WAIKATO WARM HOME STUDY

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ABSTRACT

New Zealand houses are cold, damp, and poorly insulated by international standards. Our substandard housing stock has negative effects on health, quality of life, productivity, winter air quality, energy use and transmission. Investment in home energy efficiency is below the socially optimal level due to information asymmetries, bounded rationality and to some degree, non-excludability. Uptake of government grants for insulation has been very low in some communities, especially by owners of private rental properties. This study examines consumer preferences and perceptions of home energy efficiency technologies for residents of the Waikato region. We use a choice experiment approach to determine willingness to pay by owner-occupiers, landlords and tenants. Owner-occupiers are willing to pay significantly more than landlords for all features except for double-glazing. Tenants score their homes lower in terms of warmth and comfort than the landlord, and are willing to pay higher rent for improved insulation. However, the majority of tenants don't know what insulation their home already has. Solving this information asymmetry problem with home energy ratings may be a more efficient way to increase investment than larger subsidies for landlords.

CONTENTS

1 INTRODUCTION

There has been considerable publicity in recent years about the problem of cold, damp houses in New Zealand. This sub-standard housing stock has a wide range of implications for health, quality of life, productivity, energy use and transmission, and environmental effects such as air pollution from home heating. The current New Zealand building code has a range of minimum requirements designed to improve the thermal efficiency of modern housing. However, the majority of New Zealand housing stock was built before any insulation was mandatory, and is significantly less energy efficient.

Longitudinal studies have proven that retrofitting older houses with energy efficiency technologies can significantly improve thermal efficiency, reduce energy requirements, and improve comfort and health for the occupants. There is a large market for these energy efficiency technologies but the market is unable to deliver a socially optimum outcome without intervention.

2 OBJECTIVE

The purpose of this study is to investigate consumer perceptions and values for home energy efficiency technologies and relate this to consumer behaviour in the market for energy efficiency upgrades.

There has been a lot of research published about home energy efficiency in recent years. There is a lot of technical data available, and longitudinal studies measuring the effects of insulation upgrades. This study, however, examines the perceptions and willingness to pay of people who have not yet upgraded their homes. This is an issue for organisations looking to fund, promote, or deliver energy efficiency improvements. If the subsidy is too low, it will not be enough of an incentive for some households. If the subsidy is too high, it is an inefficient use of public money.

This study is focussed on Waikato communities because there is currently very little information specific to the Waikato region, especially smaller towns. Waikato organisations do not know how much further funding will be required, or how long it will take to upgrade all Waikato housing to 1978 energy efficiency standard.

The range of energy efficiency technologies in this study is limited to those which effect residential space heating efficiency and are possible to retrofit into existing homes. This includes ceiling and floor insulation and energy efficient heating, which are subsidised under the Warm Up New Zealand programme. Wall insulation and double glazing are also included although these are not yet subsidised. Thermal curtains are not included as they are relatively low cost, not very durable, and do not qualify for subsidies.

This study also investigates whether people are willing to pay for an independent home energy rating. Energy ratings are a useful signal which reduce information asymmetry and therefore reduce the "wedge" between social value and market value (Clinch & Healy, 2000). A home energy rating certificate is included in the choice experiment to determine if home owners are willing to pay to obtain an independent rating of their property.

With energy efficiency technologies, the consumer does not value the product *per se,* but values the associated energy savings, comfort, health, or environmental benefits. However, the benefits expected by the homeowner may be different to actual results obtained from technical testing and longitudinal studies published by BRANZ (2006, 2007, 2008) and others (Beacon Pathway, 2007, Lloyd et al, 2006, Howden-Chapman et al, 2007 & 2009). This study also investigates whether tenants are willing to pay higher rent for energy efficiency improvements to their rented home.

Evidence is examined in regard to the following hypotheses:

1. Average insulation levels are lower in small, remote communities than in city centres.

2. Tenants of private rental properties are less knowledgeable about the level of existing information in their home than the landlord.

3. Consumers have a lower perception of the benefits of insulation than is warranted from the results of product testing and longitudinal studies.

4. Owners of private rental properties have a lower willingness-to-pay for improvements than owner-occupiers.

3 BACKGROUND

New Zealand houses have a reputation for being cold and damp compared with other countries. Prior to 1978, there was no requirement for new houses to be insulated. It was estimated that 75% of existing houses in 1971 had no insulation. Aside from the fact that it wasn't mandatory, other reasons for this situation may include the temperate climate and relatively cheap, government-subsidised electricity (Lloyd, 2006).

In 1978 the building code was updated to make insulation mandatory, and again in 2000 when minimum standards were increased. The current code divides New Zealand into three climatic zones with higher standards for colder zones and also introduces standards for windows. There are no regulations requiring existing homes to be upgraded.

3.1 FUEL POVERTY AND HEALTH

New Zealand had the lowest space heating intensity of any OECD country in 1995, (Schipper et al, 2001). Many households maintain indoor temperatures below the World Health Organisation recommended minimum of 16 degrees. A household is in fuel poverty if it would need to spend more than 10% of household income on all fuels to achieve a satisfactory indoor environment. Lloyd (2006a) estimated that 10%-14% of New Zealand households experience fuel poverty but the proportion may be much higher in low-income or cold areas. Fuel poverty is commonly associated with housing tenure, building age and energy efficiency (Lloyd, 2006a, Clinch and Healy, 2004).

Living in cold, damp homes is known to have detrimental affects on health. These effects include physiological stress, respiratory illness and allergic reactions to mould. Longitudinal studies have shown that insulation and heating upgrades reduce hospital visits, absence from work or school, and improve self-rated health and comfort (Howden-Chapman et al, 2005, 2007).

3.2 ENERGY EFFICIENCY AND AIR QUALITY

Another characteristic of New Zealand households is that solid fuel is a significant source of space heating, equivalent to a 530MW power station "hiding in the woodshed" (BRANZ, 2006). While solid fuel provides an affordable energy source for many households, the emissions from home burners cause over 90% of winter air pollution. Health effects from this pollution range from minor nose and throat irritation to aggravation of respiratory and cardiovascular disease, increased hospital emissions, and premature death (Ministry for the Environment, 2003).

Home insulation upgrades simultaneously improve indoor environments and reduce air pollution by reducing the amount of fuel required to heat the home. Larger benefits are obtained by replacing old wood burners with modern, low-emission burners or heat-pumps.

3.3 RETROFIT PROGRAMMES AND STUDIES

In 1995, the Efficiency and Conservation Authority (EECA) and Building Research Association (BRANZ) established the Household Energy End-Use Project (HEEP) which monitored 400 houses over 10 years. HEEP collected detailed energy, temperature, social and physical house data on 400 houses around the country. The study provided a wealth of technical data and confirmed that post-1978 households are warmer and use less energy.

The National Energy Efficiency and Conservation Strategy released in 2004 outlined a goal of having all pre-1978 houses retrofitted with insulation by 2016. Results from the Housing Condition Survey of Auckland, Wellington and Christchurch (BRANZ, 2005) implied this would require upgrading an average 75,000 houses per year. This may seem like an ambitious target, but there are already an estimated 80,000 renovations occurring each year. The problem is that the majority of previous renovations were purely cosmetic, and didn’t improve energy efficiency.

EECA launched the Energywise home grants programme in 2004 with an initial target of upgrading 6000 low-income households. In 2009 this programme was expanded to include middle-income households, with an additional $243.7 million in funding and a new target of 60,500 homes per year (Brownlee, 2009). The clean heat grant project was also extended. Previously, households had to be in one of the worst ten airsheds in order to qualify for a heating appliance subsidy but this restriction no longer applies.

There have been longitudinal studies of state house upgrades and randomised trials to investigate energy savings (Lloyd, 2006b) and health impacts (Howden-Chapman et al 2007 & 2009)

3.4 BARRIERS TO IMPROVING ENERGY EFFICIENCY

Home energy efficiency improvements generally result in significant private benefits to the householder (Beacon Pathway, 2007). If the market was efficient then New Zealanders would have already upgraded their homes without any need for intervention.

Commonly reasons for market failure are information gaps and bounded rationality. A large proportion of householders may be unaware of the existence of benefits of energy saving technologies (Healy & Clinch, 2004). Sanstad and Howarth (1994) suggest that the average consumer is not only uninformed, but also has difficulty making correct choices when provided with full information about energy technologies. A fully rational consumer would need to solve complex optimisation and forecasting problems that are difficult even for experts.

Consumers tend to attach excessive weight to factors that are easily observed, such as turning lights off, when the actual savings are minimal. They may neglect to consider non-monetary benefits such as comfort and health. There are also information asymmetries between buyers and sellers of both energy efficiency technologies and houses. Visible property characteristics provide only limited potential for identifying relative energy efficiency, and the transaction costs of obtaining full information are high. Regulated minimum standards are a way to bypass problems with bounded rationality (Sanstad and Howarth, 1994).

Financial constraints are another barrier since the households most in need of improvements also tend to have lower incomes. The current EECA scheme addresses these issues by providing subsidies and facilitating low-cost loans from Councils, Banks, or electricity retailers.

Finally, there is the issue of market value. Only a small minority of house buyers and tenants check for insulation (NZBCSD, 2008). If potential buyers or tenants are not even aware of the investment then the owner is unlikely to receive an adequate return for it and under-investment is the result. This issue is most problematic for of rental properties, where the owner receives none of the energy savings or health or comfort benefits.

An independent home energy rating system could assist market recognition of conservation investments and energy efficient designs. There is an initiative underway by BRANZ, Beacon Pathway, and the NZ Green Business Council to develop a residential rating tool for both new and existing homes (Beacon Pathway, 2009). It is not known at this stage how much a rating certificate will cost, whether it will become mandatory, or how much people are willing to pay for such a rating.

4 METHOD

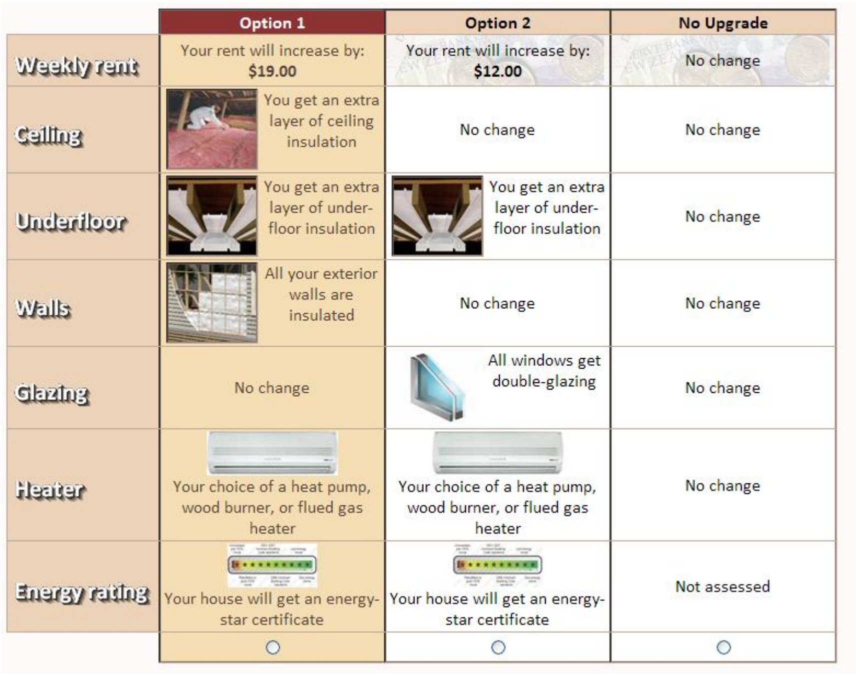
The method used for this study is a stated-preference non-market valuation technique called choice modelling. Although a market clearly already exists for energy-efficiency technologies, the focus is on consumers who have not yet purchased these products. These consumers presumably are unwilling or unable to pay the market price and therefore the market cannot be used to determine the value of the products to them. A survey is used to present people with a hypothetical situation and elicit a response indicating willingness to pay for that situation.

Choice experiments present people with a set of alternatives that differ among attributes. Participants are requested to identify their preferred alternative from those available in each choice task. Researchers can use the observed choice data to estimate a model of choice behaviour that allows estimation of marginal values for each feature or attribute (Bateman, 2002). A choice experiment is therefore well-suited to analysing trade-offs that consumers are willing to make between different home energy efficiency technologies, and cost.

Insulation and clean-heat upgrades are commonly sold as package deals, meaning that estimation of marginal values of each attribute would be difficult using actual market data. A choice experiment, on the other hand, allows the design of scenarios that avoid this collinearity problem.

4.1 EXPERIMENTAL DESIGN

The attributes for the choice experiment are a layer of ceiling insulation, a layer of floor insulation, insulation for all exterior walls, double-glazing for all windows, a heating appliance, a home energy star certificate, and cost - or change in rent for tenants (Figure 1).



	Option 1	Option 2	No Upgrade
Weekly rent	Your rent will increase by: $19.00	Your rent will increase by: $12.00	No change
Ceiling	You get an extra layer of ceiling insulation	No change	No change
Underfloor	You get an extra layer of under-floor insulation	You get an extra layer of under-floor insulation	No change
Walls	All your exterior walls are insulated	No change	No change
Glazing	No change	All windows get double-glazing	No change
Heater	Your choice of a heat pump, wood burner, or flued gas heater	Your choice of a heat pump, wood burner, or flued gas heater	No change
Energy rating	Your house will get an energy-star certificate	Your house will get an energy-star certificate	Not assessed
	○	○	○

Figure 1 - Example choice set for a tenant

Each energy efficiency attribute has two levels, it is either offered or not offered. This is known as an end-point design. There is evidence in the literature than end-point designs are more efficient than designs with more levels (Kanninen, 2002 & Hensher et al, 2005) because it is easy to differentiate between the levels and the cognitive burden for respondents is lower. Another reason for using an end-point design is that this is what insulation providers typically offer – a complete layer of insulation which meets minimum EECA standards. Glazing may be replaced piece-meal but for simplicity the all-or-nothing approach is used consistently.

The heating attribute combines all three types of EECA-approved heating appliance into one level. Respondents probably have different preferences for different types of heater, but this is irrelevant since each approved type is capable of providing adequate space heating for the main living area.

The configuration of the choice sets was optimised in order to efficiently obtain as much information as possible under a limited sample size. The criterion for efficiency used was the D-criterion, which seeks to maximise the determinant of the Fisher information matrix given *a-priori* information on the parameter vector. D-optimal designs are efficient under correct a-priori information and are also robust to some mis-specifications (Ferrini & Scarpa 2007). The initial priors used were typical market prices for each product (see section 5.7.8). Main effects and second-order interactions were included in the optimisation.

The design was produced using Ngene software, and subsequently revised with coefficients from the pilot test. The final design had four blocks of six choice sets, with three alternatives each. One of the alternatives was a zero-cost, status-quo option which is a common configuration (Ferrini & Scarpa, 2007 and Hensher et al, 2005). It is necessary to include a status quo option in order to achieve welfare measures that are consistent with demand theory. Otherwise, respondents are effectively forced to choose an alternative which they may not prefer to the current situation. The status-quo option has different meaning depending on the individual's experiences, an issue which is discussed further in section 5.7.1. The D-error of the final design was 17.2%.

4.2 SAMPLING AND DELIVERY

The survey was trialled by recruiting patrons of Hamilton City Library for a face-to-face interview where they completed the choice experiment in exchange for chocolate bars. Over sixty respondents were interviewed during this pilot. The experimental design was then updated using the pilot coefficient estimates.

The final survey was mailed to 6000 households in the Waikato region and recipients were able to fill it in online. The sample was spatially representative and stratified by urban area and census area-unit. All urban areas with at least 500 dwellings as at the 2006 census are included. This covers 90% of the Waikato population and all 22 gazetted airsheds as defined by Environment Waikato (Wilton, 2008 & 2009).

Respondents who owned a rental property were asked to complete the survey for their rental property. Tenants of rental properties were asked to fill in a different version of the choice experiment which specifies change in weekly rent as the price attribute, instead of installed cost.

A combination of contingent and non-contingent incentives was offered by including a cappuccino sachet with a letter and offering a $5 voucher for an online music retailer with every returned survey.

5 RESULTS

Seven hundred and sixty-eight surveys were returned for homes in the Waikato region. Hauraki district had the lowest response rate and Hamilton city, the highest. Fifteen percent of the sample live in Franklin or Thames-Coromandel, which are climate zone one with relatively mild winters. 75% live in zone two and 10% live in zone three, the central volcanic plateau.

5.1 SAMPLE DEMOGRAPHICS

5.1.1 HOME OWNERSHIP

A large portion of the Waikato respondents (80%) stated they own the home they live in, either directly or through a family trust. This is significantly higher than the 61% home ownership rate recorded by the 2006 census (Statistics NZ, 2006). 19% of sample live in privately owned rental properties, and 1% are Housing New Zealand tenants. 13% of respondents own a residential rental property.

The Housing New Zealand tenants are excluded from subsequent analysis; partly due to the small sample, and because Housing New Zealand has already retro-fitted all state housing with insulation.

5.1.2 HOUSEHOLD INCOME

The majority of respondents (82%) answered the question about household income. The average income for the sample is $63,860, or $1249 per week. This is lower than the official estimate of $1395 for the Waikato region (Statistics NZ, 2009), probably because the sampling method disproportionately favoured small towns. The average household income for owners of rental properties is $88,300, while the average for tenants is $51,300.

5.1.3 EDUCATION

People with higher education qualifications are over-represented in the sample. 36% of the sample have a bachelor degree or higher, compared with 11% of the Waikato region population.

5.2 SUBJECTIVE HOME COMFORT

Respondents answered a series of subjective questions about home comfort. Figure 2 shows that most owner-occupiers disagree with the statement that their living room is too cold in winter. Most landlords also disagree that the living room of their rental property is cold. However, most tenants state that their living room is in fact, cold. Tenants are also significantly more likely to agree that their bedrooms are cold, the house is damp, and expensive to heat.

These results suggest that property owners underestimate the burden of heating fuel cost on tenants. Research by Otago University (Lloyd, 2006) indicates that between 10-14% of New Zealand households are in fuel poverty. The incidence of fuel poverty in rented homes is probably higher due to lower average income.

A third of tenants state someone in the household has health problems which are exacerbated by cold, damp conditions. Only 10% of landlords say they have tenants with health problems, although a third state they do not know.

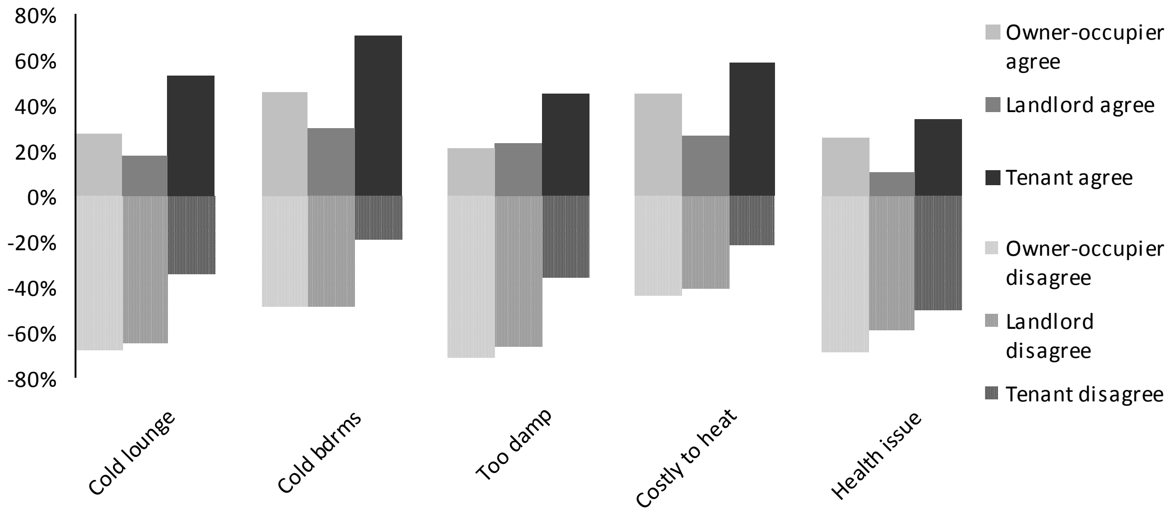


Figure 2 - Subjective home comfort

5.3 EXISTING INSULATION

Each respondent answered a series of questions about existing insulation, and age of the insulation, if known.

5.3.1 KNOWLEDGE OF INSULATION

Over 90% of owner-occupiers know whether they have ceiling or floor insulation. Landlords are slightly less likely to know.

Property owners are least likely to know whether they have wall insulation, probably because this is most difficult to verify. Owners of rental properties are less likely to know about wall insulation than owner-occupiers.

Tenants appear to be more confident about their knowledge of wall insulation than ceiling or floor insulation, an unexpected result. It is possible that tenants are simply guessing based on the age of the property. Almost all owners and tenants know whether or not they have double-glazed windows.

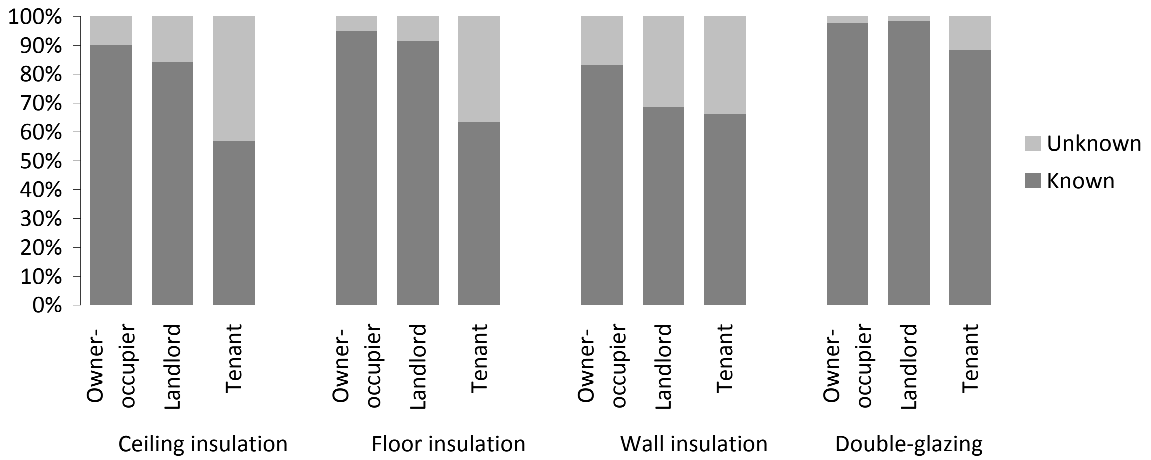


Figure 3 - Knowledge of existing insulation by tenure

5.3.2 PROPORTION OF RESPONDENTS WITH INSULATION

In 2005 there was a National House Condition Survey (BRANZ 2005), in which houses were inspected by qualified assessors. This study found that 94% of houses have at least some ceiling insulation, 30% have floor insulation, and 44% have wall insulation. The BRANZ sample only included Auckland, Christchurch, and Wellington. The Waikato region has an older average building age and lower household income than the BRANZ sample, so levels of insulation may well be lower. The following Figure 4 shows the results from Waikato respondents who know whether or not their home is insulated.

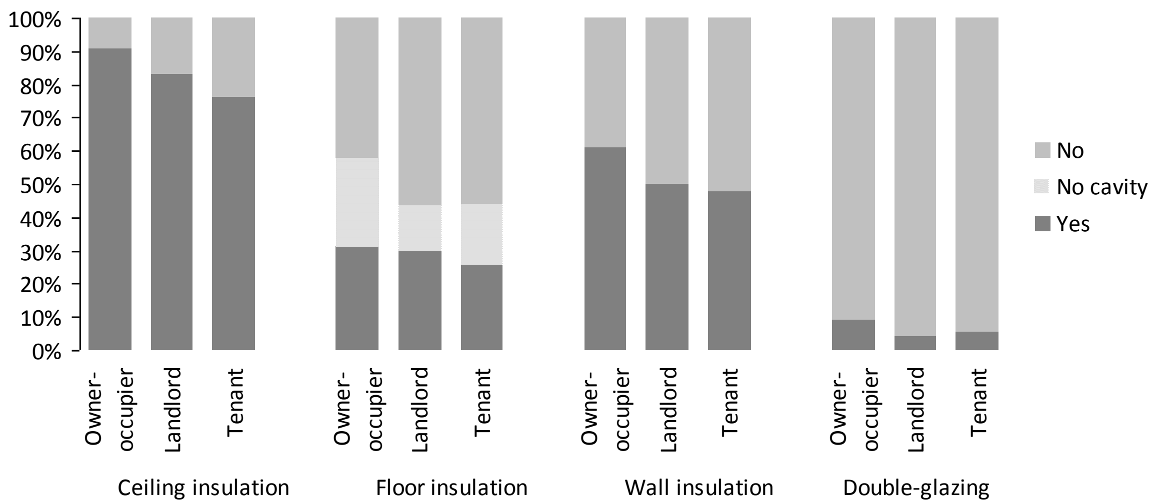


Figure 4 - Existing insulation by tenure - excluding unknown

Over 90% of owner-occupiers state they have at least some ceiling insulation but only 83% of landlords and 76% of tenants. A Waikato rental property is therefore twice as likely to have no ceiling insulation as an owner-occupied home. The difference between landlords and tenants may be due to under-estimation by the tenants.

Less than a third of respondents say they have under-floor insulation, similar to the BRANZ results. However, a significant proportion of modern homes have concrete slab floors that cannot be retro-fitted with insulation. The proportion of homes that require under-floor insulation is therefore 42% of owner-occupied homes and 56% of rental properties.

The proportion with wall insulation is higher than expected, considering the average age of the homes in the sample. In the Waikato sample, 90% of respondents with post-1980 houses and 43% with pre-1980 houses say they have wall insulation. However, BRANZ (2006) estimates that only 27% of pre-1978 houses have wall insulation so there may be significant measurement error in this variable.

Few respondents say they have double-glazed windows; 9% of owner-occupiers and 4%-5% for rental properties. With a couple of exceptions, the homes with double glazing were all built after 1990.

5.3.3 AGE OF INSULATION

Age of existing insulation is an important issue, because inspections show that most ceilings insulated in the 80s and 90s do not comply with modern thermal resistance standards (BRANZ, 2005). Floor insulation from the same period was predominantly reflective foil, which is not as effective as solid fill insulation. Wall insulation does not have the same issues because standards have not changed as much since 1978, and it is not as likely to be disturbed or damaged.

A house becomes eligible for an EECA-subsidised insulation top-up if the existing ceiling or floor insulation is more than 10 years old. Existing ceiling and floor insulation less than 10 years old is therefore defined as "adequate" for the purposes of this study, and anything older is "inadequate". A concrete floor slab also counts as "adequate" floor insulation.

Figure 5 shows the age breakdown of reported ceiling and floor insulation by Waikato respondents. Less than half of existing ceiling insulation is less than 10 years old. If we assume that owners who do not know about their insulation are very unlikely to have installed it recently, then just 37% of owner-occupied homes and 30% of rentals have adequate ceiling insulation in the Waikato region. For under-floor insulation, the proportions are 45% and 30%.

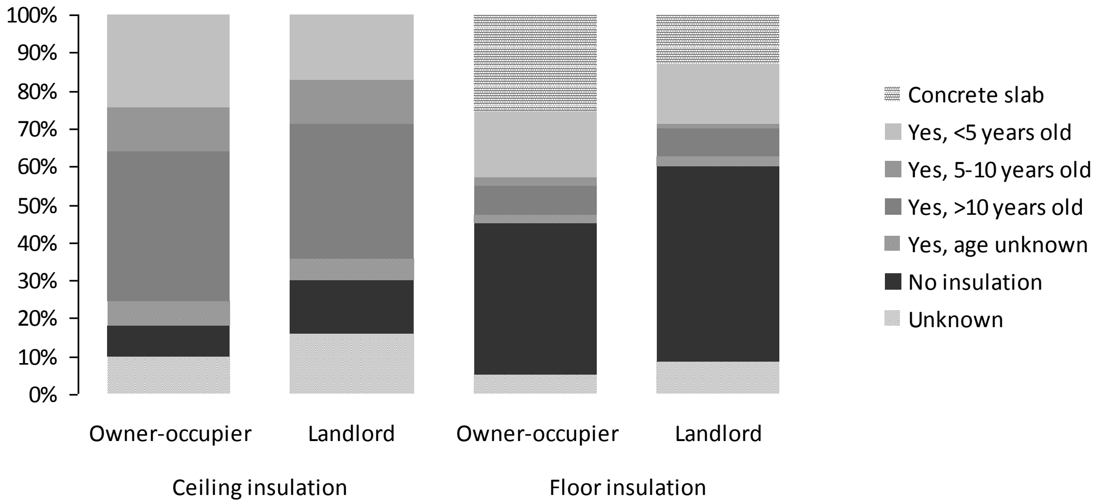


Figure 5 – Existence and age of ceiling insulation by ownership type

5.4 REGRESSION ANALYSIS OF EXISTING INSULATION

Probit regressions are used to determine which variables are correlated with having adequate ceiling and floor insulation. Results are reported in appendix 8.1. Tenant responses are not used due to the large proportion of "do not know" responses.

Building age dummy variables are highly significant and have the largest impact on the predicted probability of a house having adequate insulation. This is consistent with inspection results reported by BRANZ (2005 & 2007). Household income has a small and barely significant correlation with adequate insulation. Variables found not to be significant include respondent age, the presence of children in the home, respondent education level, length of time owning the home, how long the respondent expects to own the home, climate zone, location variables (city versus small town, inland versus coastal).

Table 1 shows the predicted probability of adequate ceiling insulation for different income levels and building ages. This table shows that the effect of income on the predicted probability is small compared with the effect of building age.

Table 1 - Predicted probability of adequate ceiling insulation for owner-occupied homes

Owner income	Post 2000	1950-2000	Pre 1950
<$60k	100%	38%	69%
$60-100k	100%	21%	50%
$100-120k	100%	32%	63%
>$150k	100%	39%	69%

Different towns in the Waikato sample have varying levels of insulation. These differences can be explained by home ownership rates, building age, and incomes. There is no evidence of location-specific effects within the region, although sample sizes are small.

5.5 UPGRADE PLANS

Almost half of owner-occupiers with inadequate insulation plan to upgrade, and a quarter plan to do so within a year. The proportion of landlords who plan to upgrade is lower, with only 15% planning to upgrade within the next year. This result is consistent with a national survey conducted by the New Zealand Business Council for Sustainability (NZBCSD, 2009), which reported that 28% of home owners plan to apply for a government insulation grant. The Warm Up New Zealand programme has significantly accelerated the rate of insulation upgrades (Rotmann, 2010).

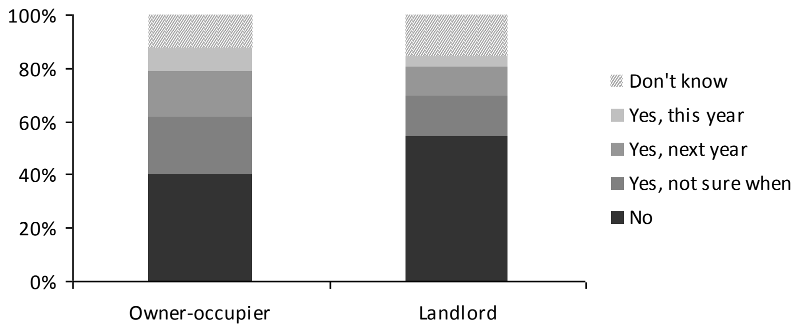


Figure 6 - Whether owners with inadequate insulation plan to upgrade

Respondents who answered “no” to the upgrade question were asked to provide reasons for not wanting to upgrade. Table 2 shows the most common reasons given by owner-occupiers and landlords. The most common reason cited is that the current insulation and heating is already good enough. This is an interesting response because the respondents' answers to the insulation questions suggest that these homes are very unlikely to meet modern thermal efficiency standards. This similar to findings by Healy and Clinch (2004), who reported that over half of households in Ireland are unaware of the benefits of energy-saving measures.

The second most common reason cited is financial constraints. A quarter of owner-occupiers and a fifth of landlords say that they cannot afford to upgrade the insulation or heating in their property. Small numbers of respondents give other reasons for not upgrading, such as difficulty, lack of time, or lack of knowledge.

Table 2 - Owner reasons for not upgrading

Reason	Owner-occupier	Landlord
Already good enough	60%	47%
Cost	25%	21%
Bad investment	6%	6%
Too difficult	6%	3%
Too busy	3%	6%
Selling soon	2%	5%
Lack of knowledge	1%	3%

Tenants with inadequate insulation are asked if they have requested an upgrade from their landlord, or if landlord, or if not, why not. The results are reported in

Table 3. Only 18% have already asked their landlord for insulation or heating upgrades. A quarter of respondents do not know or do not want to specify why they have not asked for an upgrade. A quarter of tenants do not want to ask because they expect it would be accompanied by a rent increase. Some (16%) believe the insulation is already good enough, a much lower proportion than among owners. A large proportion of tenants either have no contact with their landlord, do not want to ask, or do not know what to ask *for*.

Table 3 - Tenant reasons for not asking landlord for an upgrade

Reason	Tenants
Do not know	27%
Rent would increase	24%
Already good enough	16%
Do not want to ask	13%
Lack of knowledge	11%
Landlord would say no	9%
No contact with landlord	8%

5.6 PERCEPTION OF BENEFITS FROM UPGRADES

Respondents were asked to imagine their home is fully insulated with double glazing and an efficient new heating appliance, and then think about the potential benefits in terms of heating costs, comfort, and health. Figure 7 shows that the most common expectation for owner-occupiers is energy savings of less than $50 per month. Tenants expect to save more on average.

Actual savings from improving energy efficiency depend on the previous level of insulation and the level of take back of energy savings for higher indoor temperatures. Lloyd and Callau (2009) report that a typical fully insulated (including double glazing) standalone house in zone 2 requires 1200KWh per year for space heating to maintain a healthy indoor temperature. A home with only ceiling and floor insulation (and thermal curtains) requires 6000KWh. An un-insulated house requires 10,500KWh. Full insulation result in annual savings in the order of $1000-$2000. However, most New Zealand homes are not heated to recommended temperatures so the true savings are unlikely to be this high.

Longitudinal studies have reported savings of 9-14% (Lloyd and Callau, 2006) or $1060 per year (Howden-Chapman, 2004) for ceiling and wall insulation upgrades. There are no longitudinal studies for wall insulation or double glazing but the savings should be at least as high again. Respondents may be under-estimating the benefits of full insulation, but this is difficult to determine without knowing current energy usage.

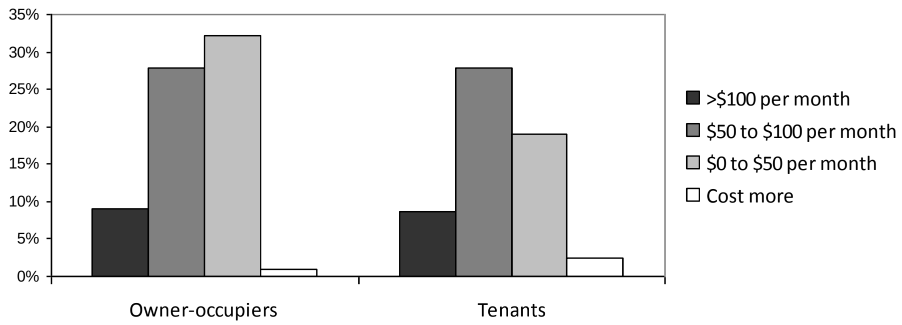


Figure 7 - Expected savings on winter heating costs

Stoecklein et al (2005) reported that most people place a higher value on "lifestyle benefits" from energy efficiency features rather than energy savings. Figure 8 shows that most respondents, especially tenants, believe that completely upgrading their home would make it "a lot more comfortable". This variable is highly correlated with WTP for all attributes, consistent with Stoecklein's findings. The answers for energy savings and health effects, on the other hand, are not statistically significant explanatory variables for WTP.

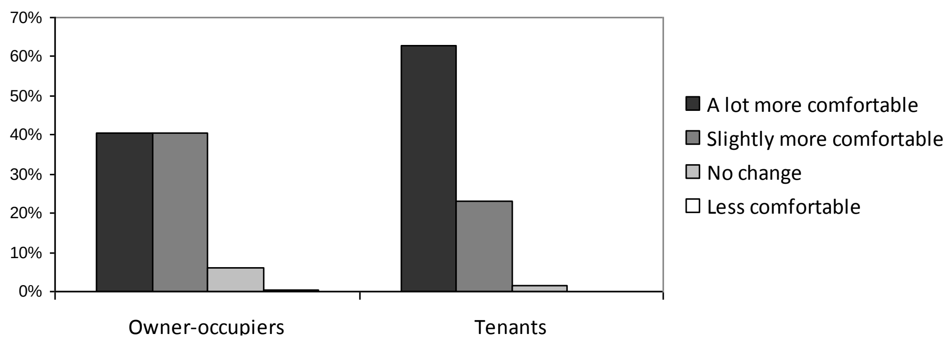


Figure 8 - Expected effect on comfort

Figure 9 shows that half of owner-occupiers and 70% of tenants believe there would be at least a small improvement in their health if their home was fully insulated. There is evidence to support this expectation from a randomised, controlled study reported in Chapman and Howden-Chapman (2004).

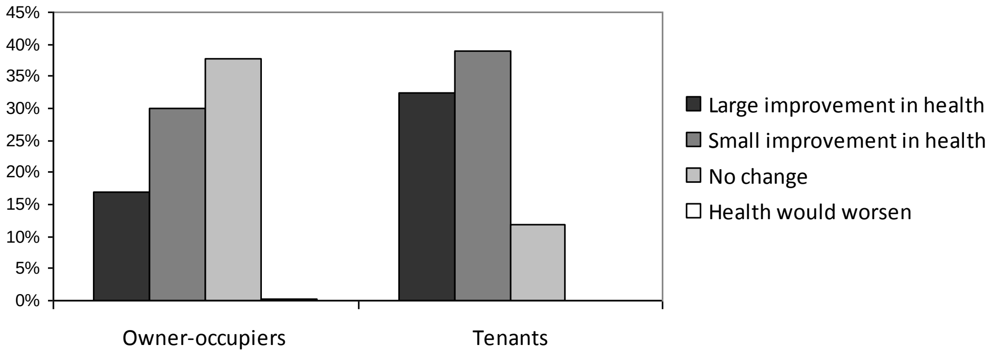


Figure 9 - Expected benefit to health

5.7 CHOICE EXPERIMENT RESULTS

5.7.1 MODEL SPECIFICATION

Each respondent in the sample has a different set of experiences with home energy efficiency, and different levels of existing insulation. Framing the decision of the choice task within the current situation of the respondent makes it more meaningful to the individual (Rose, Bliemer, Hensher, & Collins, 2008). The choice sets are therefore constructed to offer an additional layer of ceiling and floor insulation, replacement wall insulation, replacement double-glazing, and an additional fixed heating appliance; to allow for respondents who already have these features.

The observed component of individual utility is assumed to be a linear, additive function of the attributes. However, these attributes have different embedded meaning for respondents with or without existing insulation and heating. The gain in utility from the first layer of insulation is expected to be higher than for additional or replacement insulation. The utility function therefore has split parameters for adequate versus inadequate existing insulation and heat. The utility gained by individual *n* with *j* alternatives is represented as:

$$\begin{aligned} U_{jn} &= \beta_{ceil} ceil_{jn} + \beta_{floor} floor_{jn} + \beta_{wall} wall_{jn} + \beta_{dg} dg_{jn} + \beta_{heat} heat_{jn} + \beta_{ceil*} ceil^{*}_{jn} \\ &+ \beta_{floor*} floor^{*}_{jn} + \beta_{wall*} wall^{*}_{jn} + \beta_{dg*} dg^{*}_{jn} + \beta_{heat*} heat^{*}_{jn} + \beta_{cert} cert_{jn} + \beta_{sq} sq_{jn} + \varepsilon_{n} \end{aligned} \quad (1)$$

where ε represents unobserved factors that affect U. The elements of β reveal how important each attribute is the individual. The probability that respondent *n* would choose alternative *j* is therefore:

$$P_{njk} = \frac{e^{\mu\beta' x_{jk}}}{\sum_{j=1}^{J} e^{\mu\beta' x_{jk}}} \qquad (2)$$

5.7.2 MULTINOMIAL LOGIT MODEL RESULTS

The standard multinomial logit (MNL) specification is used as a starting point for analysing the choice the choice experiment results.

Table 4 presents the results for owner-occupiers, landlords, and tenants. For property owners, the price attribute is the cost to them of an upgrade, after any subsidies. For tenants, the price is an increase in weekly rent. The coefficient of negative price is the expected sign and highly significant for all owner-occupiers and tenants but is the wrong sign and insignificant for landlords. This problem disappears when heterogeneity is allowed for (see the following section 5.7.3)

The ceiling attribute is separated for no existing ceiling insulation, inadequate ceiling insulation (older than 10 years), or adequate ceiling insulation. Unknown insulation is included in the "no" attribute. A separate variable was tested for "unknown" but the coefficient was very similar to the "no".

The ceiling parameter estimate for owner-occupiers with no or unknown existing insulation is higher than for those with inadequate insulation, as expected. Insulation top-ups are beneficial for houses with existing insulation, but more so for houses with none (BRANZ, 2006 &

2007). The parameter estimate for owner-occupiers with adequate insulation is unexpectedly negative, rather than low and positive.

In the landlord model, only the parameter for ceiling insulation with existing inadequate insulation was significant at 10%, probably due to the smaller sample size. For tenants, the parameter with inadequate ceiling insulation is higher than adequate, as expected. The parameter for no existing insulation is negative, but not significant.

There are too few responses for existing floor insulation older than 10 years, so this variable is split into yes or no/unknown rather than three categories as with ceiling insulation. For each group the parameter for none/unknown insulation is higher than for existing insulation. Wall insulation and double glazing are similarly split between yes and no/unknown for existing measures. The heater parameter is split between those who already have a heat pump, burner or flued gas heater ("adequate") and those who do not ("inadequate"). A parameter for existing heat pumps was also tested but found to be less significant.

Parameters for attributes that the respondent already possesses are expected to be insignificantly different from zero, due to diminishing returns or the physical impossibility of squeezing more insulation into an already-insulated cavity. There is some evidence that some coefficients may not in fact be zero, for example owner-occupiers with existing floor insulation, double-glazing or heating. This could reflect a of perceived loss of value due to aging or wear and tear of existing items.

The parameters estimates for home energy star ratings are positive and significant for all groups, though small relative to other attributes.

The status quo parameter is positive for all three groups, but only statistically significant for owner-occupiers and landlords. This status quo effect may be due to transaction costs involved in upgrading such as finding a provider, applying for a grant or finance, and organising installation.

The model fit for landlords is much better than for owner-occupiers and tenants, with a pseudo r-square of 0.16 compared with 0.07 and 0.05.

Table 4 - Multinomial logit estimates

Attribute	Existing level	Owner-occupier Coefficient	Z	Landlord Coefficient	Z	Tenant Coefficient	Z
Negative price ($000s for owners)		0.35	9.96	-0.17	-0.34	0.04	3.33
Ceiling insulation	No/Unknown	0.36	2.94	0.10	0.36	-0.05	-0.25
Ceiling insulation	Inadequate	0.22	2.34	0.42	1.93	0.60	2.61
Ceiling insulation	Adequate	-0.42	-3.02	0.21	0.80	0.54	2.11
Floor insulation	No/Unknown	0.95	12.47	1.19	6.46	0.80	5.90
Floor insulation	Yes	0.19	2.53	-0.32	-1.41	0.53	3.01
Wall insulation	No/Unknown	0.60	6.42	0.56	2.79	0.41	2.37
Wall insulation	Yes	0.14	1.55	-0.08	-0.32	-0.20	-0.92
Double glazing	No/Unknown	1.01	11.66	1.46	7.06	0.42	2.39
Double glazing	Yes	0.56	3.41	-1.45	-1.38	0.56	1.64
Heater	Inadequate	1.20	5.73	0.99	0.80	-0.10	-0.45
Heater	Adequate	0.60	3.56	2.10	1.82	0.22	0.73
Energy Star rating	No	0.25	4.79	0.35	2.41	0.32	3.02
Status quo		0.45	4.63	2.08	7.10	0.29	1.45
Log-likelihood			-3008.480		-451.94		-738.886
Psuedo-R2			.0686		.1638		.05005
Individuals			490		82		118

5.7.3 RANDOM PARAMETERS LOGIT

The fixed coefficients in the MNL model assume that all respondents have similar preferences, after accounting for observable characteristics. In practice however, there is a generally a lot of heterogeneity which cannot be accounted for using observable characteristics (Fosgerau & Bielaire, 2007). Failure to account for variation can also cause a bias in MNL estimates (Hess & Axhausen, 2005).

This is where the random parameters logit (RPL) model becomes useful by allowing the parameters of the utility function to vary by individual. RPL models have been used recently in several environmental economics applications including renewable energy (Scarpa & Willis, 2010), protection of natural resources (Hoyos et al, 2009), and rural landscape improvements (Campbell, Hutchinson and Scarpa, 2009).

It is not unusual in RPL models for the price coefficient to be fixed, assuming a constant marginal utility of money (Hoyos, 2010). However, this also assumes the standard deviation of unobserved utility (the scale parameter) is the same for all observations. A variation in scale would erroneously translate into variation in willingness-to-pay (WTP). For this reason it is desirable to allow the price coefficient to vary as well.

An important issue is the choice of population distribution for the random parameters. Inappropriate choice of distribution may lead to bias or counter-intuitive signs in the estimated parameters (Fosgerau & Bielaire, 2007). Normal and lognormal distributions are commonly used in RPL modelling. The log-normal distribution is typically used where there is an *a priori* assumption that negative values do not exist in the population. However, the lognormal distribution can cause problems with long tails. Hess and Axhausen (2005) and Hoyos (2009) advocate using triangular distributions for this reason.

Hess and Axhausen (2005) also find that the uniform distribution might be a more appropriate choice in the initial search for random taste variation, as it has a lower risk of misspecification than less flexible distributions. The ideal distribution mix would signal the presence of a non-zero probability of a coefficient of the wrong sign, with minimal risk of the effect being caused by the distribution itself.

5.7.4 DISTRIBUTIONAL ASSUMPTIONS

A range of distribution mixtures were tested using the same attributes from the MNL models in

Table 4. The distributions used in the final model are constrained triangular for negative price, and uniform for all other attributes. There is *a priori* reason to believe the coefficient on negative price should always be positive, and the triangular distribution avoids the "fat tails" problem discussed by Hess and Axhausen (2005) and Hoyos (2009). These authors recommended a flexible uniform distribution for other attributes, and this did have the advantage of improved goodness-of-fit and lower variance than any other mix of distributions for this study.

5.7.5 RANDOM PARAMETERS LOGIT RESULTS

The results from the RPL model are presented in Table 5, below. The utility specification is the same as for the MNL model, except that parameter estimates vary by individual. The results show a significant improvement in goodness-of-fit compared with the MNL, particularly the model for tenants. The pseudo r-square for tenants improved from 0.05 to 0.16.

The price coefficient is now significant for landlords, and the standard deviation is significant at less than 1% for all three groups. The means for ceiling insulation with no/unknown existing insulation are now significant for all three groups, but the standard deviations for landlords and tenants are not significantly different from zero. The coefficient on heater is now significant for landlords, but still insignificant for tenants.

Status quo is retained as a fixed parameter and is still insignificant for tenants. This may reflect the fact that it is the landlords, not the tenants, who would have to find and organise insulation products and providers.

Table 5 - Random parameters logit results

Attribute	Existing level	Measure	Owner-occupier Coefficient	Owner-occupier Z	Landlord Coefficient	Landlord Z	Tenant Coefficient	Tenant Z
Negative price ($000s for owners)		$\hat{\mu}$	0.81	12.35	2.24	7.22	0.18	6.27
		$\hat{\sigma}$	0.81	12.35	0.00	7.22	0.18	6.27
Ceiling insulation	None	$\hat{\mu}$	0.86	2.79	1.50	2.55	0.93	2.81
		$\hat{\sigma}$	3.45	6.04	0.16	0.15	0.22	0.20
Ceiling insulation	Inadequate	$\hat{\mu}$	0.56	3.17	1.15	2.78	1.39	2.81
		$\hat{\sigma}$	1.99	5.06	1.33	1.25	2.02	1.56
Ceiling insulation	Adequate	$\hat{\mu}$	-0.01	-0.06	0.20	0.42	1.56	1.86
		$\hat{\sigma}$	2.02	4.64	0.95	0.69	4.11	3.85
Floor insulation	No	$\hat{\mu}$	1.52	8.70	2.83	5.45	1.60	4.65
		$\hat{\sigma}$	2.90	10.14	5.54	5.43	3.44	5.34
Floor insulation	Yes	$\hat{\mu}$	0.06	0.34	-0.73	-1.98	0.81	1.58
		$\hat{\sigma}$	2.98	10.71	0.18	0.15	3.61	4.80
Wall insulation	No	$\hat{\mu}$	1.13	5.93	1.91	4.16	1.37	4.07
		$\hat{\sigma}$	2.95	9.69	2.76	3.69	2.80	5.12
Wall insulation	Yes	$\hat{\mu}$	0.24	1.30	0.33	0.67	0.49	1.07
		$\hat{\sigma}$	2.60	8.20	1.91	1.78	3.09	3.88
Double glazing	No	$\hat{\mu}$	1.95	11.53	5.22	9.77	1.77	5.20
		$\hat{\sigma}$	3.03	14.08	1.87	2.53	1.69	2.90
Double glazing	Yes	$\hat{\mu}$	0.80	1.66	-1.68	-0.83	2.00	2.33
		$\hat{\sigma}$	3.31	4.92	0.62	0.13	2.82	1.58
Heater	No fixed appliance	$\hat{\mu}$	2.58	3.53	5.70	2.94	0.29	0.74
		$\hat{\sigma}$	4.95	3.51	2.09	0.66	0.30	0.18
Heater	Heat pump/ burner/ flued gas	$\hat{\mu}$	1.86	2.48	5.47	2.30	1.69	1.54
		$\hat{\sigma}$	6.10	4.68	0.19	0.03	6.02	2.90
Energy Star rating	None	$\hat{\mu}$	0.52	5.42	0.84	2.67	0.71	3.21
		$\hat{\sigma}$	1.32	5.62	0.40	0.22	2.10	4.79
Status quo	N/A		0.43	2.99	1.27	2.36	-0.02	-0.05
Log-likelihood			-2564.89		-451.86		-723.32	
Psuedo-R2			.1240		.2501		.1612	
AIC			1.76		1.48		1.79	
BIC			1.82		170		1.96	

5.7.6 WILLINGNESS-TO-PAY FOR PROPERTY OWNERS

A summary of the WTP distributions for owner-occupiers and landlords is presented in Table 6 and **Error! Reference source not found.**. The distributions for existing floor insulation, wall insulation, and double glazing are not included because these coefficients are not statistically significant from zero.

The 5th percentile values include negative WTP amounts for several attributes. Theoretically all the attributes (where the existing level is inadequate) should be strictly positive; otherwise some consumers would pay to avoid insulation. However, using bounded distributions resulted in a very poor model fit.

The WTP for floor insulation is higher than for ceiling insulation, despite the fact that significantly more heat is lost through the ceiling and ceiling insulation has a shorter payback period (BRANZ, 2009). There could be a psychological component in which respondents want a warm floor under their feet.

The median WTP for landlords is lower than owner-occupiers for nearly every attribute. For ceiling insulation, landlord WTP is two-thirds of owner-occupier WTP. For floor insulation it is 44%, wall insulation 56%, and home energy rating 39%. Where the current heating is inadequate, landlord WTP is lower but the opposite is true when current heating is adequate. Perhaps the heating appliances in rental properties are older on average, and there is higher perceived value in replacing them with modern units. It should be noted that the landlords in the sample have higher household incomes than the owner-occupiers, a result which is probably true of the population as well.

For double-glazing the median WTP for landlords is slightly higher than owner-occupiers. Occupants would benefit more from ceiling or floor insulation upgrades (Beacon Pathway, 2007), but landlords and owner-occupiers are willing to pay more for double glazing. It is perhaps no coincidence that double-glazing is the most visible type of insulation, and the easiest to verify. Consumers attach excessive weight to factors that are easily observed (Sanstad and Howarth, 1994), so double-glazing may have the largest effect on perceived value of the property. Double-glazing is also the most expensive product in the list, which may be another reason why property owners attach a high value to it.

A home energy star rating has no effect on the energy efficiency of a home, but most respondents are nonetheless willing to pay to have one. Theoretically, an energy rating is valuable because of the information it provides, particularly when the existence of insulation is difficult to verify (NZBCSD, 2008b). However, there is no significant difference in WTP for owners who know what insulation they have, versus those who do not.

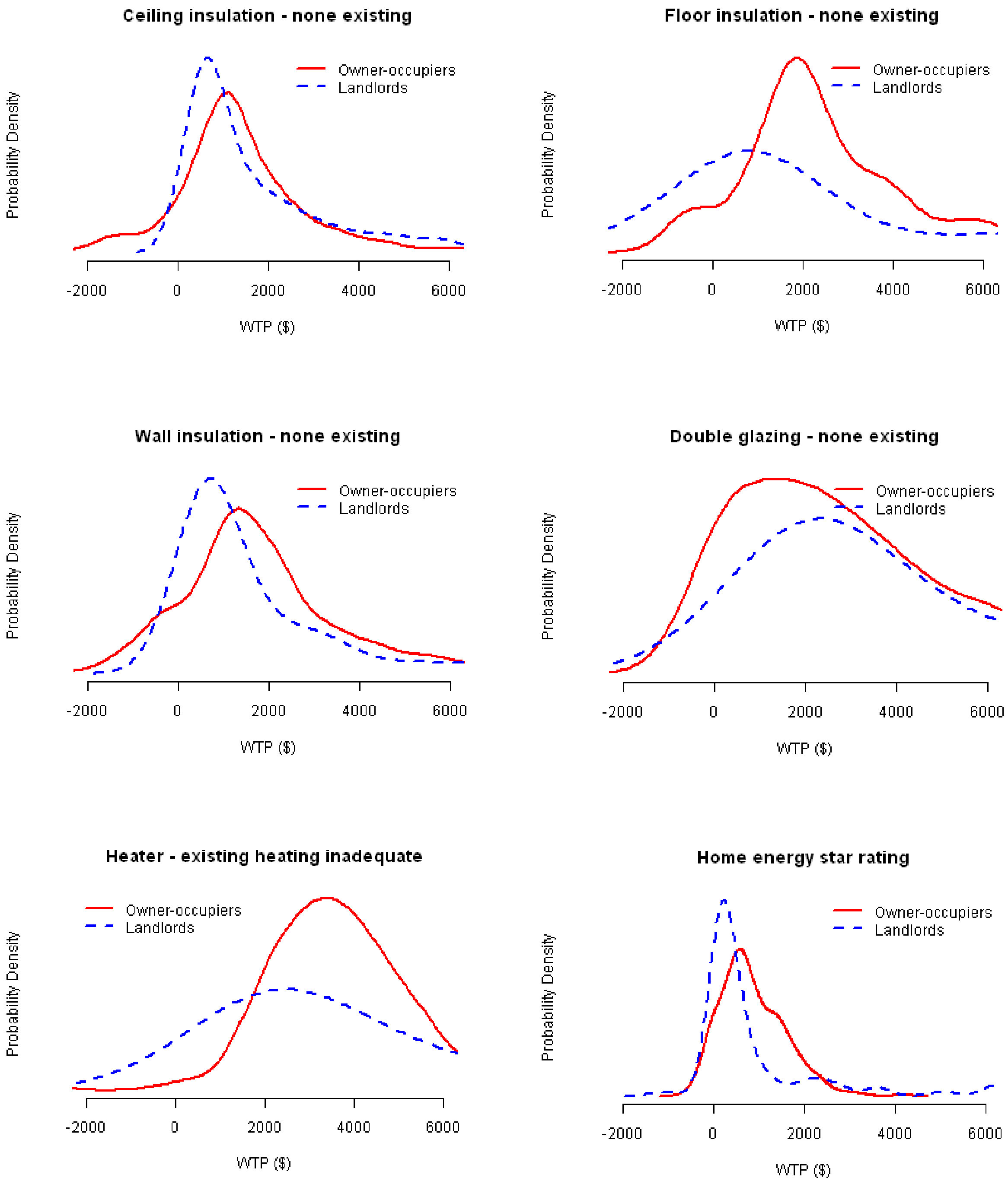
A home energy rating may have value because it improves the perceived marketability of the home. Owner-occupiers and landlords with higher scores on the subjective comfort of their properties have higher average WTP for home energy ratings, giving some support to this theory. Energy efficiency also has an element of "competitive altruism" (Griskevicius et al, 2010), so a home energy rating certificate may also have value as a status symbol.

The status quo effect is very similar for owner-occupiers and landlords, probably because they would bear the same search and transaction costs when upgrading their properties.

Table 6 – Willingness-to-pay percentiles for owner-occupiers and landlords

		Owner-Occupier			Landlord		
Attribute	**Existing**	**Median**	**5 %tile**	**95 %tile**	**Median**	**5 %tile**	**95 %tile**
Ceiling insulation	None/Unknown	1193	-1252	4723	784	515	5022
Ceiling insulation	Inadequate	794	-816	3238	566	314	4132
Floor insulation	None/Unknown	2170	-430	7518	956	-1074	12715
Wall insulation	None/Unknown	1582	-708	6387	888	348	10318
Double glazing	None/Unknown	2594	-124	9111	2705	1659	19972
Heater	Inadequate	3739	1531	9756	2771	1850	28684
Heater	Adequate	1741	-1166	6980	2489	1577	19946
Energy Star rating	None	719	-106	2184	282	62	7408
Status quo	N/A	535			567		

Table 7 - Comparison of WTP distributions for owner-occupiers and landlords



5.7.7 WILLINGNESS-TO-PAY FOR TENANTS

Table 8 shows the WTP results for tenants, in dollars per week. The WTP values range from $2 to $12 per week. The WTP for ceiling insulation is higher for respondents with existing (inadequate) insulation than those with none/unknown. However, tenants in the sample with no insulation have lower incomes than average, so this is most likely an income effect.

The WTP for floor insulation is again higher than for ceiling insulation, similar to the results for property owners. If tenants are willing to pay $11 per week for floor insulation that costs around $2000 (section 5.7.8), then the investment could conceivably be recovered by landlords within 4 years.

The WTP for double glazing is the highest, more evidence that consumers value factors that are easily observed rather than those which will have the greatest effect on comfort and energy efficiency.

The WTP for a clean heat appliance is only $2, a pay-back period of more than 30 years for a typical heat pump. Fuel poverty may be the reason for this low value. Figure 2 from section 5.2 showed that landlords probably underestimate the effect of fuel poverty on tenants. A heater is not much use to a tenant who cannot afford the fuel.

The median WTP for a home energy star rating is $3.23. The individual values are positively correlated with income but not knowledge of existing insulation or level of existing insulation. This suggests that the rating may have value as a status symbol but little else. The result might have been different if tenants were asked to choose between houses that they had no experience of, where the energy rating would be a signal of relative energy efficiency. However, there is presumably little information value to be gained from a rating when the occupant already knows how cold the home is.

Table 8 - WTP for tenants ($ per week)

Attribute	Existing	Median	5 %tile	95 %tile
Ceiling insulation	None/Unknown	6.47	3.84	18.12
Ceiling insulation	Inadequate	10.06	3.72	35.70
Floor insulation	None/Unknown	11.15	-3.40	33.34
Wall insulation	None/Unknown	8.08	-1.40	45.69
Double glazing	None/Unknown	11.66	4.32	42.94
Heater	Inadequate	1.98	1.22	7.02
Home Energy Star rating	None	3.23	-2.95	19.15

5.7.8 COMPARISON OF WTP AND MARKET PRICES

The market cost of insulation retrofits depends on the type of products being installed, the size of the home, and ease of access for installation. For ceiling and floor insulation, the installed price typically ranges from $17-$25 per square metre (Consumer Magazine, 2008). The total cost therefore ranges from $1700 for a small home (100 square metres) to over $6000 for a large home. Foil used to be a common choice for under-floor insulation, and it was relatively cheap. But modern thermal efficiency standards now require solid-fill insulation with a similar cost to ceiling products. The cost may be higher for difficult access or R-values above the required minimum.

The options to retrofit wall insulation are to re-line/re-clad the walls or inject liquid foam which later solidifies. The injection option is significantly cheaper. Table 9 gives the approximate cost of foam injection for small, medium, and large homes (Airfoam insulation, personal communication, July 8, 2010).

Double-glazing may involve replacing single panes of glass with sealed double-glazed units, or the whole frame may need to be replaced. The cost depends primarily on the total glazed area of the home. A ballpark range is $20,000 - $30,000 (Ryan windows & doors, personal communication, July 8, 2010)

Table 9 shows the percentage of owner-occupiers and landlords who have a WTP that is higher than the specified market price. A third of owner-occupiers have a WTP for ceiling insulation that is above the “low” price. However, the “low” price is for small homes and these owners may in fact have larger homes which will cost more. 13% of owner-occupiers and 18% of landlords have a WTP above the medium price. Although landlords have a lower median WTP, the distribution has fatter tails than for owner-occupiers.

A large proportion of both owner-occupiers and landlords have WTP higher than the market price of floor insulation, even at the high end of the price range. This begs the question why have not these owners upgraded their floor insulation already? The answer may lie partly in status quo bias, transaction costs, limited knowledge, or perhaps hypothetical bias, a common issue in stated preference studies (Bateman, 2002).

Double glazing has the highest median WTP values but the actual cost is so high that few individual values are anywhere near market value.

The largest overlap between WTP and market price is in heating. Almost half of owner-occupiers and landlords have a WTP that would afford a large heat pump or small solid-fuel burner so why have not they bought one already? For landlords the answer may lie in the fact that their tenants probably have not asked for one (see section 5.5). For owner-occupiers it is probably status quo bias and/or hypothetical bias again.

Table 9 - Comparison of market price and WTP distributions

		% WTP > price	
Product	**Installed price**	**Owner-occupier**	**Landlord**
Ceiling insulation (low)	1700	33%	34%
Ceiling insulation (medium)	3000	13%	18%
Ceiling insulation (high)	6000	3%	1%
Under-floor insulation (low)	1700	67%	38%
Under-floor insulation (medium)	3000	33%	31%
Under-floor insulation (high)	6000	10%	25%
Wall insulation (low)	4000	14%	18%
Wall insulation (medium)	6000	6%	14%
Wall insulation (high)	8000	3%	9%
Double-glazing (low)	20000	1%	5%
Double-glazing (medium)	25000	0%	1%
Double-glazing (high)	30000	0%	1%
Heater (small heat pump)	2500	80%	57%
Heater (large heat pump or small burner)	4000	45%	44%
Heater (top-of-the-range burner)	6000	17%	34%

6 DISCUSSION & CONCLUSION

The results of this study have provided new evidence with which to examine the hypotheses postulated in section 2.

The first hypothesis is that average insulation quality is lower in small, remote communities than in city centres. An analysis of self-reported existing insulation levels in section 5.3 provided some support for this hypothesis. However, the difference can be explained by the fact that small Waikato towns have older housing stock, and lower household incomes than Hamilton city. There is no evidence for any difference after controlling for these parameters. This should mean that the number of houses requiring insulation, in a particular area, can be estimated using only building age data from Quotable Value and average household incomes from Statistics New Zealand. However, further testing is recommended because the sample size per town was quite small.

The second hypothesis is that there are information asymmetries between tenants and landlords in the private rental housing market. The results confirm this because tenants were a lot more likely to answer “do not know” to the existing insulation questions (section 5.3.1).

The third hypothesis is that consumers under-value the benefits of insulation and clean heat upgrades, perhaps due to bounded rationality and a disproportionate focus on visible attributes. The results discussed in section 5.6 show that most residents believe than insulation and clean heat upgrades will save them money and improve their comfort and health. The energy savings may be underestimated but are still perceived to be significant.

The fourth hypothesis is that owner-occupiers have a higher willingness to pay for improvements than landlords. This hypothesis has a strong theoretical basis because landlords do not receive the energy savings and comfort benefits from energy efficiency improvements and there were very few private rental properties insulated under EECA grant programmes. The choice experiment results from section 5.7.6 support this hypothesis because landlords have a lower median WTP for all attributes except double glazing and replacement heaters. The rationale for this result is that double-glazing and heating are the most visible attributes and therefore may improve marketability to potential tenants.

The results of the choice experiment are useful for analysing the preferences of consumers whose willingness-to-pay is below the current market price. However, a large portion of WTP values are actually above current market prices, particularly for floor insulation and heating appliances. Transaction costs may partially explain this situation. Despite recent marketing campaigns, it still requires some effort to find a provider and arrange installation. If an owner wants to receive an EECA grant then there is the additional complication that both ceiling and floor insulation must be upgraded in order to receive the heating grant. Hypothetical bias may be another reason for the high WTP values. A large proportion of respondents stated that they plan to upgrade their homes within the next year or two, and it would be interesting to find out how many follow through.

WTP values for tenants are not insignificant, and may result in a very quick payback period if landlords make these investments and make tenants aware of them. However, marketing the invisible benefits of energy efficiency can be difficult. Policies to address the information asymmetry problems may be more efficient and effective than large subsidies for upgrades. Home energy ratings could be subsidised or made mandatory.

Studies have shown that insulation upgrades alone are not sufficient to achieve healthy indoor temperatures, and adequate space heating is an important requirement (Lloyd et al, 2006 and Chapman et al, 2004). Tenants have a very low WTP for heating appliances, presumably because they recognise they would have pay for the fuel as well. Heating fuel subsidies would probably improve the health and comfort of low-income households and, if appropriately targeted, could provide additional incentive to improve energy efficiency.

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8 APPENDIX

8.1 PROBIT REGRESSIONS FOR EXISTING INSULATION

Bdum 1 to 5 are dummies for building age (base is post-2000), idum 1 to 4 are dummies for household income of the property owner (base is less than $60,000), housetime indicates how long the current owner has owned the property, and children is a dummy variable indicating children under the age of 13 live at the property.

Table 10 - Probit regression for ceiling and floor insulation of owner-occupied properties

	Adequate Ceiling		Adequate Floor	
Variable	**Coef.**	**P-value**	**Coef.**	**P-value**
bdum1	-7.570	0%	-6.099	0%
bdum2	-8.724	0%	-6.868	0%
bdum3	-7.324	0%	-6.737	0%
bdum4	-6.744	0%	-6.770	0%
bdum5	-6.783	0%	-6.421	0%
idum1	-0.392	16%	-0.394	11%
idum2	-0.561	6%	-0.338	8%
idum3	-0.190	73%	-0.119	10%
idum4	-0.079	87%	-0.076	85%
housetime	-0.126	19%	0.012	8%
keeptime	-0.200	9%	0.095	70%
agedum1	-0.527	31%	.	.
agedum2	-0.030	95%	.	.
agedum3	0.248	49%	.	.
agedum4	0.095	76%	.	.
child	0.349	24%	0.135	54%
zone3	-0.051	90%	.	.
coast	0.121	65%	0.722	25%
city	-0.363	25%	-0.706	17%
_cons	7.621	0%	6.438	0%
Psuedo R2	0.306		0.2109	