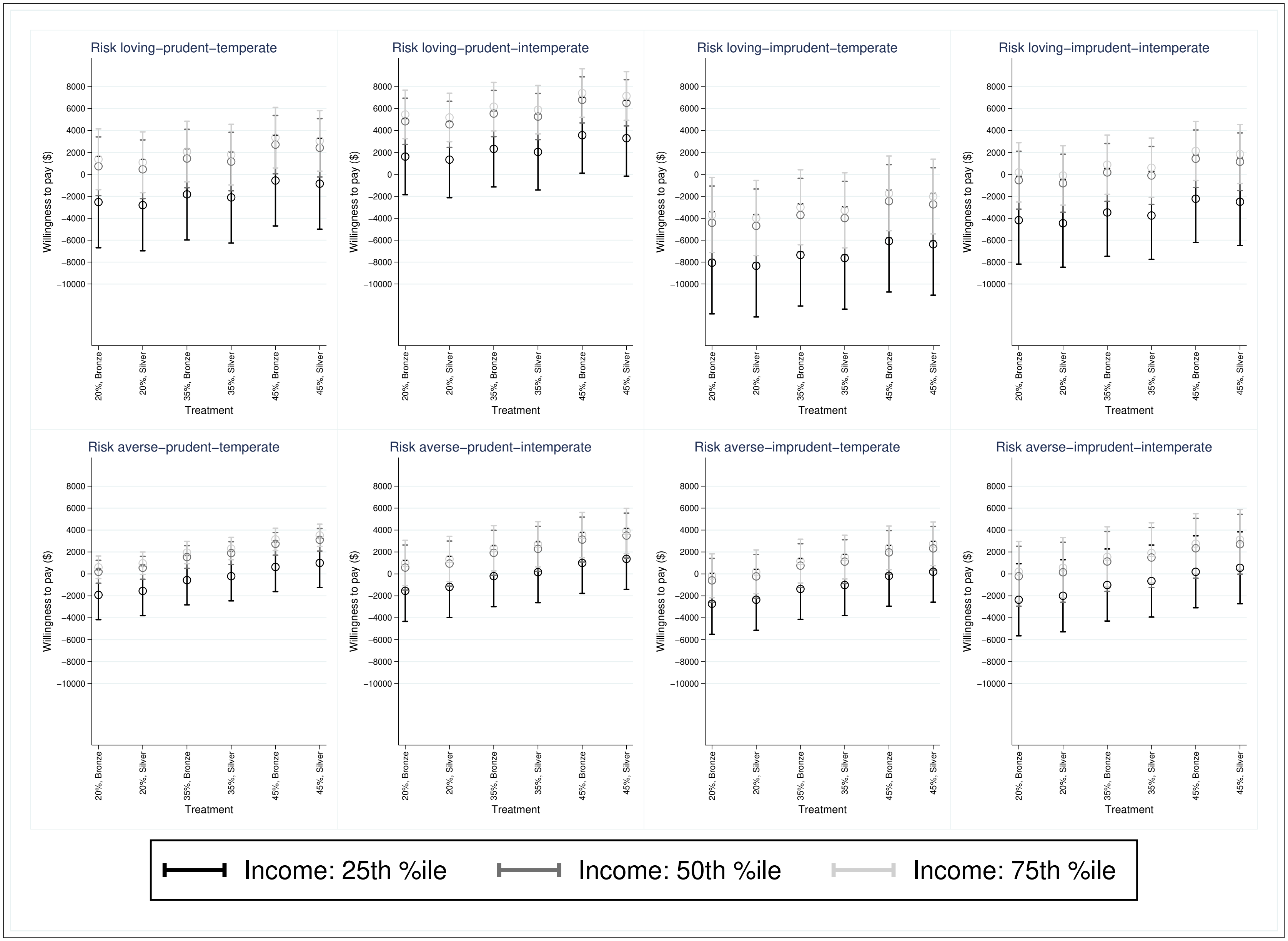


Next, we predicted WTP for combinations of *Fortified* building standards and insurance discount levels at the sample means of house size, information friction, and payment card WTP range. The results are depicted in Figure 5 for mixed risk-lovers and mixed risk averters. By basing these predictions only on the level of precaution and insurance discount, the two main attributes which characterize the Alabama State insurance mandate and subsidy program, we derive average WTP estimates that could used in practice to derive near-optimal state or federal subsidies aimed at promoting specific *Fortified* designations across low, medium, and high income earners.

Results indicate that predicted WTP increases with income as expected. Risk-averse(loving), prudent, and intemperate wealthy (75th percentile income) homeowners have the highest WTP for *Fortified* designation followed by risk averse(loving), prudent, and temperate homeowners, while poor (25th percentile income) risk-averse(loving), imprudent, and temperate ones have the least WTP. However, risk-loving, prudent, and intemperate homeowners generally exhibit a higher WTP for a *Fortified* designation than risk-averse, prudent, and intemperate homeowners. In general, risk-loving, prudent, and intemperate homeowners have a nominally positive average WTP that range between $1347 and $7424 while risk-loving, imprudent, and temperate homeowners exhibit generally negative average WTP between -$8331 and -$1731. Thus, suggesting that, on average, risk-loving, imprudent, and temperate homeowners will have to be compensated (or at least fully subsidized) to take up *Fortified* Bronze and Silver designations offering insurance discounts at levels we observe.

Overall, WTP for mixed risk-lovers(averters) increases with increase in both the level of precautions and insurance discount. However, mixed risk-lovers are willing to pay more for *Fortified* Bronze than *Fortified* Silver with similar discounts while mixed risk-averters have a higher WTP for *Fortified* Silver than *Fortified* Bronze with the same level of discount. Additionally, risk-averse, imprudent, and temperate homeowners are willing to pay more for *Fortified* with similar benefits than risk-loving, imprudent, and temperate homeowners. The latter generally exhibit nominally negative WTP, indicating that they will need at least 100 percent subsidies to adopt *Fortified* building standards. Overall, risk-averse, imprudent, and intemperate homeowners are willing to pay more than risk-loving, imprudent, and intemperate homeowners for similar level of precautions and benefits.

Figure 5: Predicted average WTP for mixed risk lovers over video and payment card range attributes by (25^{th}, 50^{th}, and 75^{th}) percentile of household income



Similarly, risk-averse, prudent, and temperate homeowners are willing to pay more for *Fortified* than risk-loving, prudent, and temperate homeowners are for similar level of precautions and benefits. Compared to all four mixed risk attitude subgroups, risk-loving (risk-averse), prudent, and temperate homeowners exhibit the most similarity in terms of sign and magnitude of WTP for *Fortified*.

6 Conclusion

Seeking to bridge a gap between theory and practice, we empirically investigate the associations among and effects of HORA and information friction on the WTP for precautionary building standards and wind insurance discounts using a field experiment involving homeowners along the U.S. Gulf Coast. Coastal wind hazards and mitigation features are an ideal setting for this analysis because the loss distribution exhibits positive skewness and kurtosis, and the mitigation features reduce skewness and kurtosis.

Our experimental design employs 50 50 model-free risk apportionment lotteries to elicit homeowners' risk attitudes up to the fourth order, and a payment card WTP experiment to estimate WTP for building codes coupled with home insurance premium discounts.

Our analysis reveals strong effects of second, third, and fourth order risk attitudes and information friction on homeowners WTP for precautionary building codes. Consistent with theory and experimental findings reported by Deck and Schlesinger (2014) and Crainich et al. (2013), we find risk-lovers are also prudent and intemperate (mixed risk-loving), and exhibit an interesting dichotomy with mixed risk-averters. In general, mixed risk-lovers are willing to pay more for *Fortified* Bronze than *Fortified* Silver while mixed risk-averters are willing to pay more for *Fortified* Silver, indicating opposite effects from an increased level of precaution on the two groups. However, an increase in mixed risk-lovers and mixed risk-averter's WTP for *Fortified* Bronze and Silver, respectively, requires insurance discounts significantly above the base discount (20%). Additionally, mixed risk-averter's WTP increases with decrease in information friction about the performance of *Fortified*, as expected, while mixed risk-lovers' WTP decreases.

In general, average WTP increases with household income, and risk-loving, prudent, and intemperate homeowners exhibit the highest WTP for *Fortified* designation (between $1347 and $7424) while risk-loving, imprudent, and temperate homeowners exhibit the least WTP (between -$8331 and -$1731).

Overall, average WTP estimates are lower than estimated out-of-pocket cost for retrofitting the average house in our sample, thus raising the need for subsidies to help promote retrofitting the current housing stock to *Fortified* standards. Risk-loving, imprudent, and temperate homeowners at the 25th percentile of household income require full subsidies, at a minimum, in order to take-up *Fortified*. In addition, it is worth noting that the low WTP for *Fortified* designations relative to cost indicates that homeowners are myopic in terms of the direct and indirect benefits of *Fortified* construction, which include reduced damages, displacement time following a disaster, and increased resale value of *Fortified* houses. Awondo et al. (2017) find that *Fortified* designations are capitalized into home resale value, increasing resale value by 7% on average. This benefit alone outweighs the average direct cost and shows that investing in a *Fortified* designation is often a sound financial decision.

Finally, we reveal insights on the prevalence of HORA and their effects on WTP, which can be used to guide policymakers in the selection and promotion of a portfolio of *Fortified* designations and subsidies for targeted segments of the population. As a natural follow-up to this study, future research should leverage the WTP estimates derived in this study with cost estimates of *Fortified* home construction to conduct a cost-benefit analysis aimed at calibrating an optimal portfolio of precautionary building codes and subsidy levels by risk attitudes and income.

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