Stated WTP and rational WTP: willingness to pay for green apartments in Sweden

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Abstract

Green buildings are expected to require lower operating costs, provide better indoor environment and have a lower impact on the environment than conventional buildings. Consequently, if renting or buying green property is more beneficial, a customer may be willing to pay extra for green apartment. The aim of this paper is to study stated and rational willingness to pay for green apartments in Sweden. A database consisting of responses from 477 occupants living in green and conventional multi-family buildings was used to investigate the existence of WTP and to test the difference in opinion between respondents living in green or conventional buildings and condominiums or rental apartments.

The responses indicate that people are prepared to pay more for very low-energy buildings but not as willing to pay for a building with an environmental certificate. It was found that interest in and the perceived importance of energy and environmental factors affect the stated WTP. The results indicate that a stated willingness to pay for low-energy buildings of 5% can be considered a rational investment decision.

Keywords: residential buildings; green buildings; willingness to pay,

Introduction

The European Council decision on the energy performance of buildings (2010/31/EU, 2010) not only established new goals for European Union member states but also defined the future market for construction companies. For example, Article 9a Directive 2010/31/EU clearly states that "Member States shall ensure that by 31 December 2020 all new buildings are nearly zero energy buildings ", which means that gaining competence in building energy-efficiently became an important issue for competitive companies. For the construction industry, the European Council decision was hardly revolutionary; rather, it was a confirmation that environmental issues are not just a trend but a strategic course, changing market conditions to which developers must be prepared to respond.

However, buildings constructed with environmental and energy goals require more knowledge, competence, and cooperation from design and construction teams, implying that the total construction cost for green buildings may be higher than for conventional ones (Zalejska-Jonsson et al., 2012). Traditionally, a profit-maximizing company facing increased cost seeks to increase its prices, which inevitably means that customers must be able and/or willing to pay for the extra cost. Green buildings are expected to require lower operating costs, provide better indoor environment and have a lower impact on the environment than conventional buildings. It is rational to believe that a customer is willing to pay extra if perceived benefits from renting or buying green property are more beneficial than those from conventional buildings.

The paper aims to examine stated willingness to pay (WTP) for low-energy and environmentally labeled buildings among owners and tenants living in green and conventional multi-family buildings in Sweden. We test how apartment tenure and the importance of energy and environmental factors during apartment purchase or rental impacts the stated WTP. Since, at the point of the study, the number of green apartments on the Swedish market was limited and the information regarding transactions was unavailable, the stated WTP could not be compared to the revealed WTP. Considering these data limitations, we attempted to evaluate the rationale of investment in green building from a private investor perspective (i.e. owner) considering their stated willingness to pay.

1. The literature review

1.1. WTP for green labeled buildings

Evidence of the willingness to pay for energy efficiency and environmental factors on the real estate market in the commercial property sector has demonstrated that green-labeled buildings can generate a price premium (Dermisi 2009; Miller et al., 2009, Eichholtz et al., 2010a, Eichholtz et al., 2010b, Fuerst and McAllister, 2011a; Fuerst and McAllister, 2011b, Kok and Jennen, 2012). Recent literature provides evidence that higher WTP for green-labeled buildings and energy-saving measures may also be detected on the

residential market (table 1). Ott et al. (2006) demonstrated that prices for energy-efficient buildings, labeled with the energy and environmental label Minergie, were higher than for more conventional buildings. Results from a hedonic pricing model suggest that the price for Minergie single-family homes in Zurich was 9 percent (+/-5 percent) higher than that of comparable properties. A similar model was used in Colorado, USA, and results indicate a price premium for labeled houses, which demonstrated that Energy Star qualified buildings generated higher prices than those of comparable houses without an Energy Star label (Bloom et al., 2011). The adaptation of an energy label to the housing market in the Netherlands and the impact of such a label on the market was the focus of a study presented by Brounen and Kok (2011). The authors concluded that the price premium for energy-labeled property depends on the energy-label level and on the fact that consumers use the information disclosed by the energy label when purchasing housing property. The analysis indicates that green labels (high-energy labels “A”, “B” and “C”) generate a 3.7 percent premium. It was found that homes with the highest energy label, “A”, were sold at a 10 percent price premium compared with intermediate level “D”; however, homes at the lowest level “G” were transacted at a 5 percent discount.

A few studies have examined customers’ willingness to pay (WTP) for specified energy-saving measures rather than buildings with an energy or environmental label. In Switzerland, researchers used a choice experiment to evaluate the willingness of households to pay for energy-saving measures (Banfi, Farsi et al., 2008). A fixed logistic model was applied to data collected via telephone interviews in the summer of 2003, and results showed that both those living in rental apartments and those living in owned single-family houses are willing to pay more for ventilation systems, enhanced insulation of the façade, and energy-efficient windows. The WTP varies from 3%-13% depending on the energy-saving measure. A similar approach was chosen in a study of Korean households and their preferences for energy-saving measures (Kwak et al., 2010). Results indicate that households were prepared to pay more for more energy-efficient windows, thicker walls, and for installing a ventilation system. Mandel and Wilhelmsson (2011) showed that there was a positive WTP for environmental attributes among households that purchased single-family houses in the Stockholm area of Sweden in 2000. The analysis indicated that environmental awareness affects willingness to pay, and the calculated non-marginal WTP for environmentally aware households was about 2-4% higher for energy-efficient systems and 5-8% for water-reducing technologies.

Table 1. WTP for energy-saving measures and green residential buildings

Reference	Country	Research Method	Results
Ott et al., 2006	Switzerland	transaction prices	Price for Minergie single-family homes in Zurich was 9% (+/-5%) higher than that of comparable properties
Banfi et al., 2008	Switzerland	choice experiment	WTP measured as ratio between attribute coefficient and the rental price for apartments and the purchased price for single houses Façade: 3-6% (rental apartments) 3-7% (owned houses) Ventilation: 4 - 8% (rental apartments) 4-12% (owned houses) Windows: 10-13% (rental apartments) 8-13% (owned houses)
Kwak et al.. 2010	Korea	survey, choice experiment	MWTP for a) improved windows was $18.20; b) increased wall thickness 1mm was $1.20; c) installing ventilation system was $12.40
Mandel and Wilhelmsson, 2011	Sweden	transaction prices	Non-marginal WTP environmentally aware household was about 2-4% higher for energy-efficient systems and 5-8% higher for water-reducing technologies
Bloom et al., 2011	US, Colorado	transaction prices	Energy Star qualified homes generate higher prices than those of comparable properties
Brounen and Kok, 2011	Netherlander	transaction prices	Premium for energy-efficiency depends on label category; green labels (A,B,C) generate higher selling price (3.7%); A-label homes compared to D-label homes transact at 10.2% higher prices
Addae-Dapaah and Su Jen Chieh, 2011	Singapore	survey	Green-labeled buildings transacted at 5-12% price premium

1.2. Stated and revealed willingness to pay

There is an important distinction between stated and revealed willingness to pay. The revealed WTP is based on observed behavior and thus often uses transaction prices (e.g. Mandel and Wilhelmsson ,2011; Brounen and Kok ,2011). The stated WTP, on other hand, are based on intended choices and based on hypothetical responses collected through survey or interviews (e.g. Kwak et al. 2010).

In this article, the analysis and discussion is based on the stated WTP. There are different approaches to investigating stated preference, one of which is a contingent valuation survey and a choice experiment. In the contingent valuation method, respondents are asked to reveal their willingness to pay in a direct question (often a binary yes/no question), whereas in a choice experiment respondents are asked to select answers from multiple alternatives (Kling et al., 2012). Contingent valuation is frequently used for

assessing monetary values on environmental amenities and services (Carson, 2000). The technique is often used to obtain information when goods and services are not available on the market and therefore there is seldom actual data regarding cost and sales. The respondents are asked to reveal their preferences, which are contingent upon the hypothetical market presented in the survey. Contingent valuation (CV) may be used for assessing willingness to pay for private and public goods and service, and produced estimates might be included in market analysis, cost-benefit analysis and even judicial processes (Portney, 1994; Kling et al., 2012).

The methodical approaches to the measurement of WTP have been the subject of a long and heated debate. The critics have been pointing out problems with the underlying assumptions for contingent valuation, survey bias and the reliability of produced estimates. Firstly, opponents argue that the results from CV indicate respondents' hypothetical opinion rather than a measure of preferences for the specific project or product, questioning respondents' familiarity and understanding of the studied subject (Diamond and Hausman, 1994; Hausman, 2012). Proponents agree that CV studies place respondents in a simulated market position, but contend that this method is no different than requesting customers to purchase "unfamiliar or infrequent commodities" (Hanemann, 1994).

Secondly, opponents have argued that the quality of CV is dependent on the survey design. The critics raise the issue of wording and phrasing, the order of questions and the problem of comparability of responses (Diamond and Hausman, 1994; Hausman, 2012. They have also pointed out the hypothetical response bias that leads to producing overstated values (Murphy and Stevens, 2004; Hausman, 2012). Hausman (2012) argues that the bias in answers is often related to the specific nature of contingent valuation surveys, as respondents are asked to indicate willingness to pay expressed in specific monetary value for a certain outcome, without the possibility of different alternatives or a discussion. Moreover, the respondents are often not informed about how their answers are going to be used and therefore might be more likely to choose the answer that pleases the interviewer. Additionally, the CV surveys often face what is known as the "embedding effect" or the "scope problem". The first to explore the problem were Kahneman and Knetsch (1992), who wrote that "the assessed value for public goods is demonstrably arbitrary, because willingness to pay for the same good can vary over a wide range depending on whether the good is assessed on its own or embedded as part of a more inclusive package". The issue is broadly discussed by Diamond and Hausman (1994) and Hausman (2012). Opponents of the CV method have also questioned the accuracy of responses indicating that respondents may not be answering the question that the interviewer had in mind (Diamond and Hausman, 1994; Hausman, 2012). Additionally, the CV may not be an accurate measurement because respondents may experience a "warm glow" and express support for the good cause rather than indicating their individual preference (Diamond and Hausman, 1994). The term "warm glow"

describes the private value an individual may experience by contributing to a worthy cause (Kling et al., 2012).

Advocates of CV methodology argue that by implementing CV guidelines (Portney, 1994; Carson, 2000), conducting a reliable survey (Hanemann, 1994), and applying best practice protocols (Kling et al., 2012), the results obtained via CV can be reliable and any potential bias can be reduced. The survey bias and overestimation of stated WTP can be reduced: when the criterion of value are clearly stated, presenting respondents with information on how the results may influence policies or strategies (Kling et al. 2012), when participants are warned of a tendency to increase the values (Cumming and Taylor, 1999) and when certainty statements are included in the questionnaire (Blumenschein et al., 2008).

Finally, the critics consider the difference between stated willingness to pay and accepted willingness to pay to be the definitive and non-dismissible argument (Diamond and Hausman, 1994; Hausman, 2012). The proponents agree that a discrepancy exists between willingness to pay and to accept, but contrary to opponents, find results in line with neoclassical economic theory and behavioral economics, explaining that the predicted properties of welfare are often different (Carson, 2012).

Proponents of CV underline the fact that hedonic models and other tests based on market data are unable to provide complete information on measures of value, particularly if the value of the commodity is at least partly unrelated to consumption of complementary goods (Hanemann, 1994). Contingent valuation can capture this value, often referred to in the literature as “existence value”, “passive use value” or “non-use value” (Hanemann, 1994; Carson 2012).

1.3. The case of Sweden

Since the green residential market in Sweden is in an emerging phase, and consequently, empirical evidence for customer preference regarding green residential buildings is difficult to obtain, the data for this paper was collected through a survey. Most of the building apartments investigated in this study were sold between 2007 and 2010, when the economic crisis hit the real estate market quite hard and developers had to use different offers and discounts in order to make a sale. It is, therefore, difficult to compare sales prices, not knowing the price reduction and the contracted purchasing price.

In regard to rental apartments, the rental fees in Sweden are controlled and based on the agreement with the Tenant’s Union and often related to the building location, dwelling size and quality of the finish (for example, installed appliances) (Svensson, 1998; Atterhog and Lind, 2004; Lind, 2011). Consequently, the observed difference in rental fee between conventional and green apartments may not reflect the environmental value.

This paper does not aim to estimate the mean of willingness to pay as a reflection of an accurate monetary value that customers are ready to pay for green buildings, but rather to investigate the existence of WTP and to test the difference in opinion between respondents living in green or conventional buildings and condominiums or rental apartments. The interest of the paper is also whether the stated WTP is a rational decision in light of investment analysis theory.

2. Method and data collection

2.1. Study design

The study is based on a quasi-experimental method (Bohm and Lind, 1993), which was used to capture differences in purchasing and rental decision and overall apartment satisfaction among occupants living in green and conventional buildings. The research was designed as a multi-case study in which green and conventional residential buildings were carefully selected and paired in such a way that building characteristics were comparable and only differed in energy and environmental performance.

While selecting and matching cases, *a green building* was defined as a building designed and constructed with high energy efficiency or environmental goals. Only buildings with a very low energy requirement (close to passive house standard[i]) and buildings registered or certified according to a building environmental scheme were considered as green. It was imperative that *the conventional building* was constructed according to current Swedish Building Regulations but did not aim at better environmental or energy performance.

2.2. Data collection

The data was collected in 2012 in two collection periods: late spring and early autumn 2012. The studied cases included multi-family buildings with rental apartments (owned by municipal companies) and condominiums, with apartments owned by tenants. All selected green apartments are very low-energy buildings (with calculated annual space heating approx. 50 kWh/m2) and the majority have also been registered or certified by a building environmental scheme.

2.3. Survey design and questionnaire

The questionnaire

The survey questionnaire was divided into four sections and consisted of in total 33 questions. The first part investigated which factors impacted customer purchasing decisions and the second part focused on occupants' overall satisfaction with their apartment and perception of indoor environment quality. The third part aimed at obtaining information about respondents' perception of building environmental

certification and willingness to pay for buildings with an environmental profile. The final section asked a few background questions. The questionnaire included structured closed questions, and single or multiple choices. Respondents were offered the possibility of placing their comments in the spaces assigned to each question.

The investigation of customer-stated WTP was not the sole aim of the survey; thus, the questionnaire is not a typical contingent valuation survey. The respondents were asked a direct question whether they were willing to pay a premium for dwelling in a low-energy building and an environmentally labeled building. The respondents had the possibility to indicate the size of the premium expressed as a percentage (5% or 10%) of the purchasing price (or rental fee) compared to a conventional building. The questionnaire also included questions asking for respondents' opinion on the implications of building environmental labeling.

The terminology and distinction between low-energy and labeled buildings was preliminarily imposed due to commonly used terms in public discussion regarding green residential properties in Sweden. We anticipated that respondents would be more familiar with those descriptions than with the term "green building".

The survey collection

The survey was sent by regular mail to all occupants of the selected buildings, who at the time of the survey were 21 years of age. The envelope was addressed to individuals and included cover letter, survey questionnaire and return envelope. The particulars (name and address) were obtained from a publicly accessed online database. People invited to participate in the survey could submit their answers in paper form using the return envelope or answer online using the link indicated in the cover letter. All participants were offered a gratuity in the form of a scratchcard costing approx. EUR 0.3. Only respondents who submitted their contact details received a letter of appreciation and a gratuity. All participants were ensured that responses would be treated anonymously. In order to fulfill this promise, all responses were coded.

The participants were asked to answer the survey within 10 days. A reminder was sent to non-respondents two weeks after the first invitation letter. Answers received in paper form were manually added to the database. The survey was addressed to 1200 persons and 477 responses were received, which resulted in 40% of the total response rate. Detailed information about the response rate for each case is presented in table 2.

Table 2. Response rates

building type	tenure	questionnaire sent	response	response rate	pair number
conventional	ownership	91	38	42%	1
conventional	ownership	47	28	60%	2
conventional	ownership	63	38	60%	3
conventional	ownership	85	33	39%	4
conventional	ownership	85	30	35%	5
conventional	rental	196	56	29%	6
conventional	rental	173	55	32%	7
total		**740**	**248**	**38%**	
green	ownership	35	18	51%	1
green	ownership	21	14	67%	2
green	ownership	55	24	44%	3
green	ownership	58	31	53%	4
green	ownership	63	35	56%	5
green	rental	175	63	36%	6
green	rental	53	14	26%	7
total		**460**	**199**	**43%**	
Total		**1200**	**477**	**40%**	

2.4. Statistical analysis

In the first stage of the analysis, descriptive statistics were used. In the second step, the statistical difference in responses from occupants of green and conventional buildings was tested by the Mann-Whitney (rank sum) test. Thirdly, statistical models were applied. Individuals' and building characteristics as well as the importance of energy and environmental factors for occupants' apartment purchase or rental decision are used as explanatory variables for stated WTP. The variables included in the statistical models 1 and 2 are presented in table 3.

$$LE(WTP) = f(AGE, GENDER, FAMILY, OCCUPANTS, ROOMS, TENURE, PROFILE, ENERGY\ FACTOR)$$

(model 1)

$$ECB(WTP) = f(AGE, GENDER, FAMILY, OCCUPANTS, ROOMS, TENURE, PROFILE, ENVIRONMENTAL\ FACTOR)$$

(model 2)

Table 3. Description of variables

	Description of variables
LE(WTP)	stated willingness to pay for low-energy building *(model 1)*
ECB(WTP)	stated willingness to pay for environmentally certified building *(model 2)*
AGE	respondent age
GENDER	variable describing respondent gender; if woman =1, if man=0
FAMILY	variable describing if occupants were a family with children
OCCUPANTS	variable describing number of occupants per dwelling
ROOMS	variable describing dwelling size measured in number of rooms
TENURE	variable if condominium =1, if rental=0
PROFILE	variable for building environmental profile, if green=1, if conventional =0
ENERGY FACTOR	variable describing importance that energy factor had while making decision to purchase or rent the apartment
ENVIRONMENTAL FACTOR	variable describing importance that environmental factors had while making decision to purchase or rent the apartment

Initially, the ordered logistic regression was chosen due to the nature of the data, which has ordered categories measuring opinion and frequency using a rated scale (Borooah, 2001); however, the Brant test indicated that the parallel regression assumption was violated. Therefore, responses of a three-stage ordered scale were converted to binary scale, where the dependent variable can be described either as a willing-to-pay premium or a not-willing-to-pay premium. After the conversion, a binary logistic model was applied to the data.

The results are reported in the form of odds ratios and interpreted in this paper as likelihood of willingness to pay if the predictor variable is increased by one unit while other variables are kept constant.

The results are considered to be statistically significant at $p \leq 0.05$, unless indicated otherwise. The internal consistency test (the Cronbach alpha test) was conducted and the computed coefficient of 0.63 was considered as satisfactory.

2.5. Limitations

The present study is largely based on the survey responses and, consequently, the analysis may include errors related to the formulation of the questions, insufficient communication, or misunderstanding of questions and respondents' subjective opinion (Diamond and Hausman, 1994, Schwarz and Oyserman 2001). Additionally, in line with the adopted quasi-experimental approach, the questionnaire was addressed to occupants living in the selected buildings. The condominiums and the rental apartments were specifically chosen due to building characteristics (location, production year, size,

potential customer segment) and not randomly selected. Consequently, the presented results should be interpreted with caution.

The research study and consequently the survey questionnaire had multiple objectives; thus, the applied survey does not reflect the format of the contingent valuation survey. The presented results are, therefore, interpreted as an indication rather than an accurate and define measure of willingness to pay.

3. Results

3.1. Description of respondents

Gender distribution is very similar in the sub-groups green and conventional owned dwellings and green and conventional rental apartments: approx. 55% respondents were females. There are certain differences in age distribution among respondents between the sub-groups (figure 1). The majority of respondents in green condominiums represented two age groups: 31 and 40 (37%) and over 61 years old (30%). The largest group of respondents living in conventional condominiums were over 61 years old. On the other hand, the majority of respondents living in rental apartments, in both green and conventional, were 31-41 years old (see fig. 1). Generally, the difference in age distribution between rental and condominiums is, not surprisingly, that younger people entering their housing careers are living in rental apartments, whereas older people, being in the latter phase of their housing career, choose to live in owned apartments. The proportion of families with children in green condominiums was higher (43%) than in conventional buildings (25%).

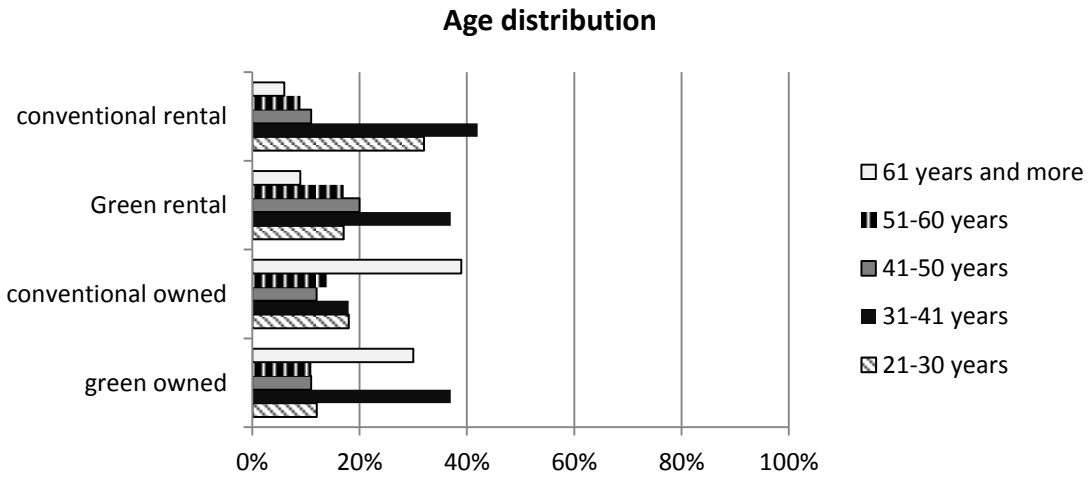

Figure 1. Respondents' age distribution

The largest group of respondents in green (40%) and in conventional (52%) rental apartments was living in 3-room dwellings (figure 2). On the other hand, the largest group of occupants of conventional condominiums declared to be living in 2-room (36%) and 3-room (38%) apartments. By comparison, the largest group of occupants in green condominiums was living in 3-room (35%) and 4-room (34%) apartments.

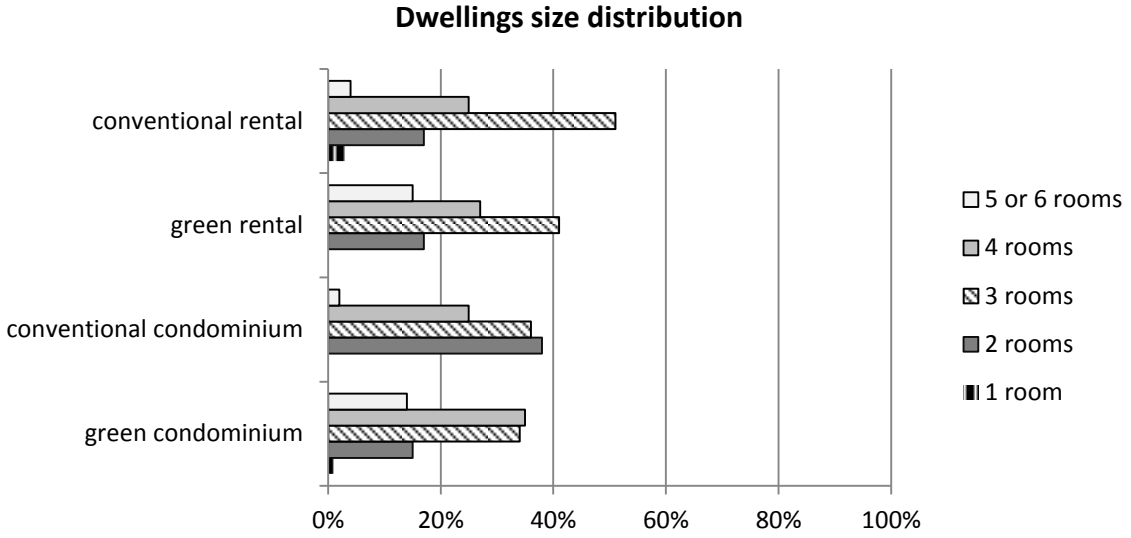

Figure 2. Dwelling size distribution

3.2. Willingness to pay premium purchasing price or extra rental fee for green buildings

The respondents are willing to include a premium in their purchasing price for low-energy buildings (1.84 mean) rather than for buildings with an environmental certificate (mean 1.49) (table 4).

Table 4. Mean values for stated willingness to pay

WTP (std) **no observ**	mean value for condominiums	mean value for rental apartments
WTP for low-energy building	1.841 (.62) 279	1.413 (.57) 186
WTP for building with environment certificate	1.49 (.58) 279	1.289 (.52) 183

response scale: 1= not willing to pay extra purchasing price / rental fee, 2= yes, 5% premium, 3= yes, 10% premium

3.2.1. Condominiums

The results indicate that the WTP for green condominiums is higher than among in conventional apartments. One fifth of green building occupants stated that they are willing to pay as much as 10% more for low-energy buildings, and 64% are prepared to pay a 5% premium. By comparison, 7% of participants living in conventional condominiums are prepared to pay 10% extra and 55% are willing to pay 5% extra for dwellings in low-energy buildings (figure 3).

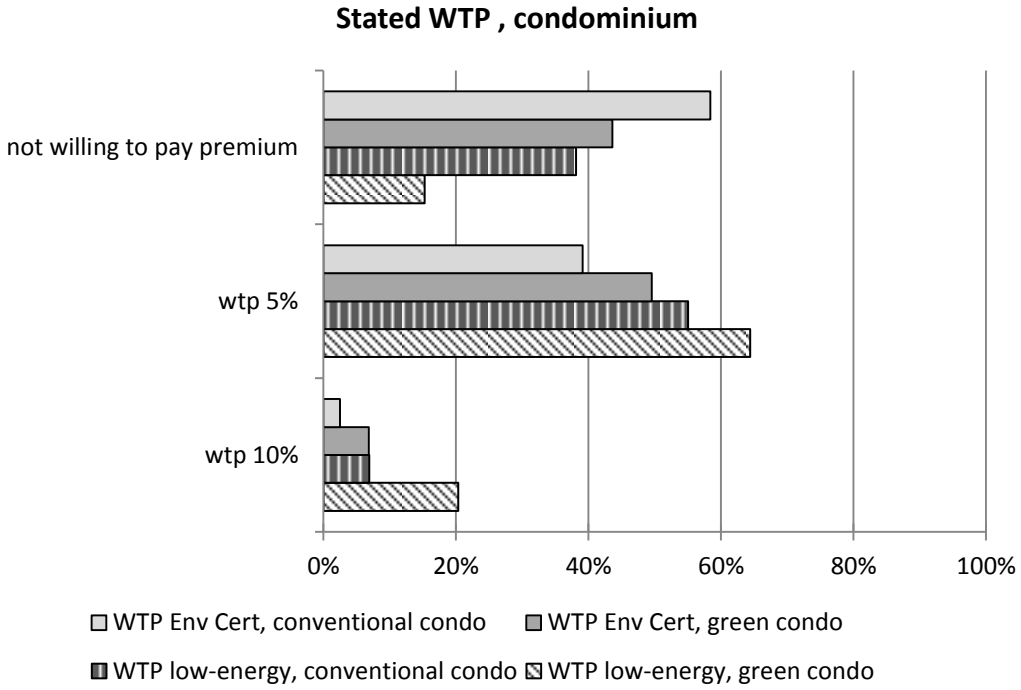

Figure 3. Willingness to pay premium at purchasing price for dwellings in buildings with low-energy and buildings with environmental certificate.

Interestingly, apartment owners indicated an environmental label as less value for money: only 7% respondents in green and 2% in conventional buildings were willing to pay 10% more (figure 3). Differences in responses were statistically significant (table 5).

Table 5. Difference in responses regarding stated willingness to pay, condominiums

	Mann-Whitney test for difference between rental and condominiums [p, probability]	Mann-Whitney test for difference between green and conventional condominiums
WTP		
WTP for low-energy building	0.0001*	0.0001*
WTP for building with environment certificate	0.0001*	0.075***

*** significant at p≤0.10; **significant at p≤0.05; * significant at p≤0.01

This is an interesting result, indicating that customers are willing to pay more for features they can understand. Customers can translate low-energy building features into lower requirement for energy and therefore lower operating costs. It may not as easy to find direct benefits from owning an apartment in a building with an environmental certificate.

3.2.2. Rental apartments

The majority of occupants of rental apartments (70%), regardless of whether they live in green or conventional buildings, were not willing to pay a premium for renting an apartment in an environmentally certified building (figure 5). However, 42% of the tenants in green buildings stated a WTP of 5% extra for renting an apartment in a low-energy building. Only one fourth (26%) of the respondents in conventional buildings agreed to the same premium. The difference in opinions was found to be not statistically significant (table 6). When interpreting these answers, we should note that respondents living in green rental apartments have a rental agreement that is somewhat unusual for Sweden, whereby space heating costs are related to the tenant's actual consumption and therefore not included in the rental fee. Commonly, space heating costs are included in the rental fee and actual consumption has no impact on rent. This may explain the difference in tenants' responses and stated willingness to pay.

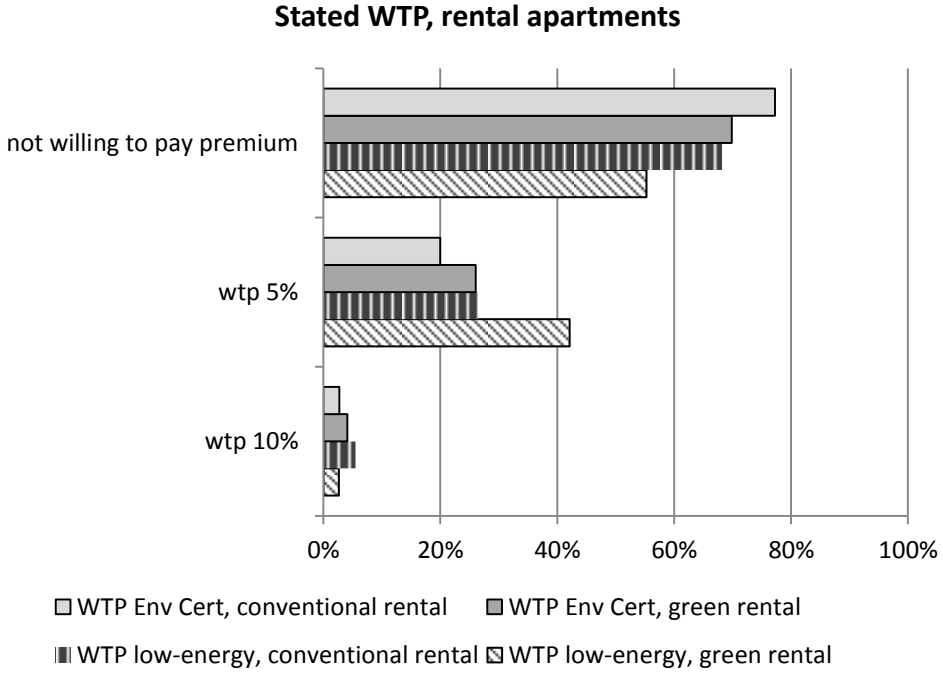

Figure 4. Willingness to pay rental premium for dwellings in buildings with low-energy and buildings with environmental certificate.

Table 6. Difference in responses regarding stated willingness to pay, rental apartments

	Mann-Whitney test for difference between rental and condominiums [p, probability]	Mann-Whitney test for difference between green and conventional buildings with rental apartments
WTP		
WTP for low-energy building	0.0001*	0.121
WTP for building with environment certificate	0.0001*	0.257

*** significant at p≤0.10; **significant at p≤0.05; * significant at p≤0.01

3.2.3. Environmental awareness and perceived importance of building certification

In contrast o the above, there might be a difference in the perceived value and the perceived significance of building environmental certification. When respondents were asked to indicate their opinion on the importance of environmental certification for buildings, a relative majority (45%) of respondents stated that environmental certification is important and that it may have a positive impact on building value or building attractiveness. Analysis indicated a statistically significant difference between responses received from occupants living in green and conventional condominiums (table 7). The majority of respondents living in green condominiums (53%) perceived that certification is

important and that it may have a positive impact on building value, whereas only 34% of occupants in conventional condominiums had the same opinion.

Table 7. Difference in responses regarding perceived importance of building environment certificate

	Mann-Whitney test for difference between rental and condominiums [p, probability]	Mann-Whitney test for difference between green and conventional condominiums	Mann-Whitney test for difference between green and conventional buildings with rental apartments
certification	.09***	.0006*	.52

*** significant at p≤0.10; **significant at p≤0.05; * significant at p≤0.01

3.2.4. Importance of energy and environment factors for decision to purchase / rent apartment and stated WTP

Even though energy and environmental factors had, in general, a relatively minor impact on the decision to purchase or rent the apartments (Zalejska-Jonsson, 2013), the responses indicate that survey participants show a certain interest in those factors.

The majority of survey participants living in the condominiums indicated that the energy factor was decisive (15%) or very important (55%) while making the apartment purchase decision. In contrast, only 8% of tenants consider this factor to be decisive and 38% to be very important while making a decision on renting the apartment. The difference is also noticeable between green and conventional apartments as 70% of respondents living in green dwellings stated that energy factors were decisive or very important. This is comparable to 54% respondents living in conventional buildings.

The majority of respondents living in condominiums considered environmental factors (other than energy) as decisive (8%) or very important (50%); in comparison, 12% of tenants consider environmental factors as decisive and 36 as very important. Approximately 65% of the survey participants living in green apartments stated that environmental factors affected their decision to purchase the apartment (decisive and very important ranking) and approximately 45% of the tenants said the same.

3.2.5. Variables significantly effecting stated willingness to pay

The results (table 8 and table 9) indicate that respondents living in green buildings are more likely than those in conventional buildings (odds ratio 2.75) to pay a premium for low energy buildings and the occupants of condominiums are more likely than tenants to pay a premium to live in a green building (odds ratio for low-energy building 4.66; odds ratio for building with environmental certificate 2.04).

The results show that the oldest group of respondents (over 61 years) is less likely (odds ratio 0.31) to pay a premium for low-energy buildings than the youngest respondents group (21-30).

Table 8. Logistic regressions: stated willingness to pay for low-energy buildings

	model 1		
	odds ratio	p, probability	conf. interval (CI 95%)
older: 31-40	.58	.14	.28-1.19
older: 41-50	.42	.05**	.14-.70
older: 51-60	.38	.03**	.16-.91
older: over60	.31	.005*	.14-.70
woman	.86	.53	.54-2.46
family	1.17	.66	.56-2.46
rooms	.99	.97	.73-1.35
occupants	1.00	.96	.72-1.40
owned dwellings	4.66	.00*	2.80-7.77
green building	2.75	.00*	1.68-4.50
energy factor decisive	2.93	.02**	1.12-7.67
energy factor high importance	2.35	.01**	1.17-4.73
energy factor low importance	1.56	.23	.75-3.23
constant	.40	.11	.12-1.24
No of observations	389		
pseudo R2	.146		

**significant at p≤0.05, * significant at p≤0.01

Table 9. Logistic regressions: stated willingness to pay for buildings with environmental certificate

	model 2		
	odds ratio	p, probability	conf. interval (CI 95%)
older: 31-40	.53	.07***	.27-1.06
older: 41-50	.87	.74	.38-1.98
older: 51-60	.58	.21	.25-1.28
older: over60	.59	.18	.27-1.28
woman	1.08	.71	.69-1.71
family	1.96	.06***	
rooms	1.15	.34	.85-1.55
occupants	.80	.20	.58-1.12
owned dwellings	2.04	.005*	1.24-3.36
green building	1.41	.14	.88-2.24
environmental factor decisive	4.12	.005*	1.52-11.15
environmental factor very important	3.60	.001*	1.70-7.61
environmental factor very low importance important	1.30	.50	.59-2.83.
constant	.18	.005	.05-.60
No of observations	381		
R2	.09		

***significant at p≤0.1, **significant at p≤0.05, * significant at p≤0.01

The results indicate that interest in energy and environment factors affects stated willingness to pay. The survey participants who considered energy factors as decisive or important are more likely to pay a premium for low-energy buildings (odds ratio 2.93 and 2.35, respectively). Also, the respondents who considered environmental factors as decisive or important are more likely to pay a premium for dwellings in environmentally certified buildings (odds ratio 4.12 and 3.60, respectively).

Those findings may provide support to comments that (CV) respondents' familiarity with or interest in the subject under study may affect their stated willingness to pay (Diamond and Hausman, 1994). On the other hand, it is not surprising that respondents who perceive specific commodity aspects as important are ready to pay more for those features. Moreover, results (table 7 and 8) suggest that perception of those features may vary depending on individual characteristics (e. G. age) and life style (e. g.. family with children).

The arguments regarding the subjectivity of responses and the tendency to overstate values point to a potential bias in stated WTP studies and question the rationale of the respondents' decision. Recognising a potential bias in the results of the stated WTP, we adopted an investment viability approach to assess the rationale of stating willingness to pay a 5% premium for low-energy buildings.

3.3. Evaluating green building premium from an apartment owner perspective

In this section, we attempt to assess whether the WTP premium stated by the majority of respondents (5% premium) could be explained by the attractiveness of the investment. In order to test this hypothesis, we calculate the viability of this investment compared with a conventional building.

Energy assumptions

It is assumed that a conventional building constructed in Sweden between 2008- 2011 fulfills Swedish Building Regulations (Boverket, 2009) and therefore in southern Sweden, the expected energy consumption is 110 kWh/m2 in the case of buildings with district heating and 55 kwh/m2 in the case of buildings with electric heating. Comparably, very low-energy buildings built according to Swedish passive house standards (Swedish Forum för energieffektiva byggnader FEBY, 2009) were expected to achieve as low energy consumption for space heating as 50 kwh/m2 in the case of buildings with district heating and 30 kwh/m2 in the case of electrically heated buildings. Neither Swedish Building Regulations nor FEBY standards include domestic energy in their requirement for energy consumption. Hence, benefits associated with energy savings come from the difference between requirements for space heating in conventional and passive house buildings.

Holding period

Firstly, we would like to discuss what holding period is adequate for this calculation. It is possible to calculate the viability of a customer investment over a short or long period of time. We could assume that a customer purchases an apartment for his or her current needs, which may change in the future and therefore the calculation period should be relatively short, for example five years. In such a case, energy-saving costs during those five years are discounted and added tofuture energy savings (residual value). However, the computed results depend heavily on residual value (exit yield), which reflects a possible price increase per m2 for a very low-energy dwelling.

On the other hand, we can also foresee that time can have a negative impact on a building and some essential elements of the building envelope (e.g. windows) and installation (HVAC) might require renovation or replacement, which means that in order to draw further benefit from energy savings new investment might be needed. Therefore, in calculating energy-saving costs over a longer period (30 years), the residual value (exit

yield) is considered to be equal to 0. Thus, the longer calculation period focuses only on potential cost/energy savings.

Discount rate and risk

The calculations were performed on real prices. The discount rate in the base-case scenario was based on a nominal ten-year fixed mortgage rate in 2011, which was approx. 4%, while the Swedish inflation target is 2% (www.riksbank.se). Consequently, the real discount rate for the household was assumed to be 2%. The base-case scenario assumes that the customer is risk-neutral; however, because the residual value reflects a potential price increase per m2 of a very low-energy building, we add a market risk factor calculated at 3% (Adair and Hutchison, 2005; Hutchison et al., 2005; Hordijk and Van de Ridder, 2005) and assume that the exit yield is 5%.

Price assumptions

The analysis focuses only on profitability of investment if purchasing a very-low-energy apartment, because, in the case of rental apartments in Sweden, the rental fee is a result of collective bargaining between municipal housing companies and local tenants' unions and does not reflect quality factors, but rather relates to building location, size and construction year (Lind, 2012).

The presumed price in this exercise is an approximation for the average square meter price for one square meter of apartment in a newly constructed building in Sweden. In reality, the property price may vary significantly depending on various factors such as size of the city, location (ex. suburbs, city center), building quality, dwelling size and apartment design. The main assumptions are presented in table 10.

Table 10. Calculation assumptions.

Dwelling price and WTP	
average price for m2 dwelling in newly constructed building (2011) [EUR/m2]	3300
willingness to pay for m2 low-energy building	5%
willingness to pay 5% purchase price [EUR/m2]	165
Energy requirement	
conventional building space heating (BBR18), Sweden-south [kWh/m2 per year] district heating	110
passive house building space heating (FEBY 2009), Sweden-south [kWh/m2 per year] district heating	50
conventional building space heating (BBR18), Sweden-south [kWh/m2 per year] electric heating	55
Passive house building space heating (FEBY 2009), Sweden-south [kWh/m2 per year] electric heating	30
Energy prices	
domestic heating prices (average 2011) [EUR/kWh]	0.11
electricity heating prices (average 2011) [EUR/kWh]	0.14
Investment assumptions	
calculation period	
short	5 years
long	30 years
real interest rate	2%

Results

Building regulations for electrically heated buildings are stricter than for those with district heating and consequently the difference between passive house standard and conventional building is relatively small, which reflects on the energy-saving costs. The results (table 11) indicate that energy savings in building with electric heating will not recoup an investment higher than 90 EUR/m2, which is 3% at assumed dwelling prices. On the other hand, the majority of dwellings in Sweden (approx. 70%) are heated by district heating, and in this case investing 5% seems to be a rational decision. The extra investment, 5% at assumed dwelling prices, which corresponds to 165 EUR/m2, is recouped by an energy-saving cost if district-heating prices were to increase annually by 1% over inflation. Annual energy savings for an average dwelling of 75m2 in a building with electric heating could reach about 250 EUR and in a building with district heating about 480 EUR.

Table 11. Present value of energy cost savings for short period of 5 years, including exit yield, for risk-neutral customer, discount rate 2%.

Annual energy increase*	0%	1%	2%	3%	4%	5%
Energy cost savings (PV) building with district heating EUR/m2	163	169	175	182	188	195
Energy cost savings (PV) building with electric heating EUR/m2	87	90	93	96	100	103
Stated willingness to pay 5%					165 EUR/m2	

Table 12. Present value of energy cost savings for long period of 30 years for risk-neutral customer, discount rate 2%

Annual energy increase	0%	1%	2%	3%	4%	5%
Energy cost savings (PV) building with district heating	148	169	194	224	261	305
Energy cost savings (PV) building with electric heating	78	90	103	119	138	162
Stated willingness to pay 5%					165 EUR/m2	

*increase in energy prices is calculated only for 5 years, the assumption being that there is no growth in energy prices for years 6 and onward

If the customer is risk-neutral, the energy-cost saving depends mainly on presumed energy prices (table 12); however, there are reasons to believe that the customer is risk-averse. The customer may feel unsure about environmental benefits, may need to increase the mortgage to cover extra cost or consider allocating the premium in alternative purchase, and therefore require a higher investment return. Tables 13 and 14 present sensitivity analyses, where the discount rate is composed of the sum of the mortgage rate (2%) and the individual risk factor, and the exit yield consists of the sum of the mortgage rate (2%), the market risk (3%), and the individual risk. Since the difference in space heating requirements for very-low-energy (passive house standard) and conventional buildings with electric heating is relatively small and energy cost savings are also relatively low, the sensitivity analyses focus on buildings with district heating (table 13 and 14).

Table 11. Sensitivity analysis of energy cost savings for short period of 5 years, inclusive exit yield, for risk-averse customer

District heated buildings Relative energy price increase						
	0%	1%	2%	3%	4%	5%
individual risk						
0%	162	168	174	181	187	194
1%	140	145	150	156	161	167
2%	124	128	133	137	142	147
3%	123	127	132	136	141	146
4%	100	104	107	111	115	119

Table 12. Sensitivity analysis of energy cost savings for long period of 30 years for risk-averse customer

District heated buildings Relative energy price increase*						
	0%	1%	2%	3%	4%	5%
individual risk						
0%	148	169	194	224	261	305
1%	129	147	167	192	222	258
2%	114	129	146	166	190	219
3%	101	114	128	145	165	189
4%	91	101	113	127	144	163

*increase in energy prices is calculated only for 5 years, the assumption being that there is no growth in energy prices for years 6 and onward

Even though the attractiveness of the investment in a very low-energy building decreases if the customer is risk-averse, the results suggest that the respondents' stated willingness to pay approximately 5% extra for low-energy buildings is a rational investment decision, particularly when the difference between the energy performance of conventional and low-energy buildings is relatively large. This applies to district-heated buildings, but if a customer chooses to live in an electrically heated building, the financial benefits from energy savings are not as high; therefore the 5% extra investment in low-energy building based only on potential energy-cost savings is not justified.

4. Conclusions

The results from a survey among 477 occupants of green and conventional buildings were used to study stated WTP for apartments in low-energy and environmentally labeled buildings. It was shown that occupants in green buildings are generally more willing to pay extra for such buildings; however, respondents stated different willingness to pay for

low-energy buildings and buildings with environmental certification. Lower willingness to pay for buildings with an environmental certificate might be explained by the fact that occupants are not convinced that environmental certification translates into higher value. The results send an important signal to the industry, indicating that unless building environmental performance is taken into consideration in the valuation process, the value of certifying residential buildings can be questioned. Customers are willing to pay a premium for features they understand and can see the potential benefits of, in terms of low-energy consumption, for example. Additionally, since the environmental benefits are not observable directly and even questioned by earlier research, the customer may have reservations about environmentally profiled buildings. Customer sceptism may be reflected in the perception of a higher investment risk and lower willingness to pay.

The stated willingness to pay for low-energy buildings was found to be a rational investment decision, particularly when the difference in energy performance between conventional and very low-energy buildings is relatively large. The changes in building regulations with regard to the energy performance of buildings reduce the performance gap between conventional and low-energy buildings and consequently decrease the attractiveness of investing in low-energy buildings. Furthermore, stricter energy performance requirements for buildings are expected to result in the conventional and low-energy building markets being merged. Consequently, environmental building assessment may become a more apparent way to communicate green benefits to the customer. This emphasizes the importance of environmental education, information quality and practical denotation of building environmental assessment for customers.

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References

Adair, A. and Hutchison, N., The reporting of risk in real estate appraisal property risk scoring, *Journal of Property Investment and Finance*, 2005 23: 3, 254-268

Addae-Dapaah K and Su Jen Chie, Green mark certification: does the market understand? *Journal of Sustainable Real Estate* 2011, 3:1, 164-191

Atterhög, M. and Lind, H. How does increased competition on the housing market affect rents? An empirical study concerning Sweden. *Housing studies*, 2004, 19(1), 107-123

Banfi S., Farsi M., Filippini M., and Jakob M., Willingness to Pay for Energy-Saving Measures in Residential Buildings. *Energy Economics,* 2008*,* 30:2, 503-16.

Bloom B., Nobe M and Nobe M., 2011, Valuing green home designs: A study of ENERGY STAR Homes. *Journal of Sustainable Real Estate*, 2011, 3:1, 109-126

Blumenschein, Karen, Glenn C. Blomquist, Magnus Johannesson, Nancy Horn, and Patricia Freeman. Eliciting Willingness to Pay Without Bias: Evidence from a Field Experiment, *The Economic Journal*, 2008, 118, no. 525: 114-137.

Bohm P. and Lind H., Policy evaluation quality. A quasi-experimental study of regional employment subsidies in Sweden. *Regional Science and Urban Economics,* 1993, 23, 51-65

Borooah V.K. Logit and probit: ordered and multinominal models. Sage University Paper Series on Quantitative Applications in the Social Science, 07-138. Thousand Oaks, CA: Sage 2001

Boverket. Regelsamling för byggande, BBR; 2009; Supplement fabruari 2009; 9 Energihushållning, Boverket, Karlskrona, Sweden, 2009

Brounen D. and Kok N., On the economics of energy labels in the housing market. *Journal of Environmental Economics and Management,* 2011, 62, 166-179

Carson, Richard T. Contingent valuation: a user's guide. *Environmental science & technology* , 2000, 34, no. 8: 1413-1418.

Carson, Richard T. Contingent Valuation: A Practical Alternative When Prices Aren't Available. *Journal of Economic Perspectives*, 2012, 26(4): 27-42.

Cummings, R.G., and Taylor L. Unbiased value estimates for environmental goods: a cheap talk design for the contingent valuation method. *The American Economic Review* , 1999, 89 (3): 649-665.

Dermisi S., Effect of LEED Ratings and Levels on office property assessed and market values. *Journal of Sustainable Real Estate,* 2009, 1:1, 23-47

Diamond, P. and Hausman J. Contingent Valuation: Is Some Number Better than No Number? *Journal of Economic Perspectives*, 1994, 8(4): 45-64.

Eichholtz, P., Kok, N., and Quigley, J., Doing well by doing good? Green office buildings. *American Economic Review* , 2010a 100, 2494-2511

Eichholtz, P., Kok, N., and Quigley, J., The economics of green building. 2010b available at: http://escholarship.org/uc/item/3k16p2rj (accessed 09 12 2010).

European Parliament and Council, Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast). Official Journal of the European Union, L153/13. 2010

Forum for Energieffektiva Byggnader, FEBY. , 2009; FEBY Kravspecification för passivhus. FEBY, City, Sweden, 2009

Fuerst F. and McAllister P., Green Noise or Green Value? Measuring the Effects of Environmental Certification on Office Values. *Real Estate Economics,* 2011a, 39, 45-69

Fuerst F. and McAllister P., Eco-labeling in commercial office markets: Do LEED and Energy Star offices obtain multiple premiums? *Ecological Economics*, 2011b, 70:6, 1220-1230

Hanemann, W. M. Valuing the Environment through Contingent Valuation. *Journal of Economic Perspectives*, 1994, 8(4): 19-43.

Hausman, J. Contingent Valuation: From Dubious to Hopeless. *Journal of Economic Perspectives*, 2012, 26(4): 43-56.

Hutchison, N., Adair, A. and Leheny, I., Communicating investment risk to clients: property risk scoring. *Journal of Property Research,* 2005, 22 (2-3): 137-161

Hordijk, A. and Van de Ridder, W., Valuation model uniformity and consistency in real estate indices, The case of The Netherland. *Journal of Property Investment and Finance*, 2005, 23:2, 165-181

Kahneman, D.and Knetsch, J. L. Valuing public goods: the purchase of moral satisfaction. *Journal of environmental economics and management*, 1992, 22(1), 57-70.

Kling, C., L., Phaneuf D.J., and Jinhua Zhao. (2012) From Exxon to BP: Has Some Number Become Better Than No Number?; *Journal of Economic Perspectives*, 26(4): 3-26.

Kok, N. and Jennen, M., The impact of energy labels and accessibility on office rents. *Energy Policy,* 2012, 46, 489-497

Kwak, S. Y., S. H. Yoo, and S. J. Kwak., Valuing Energy-Saving Measures in Residential Buildings: A Choice Experiment Study. *Energy Policy,* 2010, 38(1): 673-77.

Lind, H. Pricing principles and incentives for energy efficiency investments in multi-family rental housing: The case of Sweden. *Energy Policy* 2012, 49, 528-530

Mandel S. and Wilhelmsson M., Willingness to pay for sustainable housing. *Journal of Housing Research,* 2011,20(1): 35-51

Murphy,J., and Stevens T. Contingent valuation, hypothetical bias, and experimental economics. *Agricultural and Resource Economics Review,* 2004, 33(2): 182-192.

Ott, W., Baur, M., Jakob, M., Direkte und indirekte Zusatznutzen bei energie-effizienten Wohnbauten (Direct and indirect additional benefits of energy efficiency in residential buildings); publication 260001; Study by Econcept and CEPE ETH Zurich on Behalf of the Research Programme EWG (www.ewg-bfe.ch) of the Swiss Federal Office of Energy, Bern. 2006.

Portney, P.R. The Contingent Valuation Debate: Why Economists Should Care. *Journal of Economic Perspectives*, 1994, 8(4): 3-17.

Schwarz, N. and Oyserman D. Asking Questions About Behavior: Cognition, Communication, and Questionnaire Construction. *American Journal of Evaluation* 2001, 22(2): 127-160.

Zalejska-Jonsson A., Lind H. and Hintze S. Low-energy versus conventional residential buildings: cost and profit. *Journal of European Real Estate Research,* 2012, 5(3), 211 – 228

Zalejska-Jonsson A. Impact of energy and environmental factors on decision of purchasing or renting an apartments: case of Sweden. *Working Paper, Department of Real Estate and Construction Management, KTH Royal Institute of Technology* 2013

[i] According to voluntary Swedish passive house standard (FEBY 2009) calculated space heating for residential buildings should not exceed 30 KWh/m2 annually for buildings with electric heating and 50 kWh/m2 annually for building with district heating. Space heating in comparable residential conventional building, understood here as building that fulfils current Swedish Building regulations, was 55 kWh/m2 annually for buildings with electric heating and 110 kWh/m2 annually for building with district heating.