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Individuals Willingness to Pay for Health and Wellness in the Built Environment

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Cover Page Footnote

Thank you Professor Sahan Dissanayake for the guidance on this project and for supplying the funds to conduct the Choice experiment survey in Amazon Turk

1. *Introduction*

Real estate is one of the largest asset classes in the world, representing more than \$531 billion in annual revenues, nearly \$62 billion in annual payroll, and more than 1.7 million employees. (Economic Census 2002) While real estate is a well-established and profitable market, consumers are not well educated on the potential health risks associated with being indoors. We spend 90% of our time indoors and indoor levels of pollutants may be two to five times higher than outdoor levels, yet indoor air quality is still a pressing issue that has resulted in \$150 billion of illness-related economic costs (The Inside Story: A Guide to Indoor Air Quality). There has been minimal economic analysis regarding the impact of disease and lost productivity associated with poor indoor home environments; therefore, it is necessary to gauge individuals willingness to pay for new amenities that will improve individuals health and well-being. According to the EPA, nearly one out of every 15 homes has radon concentrations above the EPA recommended action level (National Residential Radon Survey 1992), a very high ratio considering there are easy steps homeowners can take to prevent and test for radon in their homes.

Poor indoor air quality is only one of many issues with the built environment. Features of the built environment that impact human health and well-being include air, water, nourishment, light, fitness, comfort and mind. Each feature provides a unique impact on our health and wellness. For example, comfort not only impacts our ability to feel a sense of relaxation and peace of mind but also our ability to concentrate and be productive (Lomonaco and Miller 1996). In 2007, national health care expenditures in the United States totaled \$2.2 trillion or 16% of its gross domestic product, a 14% increase from 2000 (National Center for Health Statistics 2010), which implies that consumers are spending more and more on health care every year. In parallel with health care expenditures, the amount of indoor environment related illnesses is extremely high, demonstrating that there is a huge market for preventive medical interventions in the built environment that is still in its infancy phase. Individuals with asthma may be the first to incorporate health and wellness amenities into their homes because there is a direct relationship with indoor air quality and the risk of asthma. As shown by several studies, occupants of homes or schools with evidence of dampness (or presence of molds) have approximately a 30% to 60% higher prevalence of asthma or lower respiratory symptoms (e.g., Brunekreef, 1992; Dales et al., 1991; Spengler et al., 1996; Smedje et al., 1997). Since a lack of preventive medical interventions are built into indoor environments today, understanding individuals' preferences for different health and wellness features in monetary terms will help foster improvements in human well-being.

2. Choice Experiment Design

A CE survey is a stated preference valuation method that collects information about respondents preferences by observing hypothetical situations presented in the survey. The first step in CE design is to define the good to be valued in terms of its attributes (or characteristics) and the levels of the attributes. The good to be valued in this CE is health and wellness in the built environment. The attributes were selected using the guidelines of the WELL Building Standard, the first rating system to focus on improving human wellness within the built environment by identifying specific conditions that enhance the health and wellbeing of the occupants.

The selected attributes and their levels are reported in Table 1. No CE study has ever been done using a holistic view of health and wellness in the built environment. Therefore, this study will serve as a benchmark for future studies done on valuing improved health and wellness. In the CE presented here, four essential attributes of buildings that promote biological sustainability were selected to reflect the variety of ways you can improve human well-being in the built environment.

Respondents were given the option of choosing from two scenarios of health and wellness improvements (each with different levels of the 4 attributes at specific cost) and their current living situation (the status quo). Appendix A presents one example of a choice question utilized in the survey. Each respondent answered six randomly generated choice questions were asked to each respondent and then they were asked the first question again. By repeating the first question as the last question and then dropping the first choice question you can account for any "learning effects"[1]. In addition to the choice questions, respondents were asked a series of demographic question. By asking individuals question such as have you engage in yoga, do you exercise regularly, do you suffer from asthma, what is you annual family income, it becomes possible to compare WTP values depending on certain demographic areas.

[1] The first question can be a learning experience for respondents about how to answer the choice question. Dropping it can improve results.

Table 1: Choice Experiment Attributes

Attribute	Definition	Level
Indoor Air Quality	Reducing airborne contaminants through enhanced ventilation and filtration can reduce health issues such as allergies, asthma, respiratory health and eye irritations	No air contamination, low levels of contaminants or significant air quality issues
Water Quality	The average person needs to consumer about 2 liters of water per day. Making sure that water is clean and free of potential pathogens can enable proper hydration without potentially deleterious impacts on human health	Drinking water: no health issues, Drinking water: potential contamination, or Drinking water: high risk of contamination
Surface Cleanliness	Bacteria can fester on surfaces that are not properly treated to minimize built up. It is important to utilize cleaning products that don't leach harmful chemicals, but still have high bacteria reduction levels	99% reduction, 95% reduction or 90% reduction in bacteria
Sleep Quality	Since indoor lighting doesn't change throughout the day, circadian systems don't receive the natural cues associated with changing outdoor lights wavelengths	Never wake up, wake up once or wake up multiple times
Cost to your household	Health and wellness improvements to your home and lifestyle vary depending on the feature. Improved air quality through updated air purification will cost significantly more than blackout shades that improve sleep quality	\$1000, \$2000, \$3000, \$4000, \$5000 or \$6000

3. *Econometric Methods*

Choice experiment data can be effectively analyzed using a mixed multinomial logit model. This model assumes that the respondents are homogeneous with regard to their preferences (the βs are identical for all respondents). This strong assumption is no typically valid and recent literature has started using the mixed multinomial logit model (MMNL)[2] as one of the standard methods to analyze discrete choice data. The MMNL incorporates heterogeneity of preferences (Hensher and Greene. 2003, Carlsson, et al. 2003). The following is a summary of the derivation of the MMNL estimator and the calculation of the WTP.

Assuming a linear utility, the utility gained by person *q* from alternative *i* in choice situation *t* is given by

$$U_{qit} = \alpha_{qi} + \beta_q X_{qit} + \varepsilon_{qit} \tag{1}$$

where X_{qit} is a vector of non-stochastic explanatory variables. The parameter α_{qi} represents an intrinsic preference for the alternative (also called the alternative specific constant). Following standard practice for logit models we assume that ε_{qit} is independently and identically distributed extreme value type I. We assume the density of β_q is given by $f(\beta \mid \Omega)$ where the true parameter of the distribution is given by Ω. The conditional choice probability of alternative *i* for individual *q* in choice situation *t* is logit[3] and given by

$$L_q(\beta_q) = \prod_t \frac{\exp(\alpha_{qi} + \beta_q X_{qitq})}{\sum_{j \in J} \exp(\alpha_{qj} + \beta_q X_{qjt})}. \tag{2}$$

The unconditional choice probability for individual *q* is given by

$$P_q(\Omega) = \int L_q(\beta) f(\beta \mid \Omega) d\beta. \tag{3}$$

The above form allows for the utility coefficients to vary among individuals while remaining constant among the choice situations for each individual (Hensher, et al. 2005, Carlsson, et al. 2003, Train. 2003). There is no closed form for the above integral; therefore P_q needs to be simulated. The unconditional choice probability can be simulated by drawing R random

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[2]This approach is also referred to as the mixed logit, hybrid logit, random parameter logit, and random coefficient logit model.

[3] The remaining error term is iid extreme value.

drawings of β , β_r , from $f(\beta\,|\,\Omega)$ [4] and then averaging the results to get

$$\tilde{P}_q(\Omega) = \frac{1}{R}\sum_{r\in R} L_q(\beta_r)\,. \qquad (4)$$

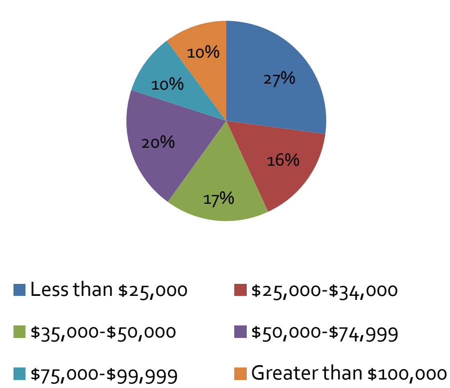
In the choice experiment questions, option A and option B are both restoration options that can be viewed as being closer substitutes with each other than with option C, the status quo option (Haaijer, *et al.* 2001; Blaeij et al. 2007). One method to incorporate this difference in substitution between options is to use an econometric specification for the mixed multinomial logit model that contains an alternative specific constant (ASC) that differentiates between the status quo option and choices that represent deviations from the status quo. This can be achieved by using a constant that is equal to one for alternative A or alternative B.

The coefficient estimates for the mixed multinomial logit model cannot be interpreted directly. Therefore, we calculate average marginal WTA for a change in each attribute *i* by dividing the coefficient estimate for each attribute with the coefficient estimate for the payment term, as given in (9) (Dissanayake 2014).

$$MWTA_i = \frac{\beta_i}{\beta_{cost}} \qquad (9)$$

By using a mixed multinomial logit model, this study hopes to answer 3 questions. (1) How do individuals willingness to pay for health and wellness differ by the type of improvements? (2) Do individuals consider health an inelastic good? (3) What demographic characteristics influence individuals' willingness to pay for health and wellness?

Figure 1: Income Distribution



4. Data Collection

Utilizing Qualtrics survey design software and Amazon Turk survey distribution system we

[4]Typically $f(\beta\,|\,\Omega)$ is assumed to be either normal or log-normal but it needs to be noted that the results are sensitive to the choice of the distribution.

obtained 247 responses. Each individual was paid $0.25 to complete the survey. While there are potential collection biases associated with paying people to take surveys online, research shows that online survey platforms are an effective way to collect data as long as the sample size is large (Savage 2008). To ensure data quality we dropped 50 respondents who answered choice question 1 and 7 differently because these questions were identical. The results presented below are from the remaining 197 respondents. All respondents were located in the U.S and about 75% were from a city or suburb. While it was originally hypothesized that a large percentage of respondents would come from the lowest income bracket (less than $25,000), the analysis found a wide range of income brackets completed the survey as demonstrated in Figure 1. Additional demographic results are attached in Appendix II.

5. Results

All coefficients were highly significant at the 1% level and all the signs are as expected. Therefore, all of the attributes are significant factors when choosing whether or not to invest in health and wellness improvements. When no binary variables were included in the model, individuals were willing to pay $3264 for high water quality vs $2230 for high air quality. It is possible that individuals are better educated on water purification systems and understand the benefits of ensuring water is clean of contaminants. In addition, individuals were willing to pay $194 for a 1 percent increase in bacteria reduction and $1162 for improved sleep quality. However, when the model was limited to individuals who exercise regularly, the WTP values increase for all attributes especially sleep quality which saw a 11.4% increase in WTP. While common knowledge suggests that individuals who exercise are more likely to pay for health and wellness improvements, this is the first study to statistically show that this relationship exists. Respondents who have updated their homes to be more energy efficient were also willing to pay higher amounts for all attributes. Specifically, they will pay 29.5% more for improved sleep quality. These individuals may be better informed on the condition of the indoor environment in their home. However, the model found that individuals who suffer from allergies are actually less willing to pay for health and wellness improvements. Since only 30% of respondents suffer from allergies it is possible that this model suffers a misrepresentation bias and a larger sample size may alter the results.

Another question this study attempted to answer was how individuals WTP changes when you control for each income bracket. While it was originally hypothesized that higher income would be correlated with higher WTP values, this study found that individuals in lower income brackets were actually willing to pay significantly more for each attribute. One interpretation of higher WTP values for low-income respondents is that individuals with higher income are convinced their homes don't need any improvements and their status quo option is significantly higher than other respondents. Future research should focus on generating a larger sample size for similar CEs and breaking down income brackets into additional levels instead of just the 6 above in Figure 1.

Table 1: Conditional Logit and Mixed Multinomial Logit Model Results

Attribute	Conditional Logit	Mixed Multinomial Logit
Air Quality	0.647***	0.930***
	(0.0656)	(0.0959)
Water Quality	1.0396***	0.1.362***
	(0.0684)	(0.108)
Bacteria Reduction	0.0545***	0.0811***
	(0.00321)	(0.00537)
Sleep Quality	0.360***	0.485***
	(0.0616)	(0.0850)
Cost	0.000288***	0.000417***
	(0.0000332)	(0.0000537)
Observations	3546	3546

Standard errors in parentheses * p<0.05, ** p<0.01, *** p<0.001

Table 2: Willingness to Pay Comparisons Mixed Logit Model[5]

	WTP	WTP if exercise	WTP if improved energy efficiency
Air Quality	2230.2***	2422.9***	2587.8***
	(5.88)	(4.26)	(4.23)
Water Quality	3264.0***	3534.5***	3888.1***
	(6.88)	(5.41)	(224.1)
Bacteria Reduction	194.3***	216.6***	224.1***
	(8.12)	(6.38)	(6.08)
Sleep Quality	1162.9***	1295.4***	1677.7***
	(4.86)	(3.89)	(4.46)

Standard errors in parentheses * p<0.05, ** p<0.01, *** p<0.001

[5] Note: WTP comparisons for conditional logit model are in Appendix C

6. Conclusion

The results of the conditional logit model imply that individuals are willing to pay a high premium for health and wellness across all income classes. The additional money low-income respondents are WTP demonstrates that the long-term growth of the health and wellness industry has serious growth potential in the next couple years. While certain air filtration systems can reach upwards of $2000 and whole-house water purification systems can range anywhere from $400-$3,000, the study shows that there is room for both cost leadership and product differentiation within this industry and that individuals will invest in their health independent of their income bracket. The significant WTP values for bacteria reduction have significant implications for the growth of new antimicrobial agents. The demand for high quality surface treatments is growing very quickly; therefore, there should be considerable room for high priced non-toxic surface treatments to capture market share over highly toxic and VOC generating surface treatments. Also, the gym/exercise market for health and wellness should see considerable growth as consumers become more aware of the benefits of healthy environments and force gyms to purchase less toxic cleaning disinfectants.

While the results of this study are a good indication of the inelasticity of human health and wellness, the results can be somewhat biased because people may not actually be willing to pay the same amounts they claim they were willing to pay for. Therefore, it would be interesting to conduct the same study with lower cost values to see if individual's perceptions change. In addition, this survey attempts to educate the surveyor before they answer any choice experiment questions by outlining the benefits of improved air quality, water quality, sleep quality and clean surfaces. However, if individuals were not given background information on the health impact of the built environment they may be less inclined to make any improvements. Less research exists on the health impacts of the built environment than building energy use even though this study shows individuals value their health as an inelastic good and will pay significant premiums. Therefore, continued research is essential for improved human health and well-being in the built environment.

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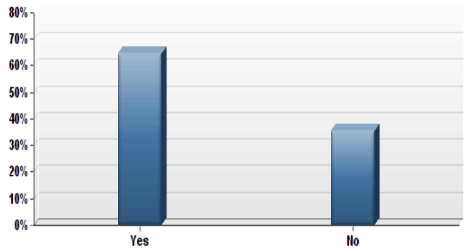
8. Appendix A: Sample Choice Question

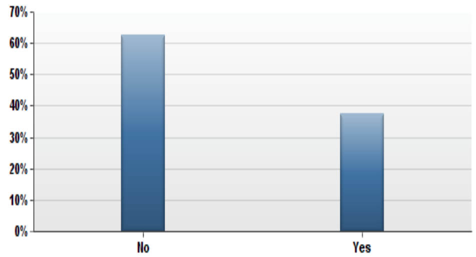
Attributes	Alternative 1	Alternative 2	Status Quo
Indoor Air Quality	**Low levels of contaminants** 	**No Air Contamination**  +	
Water Quality	**Drinking Water: No health issue**  +	**Drinking Water: potential contamination** 	**No Health and Wellness Improvements**
Surface Cleanliness	**99% reduction in bacteria**	**90% reduction in bacteria**	
Sleep Quality	**Wake up multiple times** 	**Never wake Up** 	
Cost	**$6000** 	**$4000** 	
Please tick/mark (√) only one	❒ A	❒ B	❒ C

9. Appendix B

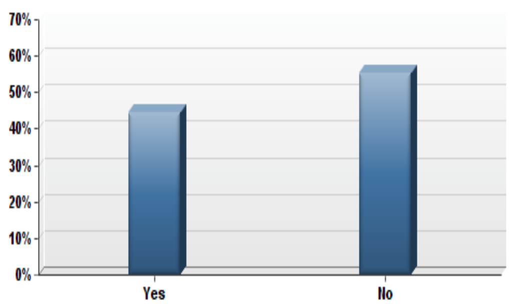
Do you regularly exercise?



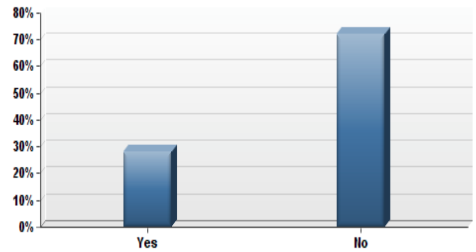
Do you suffer from allergies?



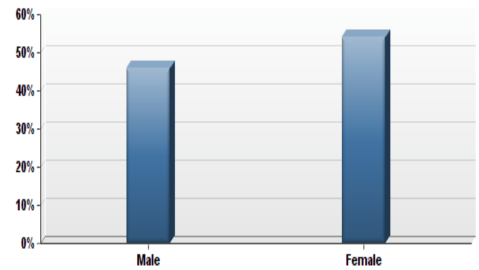
Have you updated any applications in your home to be more energy efficient



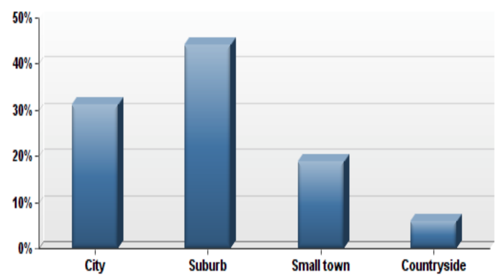
Have you ever heard of the LEED building certification system?



Gender



What best describes where you currently live



10. Appendix C

WTP Comparisons for the Conditional Logit Model

	WTP	WTP if exercise	WTP if made energy efficiency improvements
Air Quality	-2248.9^{***}	-2257.5^{***}	-2262.3^{***}
	(372.4)	(473.9)	(542.1)
Water Quality	-3612.3^{***}	-3618.8^{***}	-3841.2^{***}
	(472.2)	(601.2)	(707.3)
Bacteria Reduction	189.5^{***}	194.5^{***}	196.9^{***}
	(20.51)	(26.77)	(30.48)
Sleep Quality	-1252.4^{***}	-1362.0^{***}	-1515.2^{***}
	(245.2)	(324.9)	(371.3)
Observations	3543	2268	1617

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$