BUYING TORNADO SAFETY: WHAT WILL IT COST?

Daniel Miller, Oklahoma City University
Denny Morgan, Oklahoma City University
Cristy Womack, Oklahoma City University

INTRODUCTION

On May 3, 1999 a series of tornadoes struck Texas, Oklahoma and Kansas. The damage was extensive, more so than usual, because some of the tornadoes struck suburban areas as opposed to open lands. In the wake of the devastation public officials from the local level up to former President Clinton advocated the installation of saferooms. Oklahoma Department of Civil Emergency Management working with the Federal Emergency Management Agency (FEMA) initiated a rebate program for individuals building saferooms that was heavily over subscribed. The rebate program provided a $2,000 subsidy for the installation of a saferoom in the participants dwelling (for details see:http://www.onenet.net/~odcem/2saferoom.htm). Since then FEMA has worked with Fannie Mae to develop a funding mechanism for saferoom installation (for details see: http://www.fema.gov/mit/saferoom/fnnemae.htm).

Saferooms are highly engineered structures that protect occupants from physical injury caused by a tornado. There are a number of firms that provide in-ground and above-ground versions. These firms are only financially viable if sufficient demand exists. The above-ground versions cost approximately $4,000 to construct and serve as walk-in closets. In-ground versions cost approximately $2,000. This paper seeks to find preliminary evidence of the extent of demand for saferooms with obvious implications for the survival of firms involved in building them. We examine two related aspects of overall demand for saferooms. In the case of a house being refurbished, are people willing to pay for the installation of a saferoom? In the case of a newly built home, are people willing to pay the additional cost of a saferoom? The amount that people are willing to pay or accept will likely depend on several individual characteristics.

Individuals who have direct experience with a tornado may be more likely to seek mitigation because of the direct experience, much like insurance is more attractive after paying medical bills without insurance. Those who have not had direct experience with a tornado may also be concerned with the risk of a tornado because the information concerning the damage is so clearly put before them. Whether direct experience with a tornado does in fact alter willingness to pay should be taken into consideration when developing demand for saferooms.

If individuals believe that it is their responsibility to keep themselves and their families safe, it seems likely that they will be willing to pay more for a saferoom. If they feel some other entity is responsible for their safety they are probably not likely to pay much for a saferoom. However, if they do not believe in the efficacy of saferooms they would be unlikely to pay at all.

Consistent with the economics of the value of life we examine whether higher income is associated with greater willingness to pay for a safe-room.

Individuals with higher income have a greater ability to pay and are assumed to have a higher value for life. If saferooms are a normal good we can expect higher incomes to lead to greater willingness to pay.

The basic issue is whether people are willing to pay a high enough price to compensate the builder for costs. There are several ways by which people might pay for a saferoom. It could be a lump sum payment to the builder, a loan for the purpose or a combination of the two. Another alternative would exist if a saferoom already existed in a house, at which point the buyer would be paying for the saferoom as part of a larger purchase across time.

The above purchasing options present a difficult problem in evaluating the demand for saferooms. Economic theory and empirical evidence support the idea that there may be a significant difference between what people are willing to pay (WTP) and what they are willing to accept (WTA). If an individual has purchased a saferoom, is the amount that they paid for the safe-room the same amount they are willing to sell it for? The difference is important to developing policy to encourage saferoom ownership and in determining the most profitable marketing approach for saferoom builders.

This paper will proceed as follows: Section 2 reviews the literature pertaining to the mitigating and the willingness-to-pay/willingness-to-accept problem; Section 3 describes the data used for the study; Section 4 presents results and concludes.

REVIEW OF RELATED LITERATURE

Tornadoes, as with other natural disasters, constitute a low probability-high consequence event. As a result the efficacy of saferooms, which is well established may be ignored in the market. Economic research in the area of natural disasters has focused on events that effect a large number of people at one time such as earthquakes and hurricanes. These disasters present problems in property markets and insurance markets that have been investigated to some effect. Tornadoes present a different environment. While the storm path that spawns tornadoes may pass over many people and cover a wide swath of territory, any given tornado cuts a very concentrated path of damage within the territory.

Ehrlich and Becker (1972) developed the theoretical differences between market insurance, self-insurance and self-protection. Self-insurance and self-protection are the two mitigation techniques that apply to our study. Self-insurance is a reduction in the size of a loss whereas self-protection reduces the probability of a loss. Conceptually either of these descriptions may apply to saferooms.

In a previous study, Ozdemir and Kruse (2000), the term self-insurance was used when discussing the demand for mitigation. They write that, "self-insurance is a way of mitigation for cases when human actions cannot affect the probability of the risk, but can influence the consequences of the risk." An example of self-insurance is seen in Simmons and Kruse (2000) that examines property values in a hurricane prone region. The price for houses that do have storm shutters are compared to those that do not. The purpose of storms blinds is to, "protect the home from damage due to flying debris. The integrity of the structure is maintained, to a large degree, if no openings through the exterior walls occur. Once the building envelope is breached by a broken window, for example, pressure on the roof and other walls increases and further structural damage occurs. Additionally, damages to the contents of the home increase from disturbance by the forces of the wind and water. Typically, content

loses far exceed structural damage once the envelope is penetrated" (Simmons and Kruse, 2000).

Our interpretation is that the tornado saferoom should be classified as self-protection. Saferooms do not alter the probability of a tornado, but they do alter the probability of injury and/or death. Self-protection would preserve life or lower the probability of losing ones life or suffering injury from a tornado. Insurance fails to reimburse the deceased, but protection reduces the likelihood of dying in a tornado. Someone in a saferoom during a tornado is also likely to see reduced injury, if any is sustained. If we consider the risk to be one of injury from the event as opposed to the event itself, then saferooms constitute self-protection, in the main, and self-insurance as a secondary effect.

Kruse and Simmons (2000), shows that people are willing to pay for self-insurance in the form of storm shutters. They show, using property prices, that higher risk communities place a sufficiently higher value on mitigation measures to cover installation costs. Further, the study indicates that the value of the mitigation is a function of the damage. Storm shutters lose value as the property under consideration moves further from areas that suffer more damage. This implies that a person's perceived risk of being hit by a tornado may influence their willingness to buy a saferoom.

Oklahoma City builders noted that for the six months after the May 3, 1999 tornadoes demand for saferooms was large. Thereafter, demand was virtually non-existent; suggesting demand for disaster mitigation may be cyclical with the disaster of interest. Simmons and Willner (2001) examined this instability of demand problem for storm-shutters in the same region as Simmons and Kruse (2000). They compared real estate prices directly after being hit by a hurricane and months after a hurricane had hit. They found that demand was stable across event frequency.

To try and help measure the differences in perceived risks, Ozdemir and Kruse (2000) conducted a survey dedicated to the relationship between willingness-to-pay for storm shelters and someone's perceived risk of tornadoes. The end results showed that "there is no significant relationship between the risk ladder measure and there willingness to pay measures."

Merrell, Simmons, and Sutter (2000) considered another aspect of measuring the feasibility and demand of putting a saferoom into houses. By assuming that the government paid to have a saferoom put in every permanent residence of Oklahoma, "The worst case models generate costs per life saved in the range of $56 to $66 million." This is far in excess of the standard estimates of the value of life used in economics and by the government (see Viscusi, 1993). Their interest, in this case, is with changing the probable outcomes, given the average incidence of tornadoes.

In Shogren, et al (1994) the Willingness to Pay (WTP) and Willingness to Accept (WTA) difficulty is laid out. Typically, people value a good more if they already possess it than if they were considering buying it. This raises the question of whether or not people would value a saferoom more if it was assumed to be immediately a part of the structure and if the costs were absorbed into the mortgage payments, as opposed to being approached and asked to buy it.

Waldfogel's (1993) "The Deadweight Loss of Christmas" examines the deadweight loss of gift giving that results from the differences between WTP and WTA. The premise is that when people receive gifts, more than likely, the price paid exceeds the recipients WTP. He finds that, "the deadweight losses arising from holiday gift-giving may well be large: holiday gift expenditures in 1992 totaled $38 billion according to one estimate. If between a tenth and a third of this spending was

wasted, then the deadweight loss of 1992 holiday gift-giving was between $4 billion and $13 billion." Since people tend to keep the gifts they receive it seems that the receipt of an item as a gift leads to an increased value, else they would be inclined to sell it.

DATA COLLECTION AND DESCRIPTION {tc "DATA COLLECTION AND DESCRIPTION " \l 4}

We hypothesize that income, direct tornado experience, and the level of responsibility felt for protecting one's family from a tornado, are likely to be related to an individual's WTP and WTA for mitigation such as saferooms. Whether WTP and/or WTA are high enough to compensate the builder in a manner which would allow for sufficient profits is of primary importance in determining market demand. The data used in determining demand should reflect both WTP and WTA as well as individual characteristics under consideration.{tc " We hypothesize that income, direct tornado experience, and the level of responsibility felt for protecting one's family from a tornado, are likely to be related to an individual's WTP and WTA for mitigation such as saferooms. Whether WTP and/or WTA are high enough to compensate the builder in a manner which would allow for sufficient profits is of primary importance in determining market demand. The data used in determining demand should reflect both WTP and WTA as well as individual characteristics under consideration."}

The demand for saferooms was examined in a survey conducted in Tulsa, Oklahoma during the summer of 2000 at two locations. One was a distressed urban residential neighborhood in the early stages of rehabilitation (Urban, henceforth). The houses in this area were in immediate need and largely unsuitable for living. As such, the homes did not have saferooms in place. The second survey location was a new suburban housing development (Suburban, henceforth). Houses in this neighborhood were priced from $150,000 and had a deed restriction requiring a saferoom.{tc " The demand for saferooms was examined in a survey conducted in Tulsa, Oklahoma during the summer of 2000 at two locations. One was a distressed urban residential neighborhood in the early stages of rehabilitation (Urban, henceforth). The houses in this area were in immediate need and largely unsuitable for living. As such, the homes did not have saferooms in place. The second survey location was a new suburban housing development (Suburban, henceforth). Houses in this neighborhood were priced from $150,000 and had a deed restriction requiring a saferoom."}

The survey instrument included inquiries about direct experience with a tornado, perceived responsible for protecting family from a tornado, efficacy of safe rooms and series of questions concerning WTP and WTA. Basic demographic questions were also asked. {tc "The survey instrument included inquiries about direct experience with a tornado, perceived responsible for protecting family from a tornado, efficacy of safe rooms and series of questions concerning WTP and WTA. Basic demographic questions were also asked. "}

Table 1 gives sample demographics. Mean income for the entire group surveyed was $62,000. Though the averages were appreciably different at the two locations the differences were not significant at the 5% level. The average age of the group was 46 years. Average age at the Urban setting was significantly higher than at the Suburban site. For the entire group, the male population was 41% and the average education level was a bachelor of arts or sciences (16 years). There were 60 surveys

completed in the Suburban site and 105 surveys that were completed at the Urban site.

Table 1
Sample Demographics

Variable	Definition	Mean *(Std. Err.)*	Suburban (Std. Err.)	Urban (Std. Err.)	n
Income	Annual income of respondent (x1,000)	62.22 *(2.61)*	67.69 *(3.99)*	59.49 *(3.34)*	117
YouAge**	Age of respondent	46.44 *(1.47)*	41.92 *(2.02)*	48.31 *(1.47)*	130
Male1	Gender of respondent (1=male)	0.41 *(0.04)*	0.43 (0.08*)*	0.39 *(0.05)*	126
YouSchool	Highest level of education attained	15.85 *(0.19)*	15.73 *(0.31)*	15.91 *(0.24)*	122

**significantly different at 5% level

Beyond demographics, we considered several other factors to be of likely significance. As previously discussed, personal experience with tornadoes was thought to be potentially relevant to the demand for saferooms. Forty-three percent of those who responded indicated that they had direct experience with a tornado. Table 2 provides descriptions and summary statistics for this and other variables. There were no significant differences between samples at the two locations.

The group was also asked to consider the ability of a saferoom to afford the protection claimed. They were asked to rate the effectiveness of saferooms on a 1 to 5 basis, where 1 was "not at all" and 5 was "very much". The mean value of 4.5 is consistent with the engineering results that saferooms are very effective.

Table 2
Sample Experience and Responsibility

Variable	Definition	Mean *(Std. Err.)*	n
ExpTor	Have you or anybody in your household ever directly experienced a tornado? (1 = yes)	0.43 *(0.039)*	165
Youdo	To what extent do you feel that you can *do something (anything)* to protect yourself and your family from a possible tornado? (1 = can't do much – 5 = can do much)	3.82 *(0.09)*	164
Myself	In your opinion, what degree of responsibility does each individual/institution below have to protect you and your family from the damage of a possible tornado?(1 = Not responsible at all – 5 = very responsible)	4.48 *(0.07)*	161
LocGov	In your opinion, what degree of responsibility does each individual/institution below have to protect you and your family from the damage of a possible tornado?(1 = Not responsible at all – 5 = very responsible)	3.10 *(0.10)*	148
FedGov	In your opinion, what degree of responsibility does each individual/institution below have to protect you and your family from the damage of a possible tornado?(1 = Not responsible at	2.76 *(0.11)*	147

	all – 5 = very responsible)		
RoomProt	To what extent do you think a safe room in the home can protect you and your family from a possible tornado? (1 = Not at all – 5 = Very much)	4.50 *(0.06)*	164

**significantly different at 5%

The subjects were asked about the extent to which they felt they could do something to protect themselves and their family from tornadoes. A 1 to 5 scale was used with 1 meaning that they believed that they could do nothing and 5 meaning that they believed that they could do a great deal. The mean score was 3.8 suggesting an underlying belief that individuals could do something to protect themselves and their families from tornadoes.

The group was asked to rank the degree of responsibility for providing protection that they saw as residing in various institutions, including themselves. Once again we used the ranking system from 1 to 5, with 1 meaning not responsible at all and 5 meaning very responsible. The mean values placed responsibility highest on the individual, decreasing as the level of government was further removed from the individual. Given that the average person believed that they were most responsible, could do something to protect themselves and their families and that saferooms afforded excellent protection we expected to find a number of significant relationships among the variables.

The next set of questions focused on measures of the willingness to buy a saferoom. Table 3 gives summaries of the results. First we asked if they would be willing to buy a safe room, absent any reference to the price. An answer of 1 meant that the individual would definitely be willing to purchase a safe room for their home, if one was not already installed. In contrast, an answer of 5 meant that they were certain they would not buy a safe room for their home. The average response was a score of 2.8 suggesting ambivalence towards buying a saferoom.

Table 3
Willingness to Buy, Pay and Accept

Variable	Description	Mean (Std. Err.)	N
WillBuy	Would you be willing to purchase a safe room for your home if it were not already installed? (1 = certainly – 5 = not certainly)	2.82 (0.11)	160
Will4000	Would you be willing to pay $4000 for the safe room? (1 = certainly – 10 = not certainly)	5.71 (0.23)	158
MostPay	How much, at most, would you be willing to pay for a safe room inside your home?	2421.05 (1453.59)	152
ImplyVal	Discounted value of saferoom considering declared monthly mortgage payment reduction, declared mortgage length and assuming 10% A.P.R.	10080.55 (1915.83)	61
ImpValReasonable	ImplyVal, not including observations of monthly mortgage payment reductions in excess of $150	4510.20 (488.19)	50
ImVPosRe	ImpValReasonable, not including observations	5782.31	39

of monthly mortgage payment reductions equal to $0	(447.69)

We then asked our test subjects if they would be willing to pay $4,000 for a safe room. We used this number since it is the generally agreed upon cost of supplies and labor for installing a safe room into an existing home. For this question we used a broader scale of 1 to 10, with one being "certainly" and 10 being "not certainly". The broader scale was used to allow for some intuitive adjustment in price considerations. The mean of 5.7 suggests that the group was slightly more inclined not to purchase the safe room at the prevailing price.

Table 4
Willingness to Pay

Increments	Number
Pay $0 - $1,000	28
Pay $1,000 - $2,000	39
Pay $2,000 - $3,000	37
Pay $3,000 - $4,000	21
Pay $4,000 - $5,000	19
Pay $5,000 - $6,000	8

To add to further detail on WTP asked our respondents to indicate the greatest amount that they would be willing to pay. There were eleven $1,000 increments offered, with the final choice being more than $10,000. No one was willing to pay more than $5,000 to $6,000. Using the mid-point of the increments gives a mean WWTP of $2,421. Table 4 shows the breakdown of responses.

The results indicate that there was a consumer-imposed choke price at $6,000 and that the average consumer was not willing to pay the necessary $4,000 to install a safe room on a WTP basis.

The final question that we asked the members of our survey group concerned what the individuals would be willing to accept for the safe room. To find this, we asked each individual the expected length of their mortgage and "If there was no safe room in the home, how much lower would you expect your monthly mortgage payment to be?" Assuming a 10% interest rate we then calculated the implied WTA.

The range of answers that we received was broad. Reductions in mortgage payments ranged from $0 to as high as $750! Therefore, when we were looking at the implied value for the saferooms, we broke the responses down into three overlapping categories. The first category took into account all of the responses. The second category took into account all of the responses that were $150 or below. Our third, and final, category took into account all values below $150, not including $0. The second category was created to eliminate all answers that were deemed too extreme. This left us with values that were much more likely to be seen in an actual instance. For our third category, we took the values that were left with in our second category

and eliminated all of the responses of $0. Our reasoning here was that we felt that there would surely be some reduction in mortgage payments if a safe room was removed from the plans for a home or a home itself. Once we had broken down the range of scores into three overlapping categories, we could calculate the implied value for safe rooms much easier.

ANALYSIS AND CONCLUSION

As a first step, correlation coefficients were examined. Table 5 presents the correlation coefficients between explanatory variables and various measures of WTP and WTA. No coefficients were above 0.5 and few were significant. Of the significant correlation coefficients only RoomProt was frequently so. It was of the expected sign except in the case of ImplyVal.

The only other variable with regularly significant correlation coefficient was YouDo, the measure of belief in ability to do something to protect yourself and family. Its behavior is not regular though. While of the expected sign as far as WTP variables are concerned it is of the opposite sign with WTA variables.

Table 5
Correlations (*P-values)*

Variable	Willbuy	Will4000	Mostpay	Implyval	Impvalreasonable	Imvposre
Income	-0.08	-0.09	0.11	-0.27**	0.02	-0.04
	(0.38)	*(0.36)*	*(0.24)*	*(0.04)*	*(0.89)*	*(0.81)*
YouAge	0.028	-0.07	-0.08	-0.11	-0.00	-0.19
	(0.76)	*(0.43)*	*(0.93)*	*(0.41)*	*(0.99)*	*(0.24)*
YouSchool	-0.01	-0.07	-0.01	0.04	-0.01	0.01
	(0.89)	*(0.43)*	*(0.93)*	*(0.77)*	*(0.93)*	*(0.94)*
ExpTor	0.03	-0.03	0.10	0.11	0.17	0.19
	(0.73)	*(0.68)*	*(0.20)*	*(0.42)*	*(0.23)*	*(0.25)*
Youdo	-0.14*	-0.03	0.19**	0.05	-0.18	-0.39***
	(0.08)	*(0.72)*	*(0.02)*	*(0.69)*	*(0.21)*	*(0.01)*
Myself	-0.05	0.09	0.11	-0.24*	-0.04	-0.09
	(0.57)	*(0.26)*	*(0.18)*	*(0.07)*	*(0.81)*	*(0.59)*
LocGov	-0.23***	-0.03	0.13	0.01	0.02	0.27
	(0.01)	*(0.74)*	*(0.12)*	*(0.95)*	*(0.87)*	*(0.12)*
FedGov	-0.20**	-0.03	0.11	0.00	-0.02	0.16
	(0.02)	*(0.69)*	*(0.17)*	*(0.99)*	*(0.88)*	*(0.37)*
RoomProt	-0.21***	-0.11	0.21***	-0.25**	0.30**	0.27*
	(0.01)	*(0.16)*	*(0.01)*	*(0.05)*	*(0.03)*	*(0.09)*

*** = significant at 1%
** = significant at 5%
* = significant at 10%

Table 6
Regression Results (*Std. ERR*)

Variable	WillBuy	Will4000	MostPay	ImplyVal	ImpVal Reasonable	ImVPosRe
Intercept	4.325***	8.553**	-711.260	-723.980	-246.726	-2386.861
	(1.599)	*(3.450)*	*(1797.921)*	*(29127)*	*(10344)*	*(10048)*
Income	-0.004	-0.005	3.952	-141.018	-9.093	-24.574
	(0.005)	*(0.012)*	*(6.133)*	*(87.610)*	*(31.423)*	*(29.782)*
YouAge	-0.002	-0.044**	7.957	-339.55	-52.518	-71.005
	(0.010)	*(0.022)*	*(11.719)*	*(162.705)*	*(68.669)*	*(60.712)*

YouSchool	0.038	-0.070	-11.519	-0.004	-0.005	3.952
	(0.069)	*(0.149)*	*(77.341)*	*(0.005)*	*(0.012)*	(*6.133*)
ExpTor	0.183	0.032	257.758	-0.002	-0.044**	7.957
	(0.273)	*(0.606)*	(*315.547*)	*(0.010)*	*(0.022)*	(*11.719*)
Youdo	-0.316***	-0.196	216.253	1558.480	-222.782	-632.215
	(0.121)	*(0.267)*	(*140.907*)	*(1667.375)*	*(528.598)*	*(478.593)*
Myself	0.145	0.345	20.505	2966.140	-642.427	-209.358
	(0.172)	*(0.382)*	(*198.989*)	*(3396.610)*	*(1046.664)*	*(893.086)*
LocGov	-0.077	-0.183	65.755	-1402.504	216.472	862.271
	(0.214)	*(0.179)*	(*250.548*)	*(3587.840)*	*(1090.617)*	*(920.477)*
FedGov	-0.132	0.143	105.941	893.151	-270.410	-398.503
	(0.193)	*(0.426)*	(*221.775*)	*(3198.521)*	*(1008.050)*	*(805.927)*
RoomProt	-0.197	-0.087	289.955	-1992.904	2442.424	2657.032
	(0.187)	*(0.415)*	(*216.409*)	*(3587.889)*	*(1590.785)*	*(1630.289)*
adj. R^2	0.0563	-0.0266	0.0025	0.0919	-0.1329	0.0331
N	92	93	93	48	40	31

*** = significant at 1%
** = significant at 5%
* = significant at 10%

To further examine relationships and to develop a more complete demand function we ran a series of regressions. Table 6 shows the results of these regressions. Few variables showed significance. Those that were significant were of expected sign.

Examining the combined results of the correlation coefficients and the regressions leads us to conclude that the demand for saferooms is not well defined, nor is it likely to be sufficient to support many companies in the business of building saferooms. The choke price of $6,000, on a WTP basis, is not much above the installation cost so that the market for saferooms, to the extent that one exists is not likely to tolerate much markup. This result is contrary to the common belief and/or hope of saferoom producers that there is a self-sustaining and thriving market that needs only to be tapped.

Income, tornado experience and virtually all other factors considered appear to be insignificant explanatory variables. Combined with insignificant intercept terms on the WTA measures it would appear that, unassisted, there is little scope for substantial profits in this market.

Although the average individual was not willing to pay the necessary amount to purchase a safe room, they did think that they are beneficial and are confident of their efficacy. The gap between WTP and cost was slightly above the subsidy ($2,000 per unit) offered by FEMA. This would explain why the subsidy was oversubscribed. To the extent that a subsidy is to be provided it would seem that the amount offered was appropriate to the objective.

WTA, by all measures, was sufficiently high to cover installation costs. The loan offers available through FEMA and Fannie Mae would seem to be sufficient to interest households in putting a saferoom into a house while it is being constructed. However, since the loans are not necessarily available under these circumstances their effectiveness may be much less than desired.

If the objective of public policy is to encourage almost universal installation of saferooms, current policy is not likely to be effective unless $2,000 subsidies are provided on an unlimited basis. As an alternative, lower cost in-ground cellars may be cheaper to install and less likely to require a subsidy.

Another concern is that the interest in purchasing saferooms may be more dependent on recent events than hurricane damage mitigation devices. In this case the subsidies used or the subsidies required may change with each tornado season. In order to distribute saferoom demand more evenly across time significant promotion may be necessary.

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