# MITIGATING SEISMIC RISK:

## Societal willingness to pay

Prepared for Ministry of Business Innovation and Employment

May 2025

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|---|---|---|
|  | Reviewed by: | Charlotte Brown |

## PROJECT TEAM

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## ACKNOWLEDGEMENTS

The authors would like to thank MBIE (Lucy Keenan and Dr Kenneth Elwood) for their support in commissioning and then engaging with the research as the project proceeded. We would like to acknowledge the support and engagement from our research partners at 1000minds (Prof Paul Hansen in particular), to Dynata (Raj Mathew) for the survey deployment and to our advisory panel Olga Filippova (University of Auckland), Jenni Tipler (Wellington City Council) and Lauren Vinnell (Joint Centre for Disaster Research, Massey). Without these contributions the project would not have been possible.


## SUPPLEMENTARY REPORT

ResOrgs and JCDR (2025). Mitigating seismic risk: building remediation behaviours. Report for Ministry of Business Innovation and Employment, May 2025.

# Contents

# Executive summary

The New Zealand Ministry of Business Innovation and Employment (MBIE) wanted to research societal willingness to pay to mitigate earthquake risk. The research brief raised three main research questions concerning seismic performance of buildings:

1. What building performance attributes are most important?
2. What is societal willingness to pay for seismic performance in a range of building-use types?
3. Where should the burden of cost lie for different building-use and ownership types?

To address the first two research questions, we undertook four parallel discrete choice experiment surveys, each focused on one building-use type: apartments, offices, small retail and community buildings. The surveys asked participants to rate the importance of life safety, disruption and damage performance outcomes against increases in tax.

For the third research question, we asked participants who – taxpayers or building owners – should bear the cost of seismic strengthening across a range of building purposes covering ownership and uses. We used cluster and regression analysis to explore the socio-demographic and environment factors that influence attitudes toward willingness-to-pay taxes and share the burden of cost for seismic strengthening.

## BUILDING SEISMIC-PERFORMANCE ATTRIBUTES

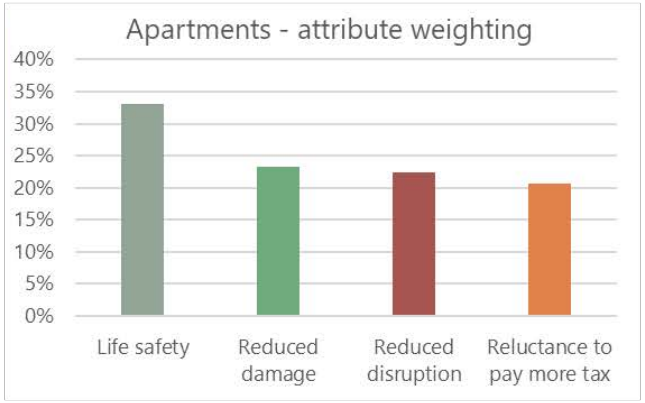
The survey results showed consistent rankings of the three seismic-performance attributes across all four building-use types:

- Life safety is the primary seismic-performance objective
- Reduced disruption and reduced damage are secondary objectives of similar importance to each other.

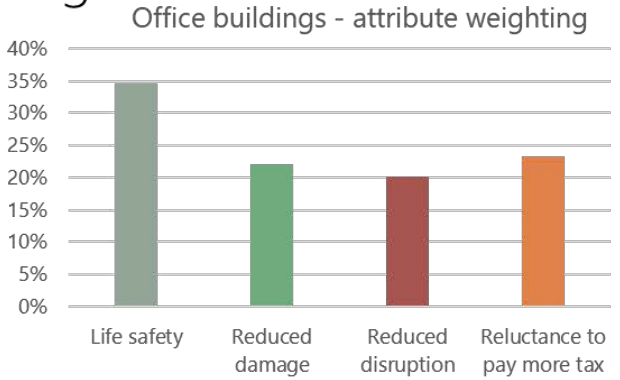
## SOCIETAL WILLINGNESS TO PAY

- Half of the respondents surveyed had a high willingness to pay tax in order to achieve life safety, reduced damage and reduced disruption building performance outcomes : they favoured achieving good seismic performance over limiting their tax contributions..
- A substantial minority (>30%) of respondents had a low willingness to pay taxes: this group prioritises minimising their tax over improving any aspect of seismic performance of buildings.
- Building purpose matters: there is a 12.5% higher willingness to pay taxes for apartments than office buildings and a higher willingness to pay taxes to support small retail than community centres.
- Responses to changes in earthquake likelihood are asymmetric: respondents were more likely to increase their willingness to pay tax to fund seismic improvements with an increase in earthquake likelihood than to decrease contributions due to a decrease in earthquake likelihood.
- Overall, the survey results indicate a social license for some tax-funded partial contributions to achieve improved seismic performance of some building-use types.

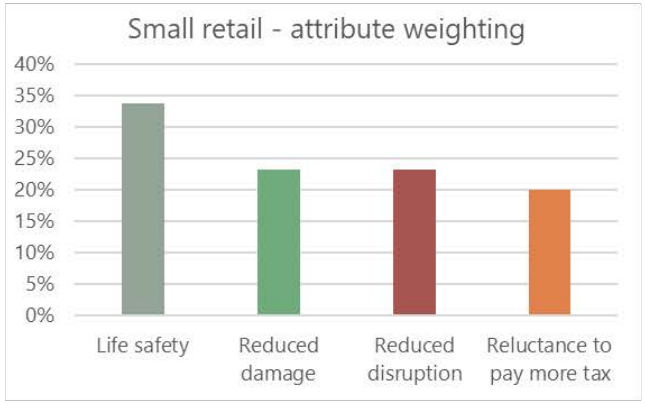
## Apartments




## Office buildings




## Small retail




## Community buildings

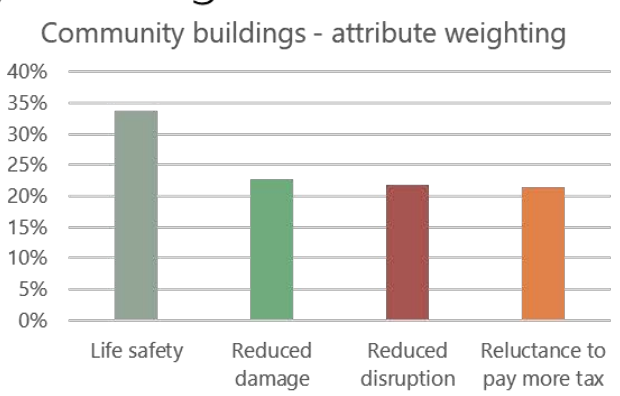



*Figure i: Relative importance of building performance attributes across building-use types (note, willingness to pay tax is expressed here as "Reluctance to pay more tax" to account for the negative correlation between the different attributes)*

## BURDEN OF COST

- The majority of participants feel private building owners should be solely responsible for paying for seismic strengthening
- There is significant support for partial tax-funded assistance (34-51% depending on building-use type)
- There is low support for sole (5%) or main (6%) tax funding
- Central government tax funding is preferred over local authority rates, for any tax-funded assistance
- The extent of support for burden of cost sharing varies by building purpose (use and ownership)
- The view that owners should have sole responsibility is particularly strong for commercial purposes such as office blocks, local restaurants and supermarkets (66/65%), whereas it is lower for social functions such as private/individually owned apartments and private health facilities (49%).

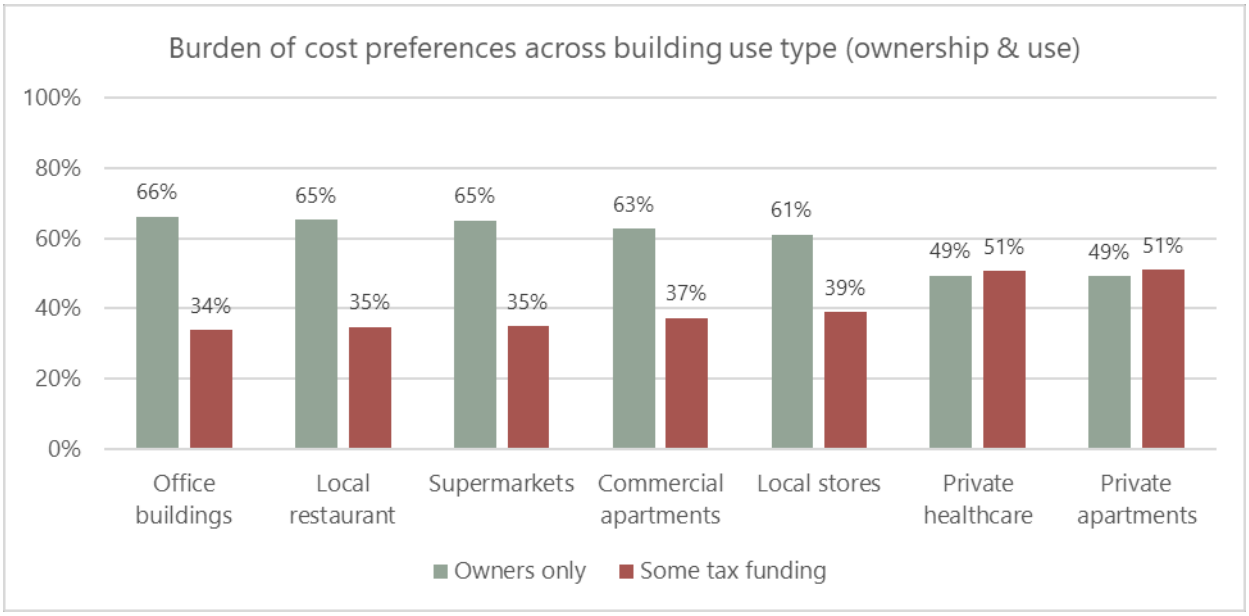



*Figure ii: Survey respondent preferences for burden of cost – owner only or some tax funding (all building purposes; n= 2033)*

## FACTORS AFFECTING PEOPLE'S ATTITUDES

The survey findings show some similarities, but also significant differences in the responses from people with the same age, gender and location.

We used a range of socio-demographic variables – gender, age, ethnicity, income, dependents under 18, property ownership, previous experience of earthquakes – and environment factors – location (urban, provincial or rural), seismic hazard zone – to investigate what characteristics might explain differences in people's attitudes.

The main finding from the regression analysis is that most of the variation in people's preferences is independent of their socio-demographic characteristics and environment factors; in other words, people's preferences are mostly idiosyncratic. Although some variables had a statistically significant effect some of the time, only three variables – age, gender and property ownership – were consistently associated with significant differences in attitudes. For example, females and younger people (18-24 years) and non-homeowners tended to have greater willingness to pay tax to fund seismic strengthening than other people. Notably, factors such as seismic hazard zone and living environment (urban, provincial and rural) had no consistent impact on responses.

# 1 Introduction

Inevitably, mitigation of seismic risk comes at a cost. As a nationally managed risk, understanding New Zealanders' perspectives on seismic risk, is an important input into determining the degree of seismic mitigation desired. Information on the seismic performance New Zealanders want from their buildings, how much they are willing to pay to reduce the risk, and who they think should bear the risk, are critical to understanding the social licence and risk tolerance of those that will both pay for, and benefit from, any changes in national regulations.

As part of the review by the Ministry of Business Innovation and Employment (MBIE) of the management of seismic risk in existing buildings ("the Review"), MBIE commissioned several research projects, including this one. ResOrgs and JCDR were commissioned to research societal willingness to pay (WTP) additional tax to mitigate the risk including injury and death, damage and disruption in the event of an earthquake, with the research findings intended to inform both the Earthquake Prone Buildings (EPB) review and the future regulation of new and existing buildings.

The research design was organised around three central research questions:

1. Which building-performance attributes are most important to New Zealanders?
2. What is societal willingness to pay for seismic performance in a range of building-use types?
3. Where should the burden of cost lie for different building-use and ownership types?

Alongside these research questions, we sought to understand the socio-demographic and environment factors that influence people's attitudes towards contributing towards seismic risk mitigation.

In support of our methodological design, a scan of the literature was undertaken that did not identify any directly comparable studies on *societal* willingness to pay for building performance. However, we found two studies which used discrete choice experiment methodology to look at *individua*l willingness to pay (that is through increased purchase price) for seismic performance of residential buildings in Italy (D'Alpaos & Bragolus 2020 & 2022). Similarly, we investigated whether there were any studies that investigated individuals' perceptions on where the burden of cost for seismic-risk mitigation of buildings should lie. No suitable studies were found. Details of the literature review are included in Appendix A.

Despite the lack of seismic specific examples, the team drew on a number of Willingness to Pay studies applied across different sectors (e.g. Gill 2023), to support our survey design.

This report has seven parts: Section 2 covers the research design and method, Sections 3-5 discuss the research findings for the three research questions, and Section 6 comprises conclusions and future directions. Appendix A includes the findings from an initial scan of the literature conducted at start of the project. Appendix B includes more technical details on the survey design and method adopted. Appendix C includes a copy of the survey questions. Appendix D and E are technical annexes that report the results from the regression and cluster analysis undertaken on willingness to pay and burden of cost respectively.

# 2 Method

## 2.1 Survey design

### 2.1.1 OVERALL

Following an initial literature scan, we designed, tested and deployed four parallel societal willingness to pay surveys. The survey design was based on applying a Discrete Choice Experiment approach (DCE) using 1000minds software to provide data on relative preferences for building performance including willingness to pay tax; technical details are in Appendix A. We also included some closed-ended questions on burden of cost, earthquake likelihood and an open-ended concluding question discussed further below.

A Low Risk Ethics Notification for the research was submitted and secured from Massey University (Ethics Notification Number: 4000030044). Ethical standards as per the University guidelines were maintained.

### 2.1.2 DISCRETE CHOICE EXPERIMENT

We ran four parallel surveys[1] (targeting 500 valid responses) for four different building-use types. Building-use types were chosen to span buildings with different importance to people: apartments, offices, small retail and community buildings. These building-use types were selected from the 'time to return to function recovery time' hierarchy from previous New Zealand research – The Resilient Buildings Project (Brown et al., 2022).

In the DCE we compared building-performance outcomes – protection of life, protection of property, protection of functionality – with incremental tax increases to fund improved seismic performance. The attributes included in the DCE are:

1. Life safety – ''*Risk to life*''
2. Reduced damage – "Risk of damage to buildings and contents"
3. Reduced disruption – "Risk of lengthy disruption to building use"
4. Willingness to pay more tax – "Increase in your tax for earthquake strengthening"[2]

These attributes were also drawn from the Resilient Buildings Project (Brown et al., 2022). Within each attribute, 5 levels of performance or severity were defined to allow the 1000minds survey engine to generate attribute trade-offs that respondents must choose between. A DCE survey screenshot is below, Figure 1. The DCE iterates through the trade-off choices in an adaptive

[1] We ran four separate surveys to manage survey length. Each survey took 10-15 minutes to complete.

[2] The values associated with willingness to pay tax differed between building-use type. This was based on an estimated cost (to each tax payer) to remediate the population of earthquake-prone buildings of each use type (based on average cost to remediate and number requiring remediation).

fashion – hence this can be recognised as an *adaptive* DCE – until a ranking of the attributes, and weights representing their relative importance, is generated for each participant.

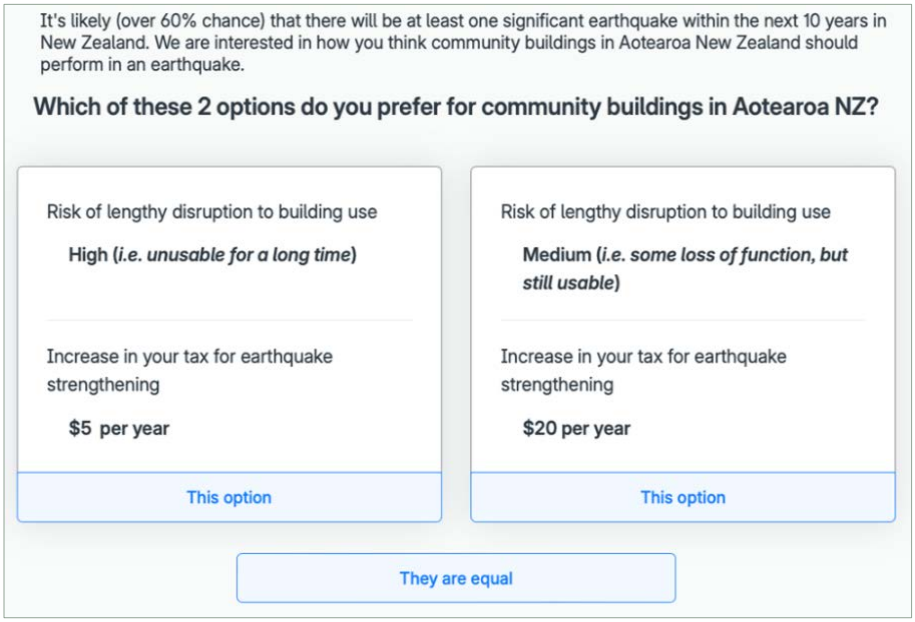



*Figure 1. Example of a DCE trade-off question in the survey*

The DCE questions in the survey were augmented with questions (mostly multi-choice) on:

- burden of cost,
- the impact on responses to changes in earthquake likelihood,
- socio-demographic characteristics, and a
- concluding over-arching question "Do you have any comments you'd like to share?".

The survey questions are included in Appendix C.

### 2.1.3 BURDEN OF COST

The aim of the burden-of-cost questions, which were included at the end of each of the four surveys, was to understand whether participants believed the cost to strengthen buildings should lie with building owners or taxpayers or some combination of the two. We also wanted to understand if this cost-sharing changed based on building use and ownership.

In the burden-of-cost section of the survey we used more standard closed-ended questions. As a result, we could get more granular data on a wider number of building-use types. Building-use types were selected using data from the Resilient Buildings Project to cover a range of perceived building function importances and individual, commercial and community-ownership objectives. These building-use types were:

- owner-occupied apartments
- apartments owned by commercial businesses
- private office buildings
- privately-owned health facilities (e.g. local medical centres)
- supermarkets
- local grocery stores (e.g. dairies)

- local restaurants

For all of the building-use types, participants were asked who they thought should bear the cost of strengthening, based on these options:

- building owners
- taxpayers
- shared but mostly building owners
- shared but mostly taxpayers

We concluded these questions by asking: If taxpayer money is used for earthquake strengthening, who should cover most of the cost?

- general taxpayers
- local ratepayers
- no preference

### 2.1.4 EARTHQUAKE LIKELIHOOD

The scenario used for framing the DCE survey questions, included a generic statement about earthquake likelihood within the next 10 years. We based the 60% earthquake likelihood on expert advice from GNS about the chance of a magnitude 7 or above earthquake occurring anywhere in New Zealand over the next 10 years (email correspondence from Matt Gerstenberger dated 3 February 2025). We included supplementary questions testing whether or not willingness to pay taxes for earthquake strengthening would change if the likelihood was 80% and 40%.

The question asked: *Imagine the chance of an earthquake within the next 10 years is [less/more likely ([40%/80%] chance). How much would your willingness to pay taxes for earthquake strengthening reduce by?*

- No change
- 5% [reduction/increase]
- 10% [reduction/increase]
- 20% [reduction/increase]
- 30% [reduction/increase]
- More than 30% [reduction/increase]

### 2.1.5 RESPONDENTS' SOCIO-DEMOGRAPHIC CHARACTERISTICS

We collected data on a range of respondent socio-demographic characteristics, including:

- Region (which was mapped, post-hoc to hazard zone)
- Environment setting (urban, regional, or rural centre)
- Gender
- Age
- Ethnicity
- Total income
- Dependents under 18
- Property ownership
- Earthquake experience

## 2.2 Validity and reliability of survey responses

### 2.2.1 SURVEY DEPLOYMENT AND REPRESENTATION

In February 2025, survey research firm Dynata was commissioned to recruit a representative sample of survey participants from across New Zealand. For each survey we used a stratified survey sample (500+ valid responses) which reflected the structure of the NZ population by age, gender, and location.[3]

The stratified samples are shown in Table 1 and Table 2 below, which compare the survey response rates against New Zealand's population mix by age, gender, settlement type and region. The final sample represented all demographic groups well except for slightly under-sampling people living in rural areas.

*Table 1. Survey response rates: socio-demographic characteristics*

| | | Census (2018) | Survey 1: Apartments | Survey 2: Community | Survey 3: Office | Survey 4: Small Retail |
|---|---|---|---|---|---|---|
| **Gender** | Male | 48% | 48% | 47% | 46% | 48% |
| | Female | 52% | 52% | 53% | 53% | 52% |
| **Age** | 18-24 | 13% | 12% | 11% | 15% | 10% |
| | 25-34 | 16% | 22% | 22% | 23% | 22% |
| | 35-44 | 18% | 19% | 23% | 20% | 21% |
| | 45-54 | 19% | 14% | 19% | 16% | 17% |
| | 55+ | 34% | 33% | 27% | 26% | 30% |
| **Settlement Type[4]** | Urban | 50% | 49% | 53% | 53% | 51% |
| | Suburban | 35% | 41% | 37% | 39% | 40% |
| | Rural | 15% | 10% | 10% | 8% | 9% |

[3] These characteristics were chosen as demographic characteristics that Dynata are able to target using existing demographic data they hold on survey panel members.

[4] Settlement types utilised the Urban Rural Indicator (IUR) and sourced data from Environmental Health Intelligence New Zealand (see: https://www.ehinz.ac.nz/indicators/population-vulnerability/urbanrural-profile/). Note that IURs were re-grouped into "Urban" (>100,000 residents), "Suburban" (1,000-99,999 residents), and "Rural" (<1,000 residents).

*Table 2. Survey response rates: region*

| | Census (2018) | Survey 1: Apartments | Survey 2: Community | Survey 3: Office | Survey 4: Small Retail |
|---|---|---|---|---|---|
| Auckland | 33.0% | 37.6% | 36.0% | 36.7% | 38.1% |
| Bay of Plenty | 6.4% | 5.2% | 6.7% | 6.2% | 5.2% |
| Canterbury | 13.1% | 13.7% | 13.4% | 14.5% | 14.3% |
| Gisborne | 0.9% | 0.2% | 0.2% | 0.4% | 0.1% |
| Hawke's Bay | 3.5% | 3.5% | 3.4% | 3.8% | 3.4% |
| Manawatu-Wanganui | 5.0% | 5.4% | 4.9% | 5.8% | 6.2% |
| Marlborough | 1.1% | 0.8% | 1.2% | 1.4% | 0.8% |
| Nelson | 1.1% | 1.2% | 1.0% | 0.8% | 0.8% |
| Northland | 3.7% | 2.9% | 3.4% | 3.0% | 2.8% |
| Otago | 5.3% | 5.6% | 4.5% | 4.2% | 4.2% |
| Southland | 2.1% | 1.7% | 2.2% | 1.6% | 1.6% |
| Taranaki | 2.4% | 1.9% | 2.4% | 2.6% | 2.4% |
| Tasman | 1.2% | 1.0% | 0.8% | 0.6% | 0.4% |
| Waikato | 9.5% | 7.7% | 8.1% | 8.1% | 7.3% |
| Wellington | 10.9% | 11.6% | 11.5% | 20.3% | 12.1% |
| West Coast | 0.8% | 0.2% | 0.2% | 0.2% | 0.6% |

### 2.2.2 VALIDITY

We examined the rankings of the four attributes in the four DCE surveys (discussed in the next sections). The surveys generated consistent distribution of results across building-use types with few anomalies or inconsistencies. These rankings are also consistent with other qualitative research in New Zealand such as the Resilient Buildings project (Brown et al., 2022). Based on this analysis, we are confident that the survey method is externally valid.

### 2.2.3 RELIABILITY

To ensure the reliability of the DCE responses used for the final analysis, several checks of "data quality" were automatically performed by the 1000minds software: consistency, "speeding", and identical answers to each DCE question.

Consistency testing involved two questions being repeated at the end of the DCE to test the consistency of each respondent's answers. Participants were excluded from the final analysis if

they failed one or more of the consistency tests. The more consistent that respondents' trade-offs are to the choice pairs, the more confidence we can have in the reliability (repeatability) of their decisions and hence of the survey.

We also tracked the median time taken for respondents to respond to each DCE question and excluded people who were judged to be too fast ("speeders") – indicative of them not adequately considering each question.

Finally, respondents who answered all their DCE trade-off questions with the same answer in terms of the button they chose – "This option" on the left-hand side or right-hand side or "They are equal" (see Figure 1 again) – were excluded, as this was interpreted as being insincere.

Based on these three data-quality checks, nearly 40% of the initial responses were excluded before at least 500 valid responses were achieved for each survey, resulting in a total of 2033 across all four surveys. Reassuringly, a significant majority (77%) of respondents with valid responses reported that they found the survey "easy" or "reasonably easy" to complete.

## 2.3 Survey analysis

We undertook the survey analysis in two stages.

In the initial stage we looked for patterns and inconsistencies in the descriptive statistics across the four surveys. These first pass findings were discussed at a sense-making workshop with the research team and summarised in an Interim Report that was discussed with MBIE. Based on feedback from these sessions, we then commissioned a more detailed quantitative analysis.

This second stage focused on identifying any socio-demographic or environment factors that affect attitudes towards willingness to pay additional tax and burden of cost. The analysis involved using these steps and statistical techniques to identify trends in peoples' preferences:

- calculating the mean weights on the attributes,
- investigating the diversity of weights across participants using non-parametric tests,
- comparing mean weights across groups defined by their socio-demographic and environment characteristics,
- finding clusters of people with similar preferences,
- using Fractional Multinomial Logistic Regression analysis to investigate the extent to which people's preferences are systematically related to their socio-demographic and environment characteristics.

Throughout survey design and analysis, we adopted a fabric approach to QA involving our external reviewer (Prof Paul Hansen), our external advisory panel and MBIE's Seismic Risk Steering Group in the project as it developed.

# 3 Building-performance attributes

## 3.1 Overall

We examined the variation in people's preferences for each attribute (life safety, reduced damage, reduced disruption) along with incremental tax increases. By tax increases we mean the willingness of people to pay tax to fund improvements in buildings' seismic performance for the four building-use types.

Across the surveys of the four building-use types, there were consistent preferences about how buildings should perform in earthquakes:

- Life safety is the most important attribute.
- Reduced disruption and reduced damage are secondary attributes, of similar importance.
- Willingness to pay (WTP) more tax is also a secondary attribute, as discussed in Section 4.

In the following graphs we show the relative importance of each attribute for the four building-use types: apartments (Figure 2), small retail (Figure 3), office buildings (Figure 4) and community buildings (Figure 5). The weight (y-axis) is the mean weight (or relative importance) assigned by participants, on average, to each of the four attributes, where these weights sum to 100%.

Note that while we refer to willingness to pay tax, the graphs refer to "Reluctance to pay tax". This is because the seismic-performance outcome variables and the willingness to pay variable are negatively correlated. Thus, where "Reluctance to pay more tax" is weighted higher, that means more people would prefer not to pay tax to improve one or more aspects of seismic performance of the building-use type.

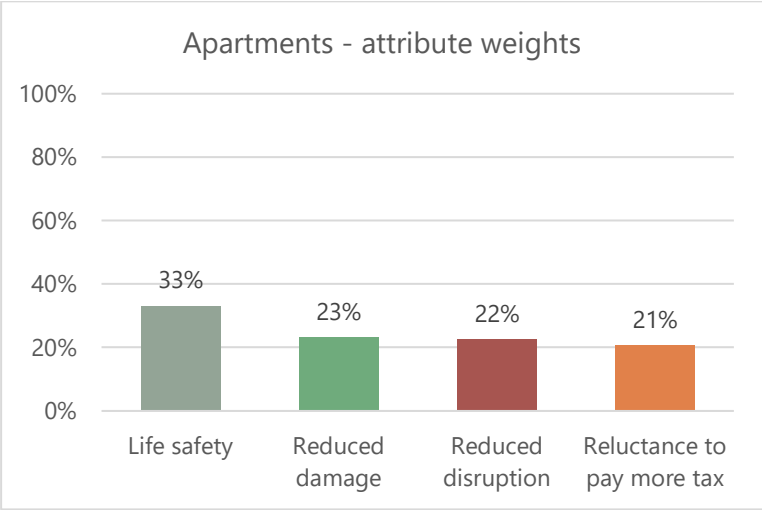



*Figure 2. Relative importance of attributes for Apartment Buildings (weighted)*

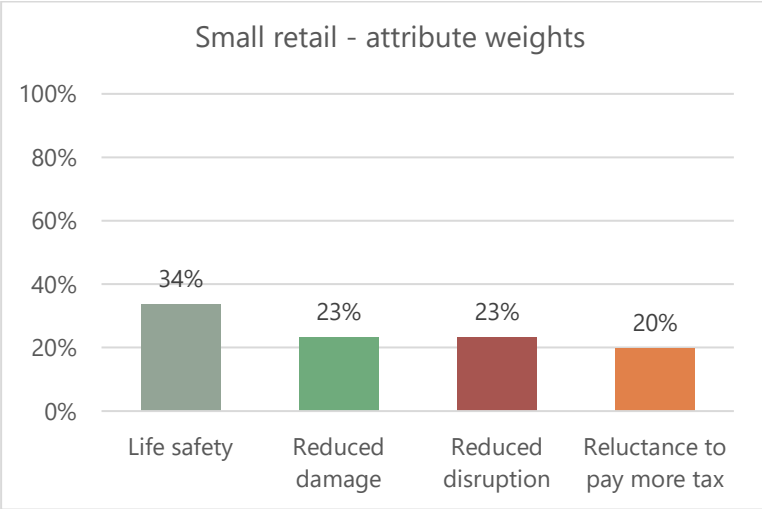



*Figure 3. Relative importance of attributes for Small Retail Buildings (weighted)*

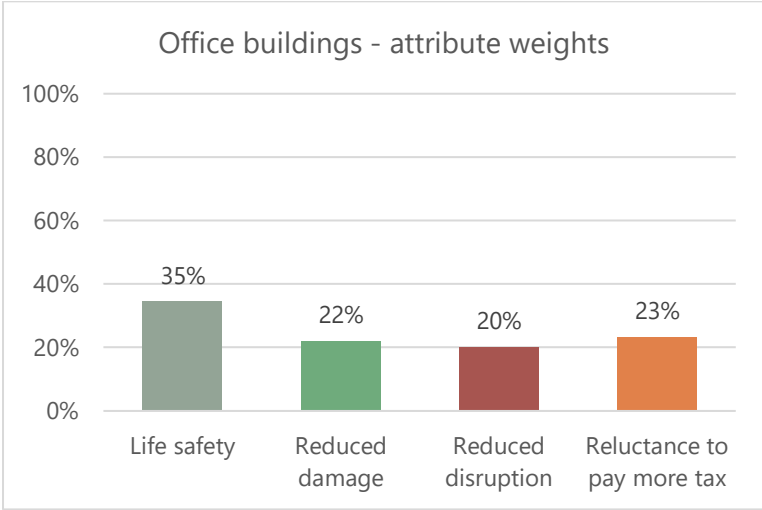



*Figure 4. Relative importance of attributes for Office Buildings (weighted)*

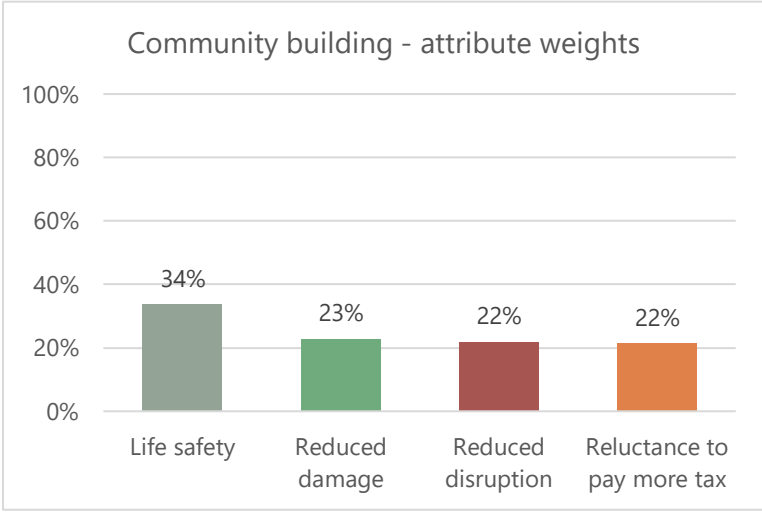



*Figure 5. Relative importance of attributes for Community Buildings (weighted)*

## 3.2 Life safety

Protecting the life safety of building users is the most important attribute across all four surveys, with 58% of respondents ranking it as first (Figure 6). This means that most participants favour reducing lives lost in a future earthquake event over reducing damage or disruption or avoiding a tax contribution to support strengthening.

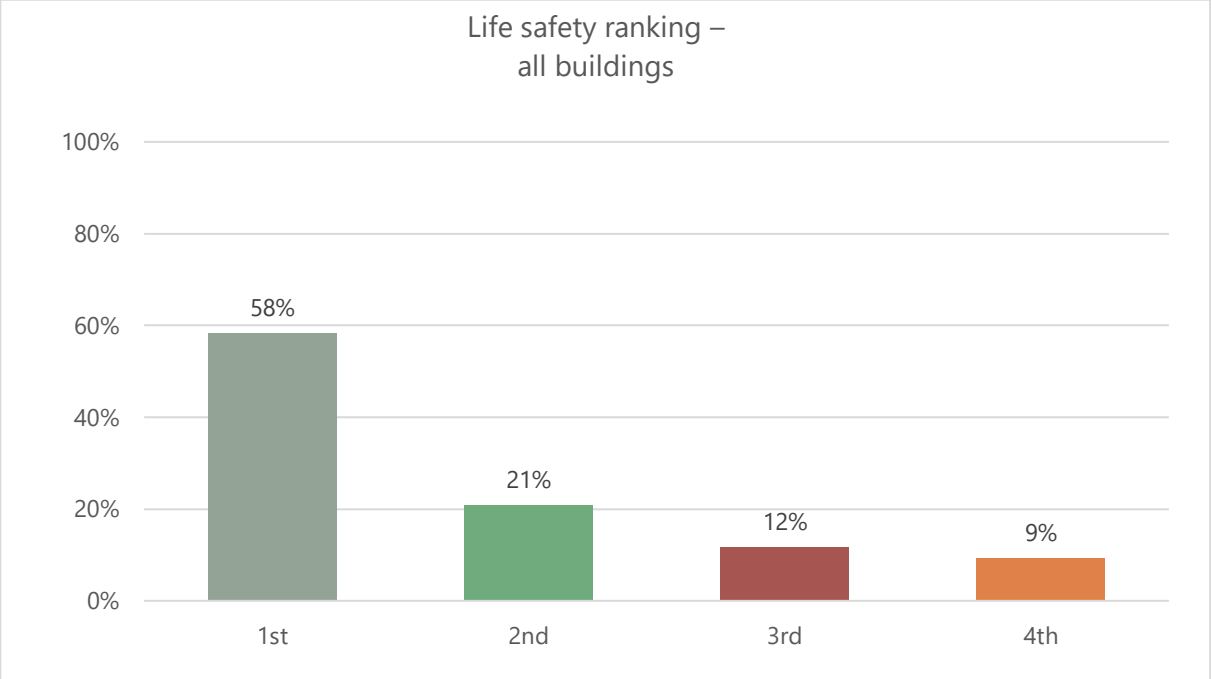



*Figure 6. Distribution of respondent rankings for the life safety attribute (all building-use types; n=2033)*

This is also reflected when looking at each of the four surveys individually, with life safety consistently ranked as the most important attribute for a majority of respondents (Figure 7-10).

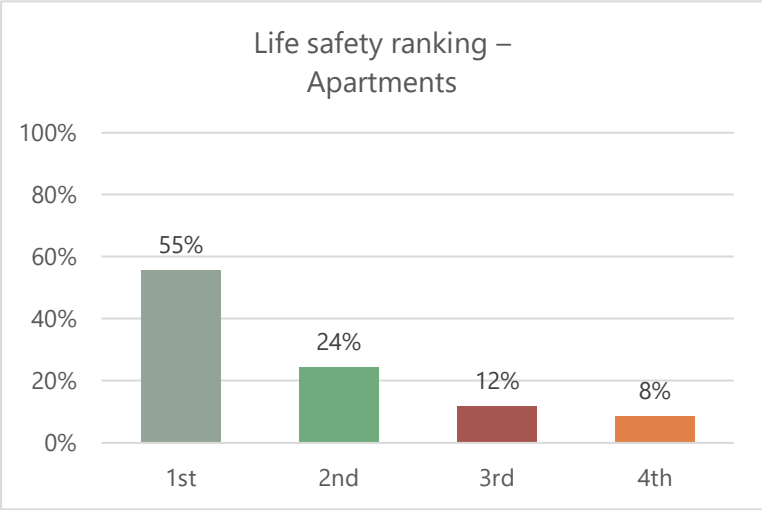



*Figure 7. Distribution of respondent rankings for the life safety attribute (apartments; n=519)*

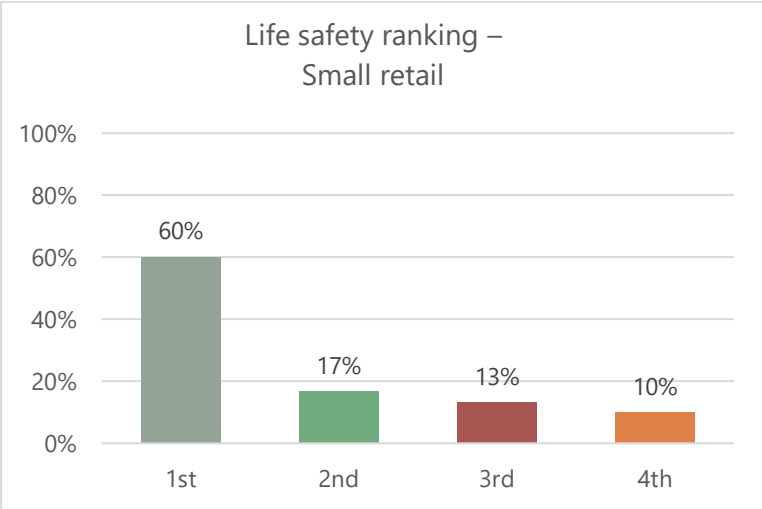



*Figure 8. Distribution of respondent rankings for the life safety attribute (small retail; n=504)*

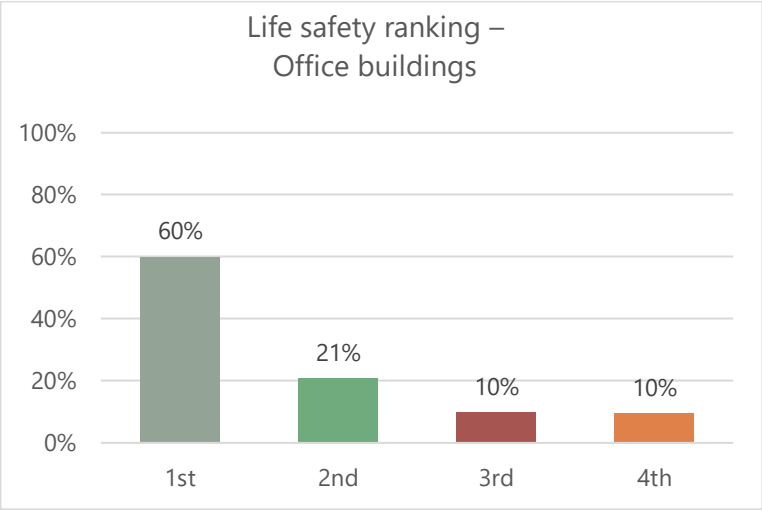



*Figure 9. Distribution of respondent rankings for the life safety attribute (office buildings; n=504)*

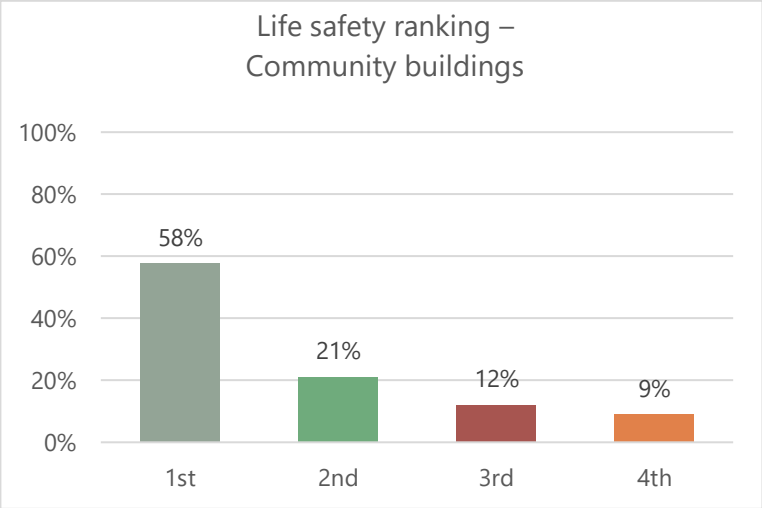



*Figure 10. Distribution of respondent rankings for the life safety attribute (community buildings; n=506)*

## 3.3 Reduced disruption

Reducing disruption is a middle-ranking attribute for all building-use types. Most respondents ranked reduced disruption as the second- or third-most important building performance attribute (3rd most frequent, 2nd overall when weighted) (Figure 11).

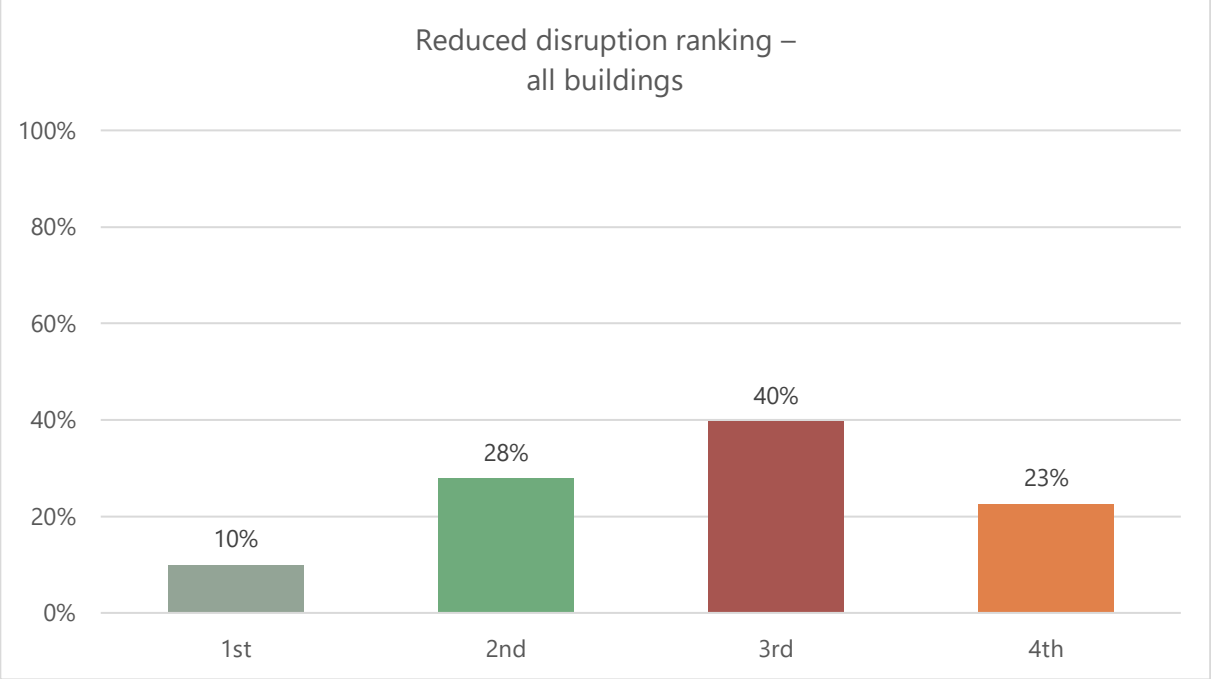



*Figure 11. Distribution of respondent rankings for the reduced disruption attribute (all building-use types; n=2033)*

This result is also revealed for each of the four surveys individually, with reduced disruption consistently ranked as the third-most important attribute for a majority of respondents (unweighted) (Figure 12-15).

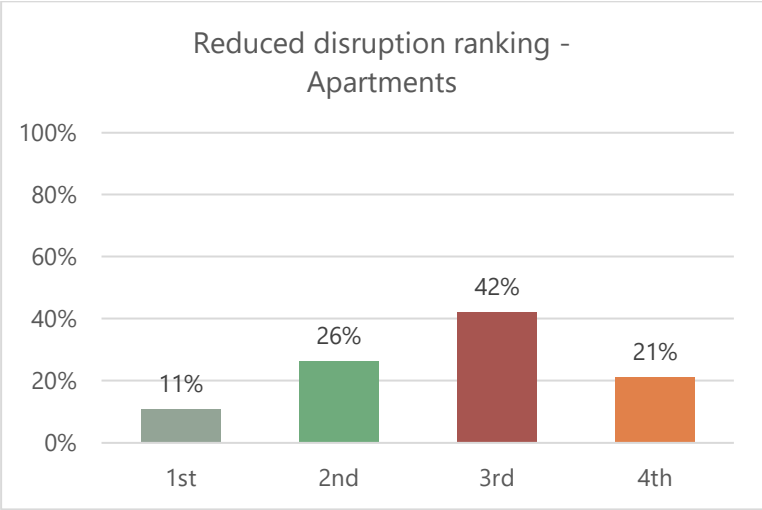



*Figure 12. Distribution of respondent rankings for the reduced disruption attribute (apartments; n=519)*

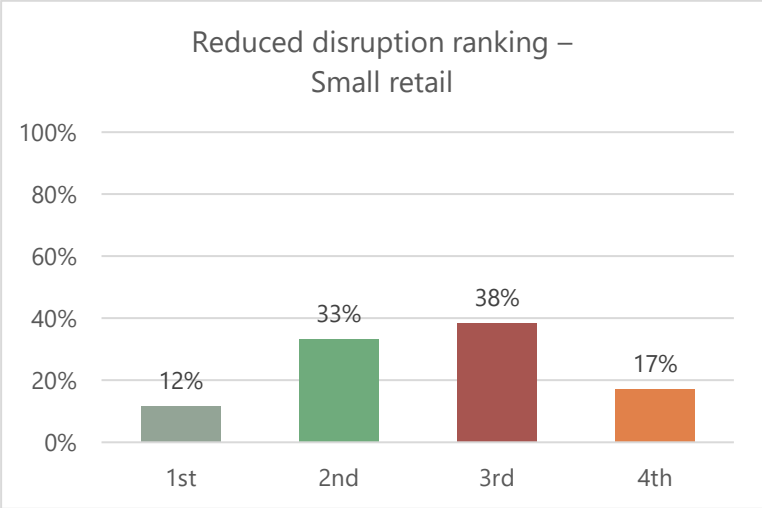



*Figure 13. Distribution of respondent rankings for the reduced disruption attribute (small retail; n=504)*

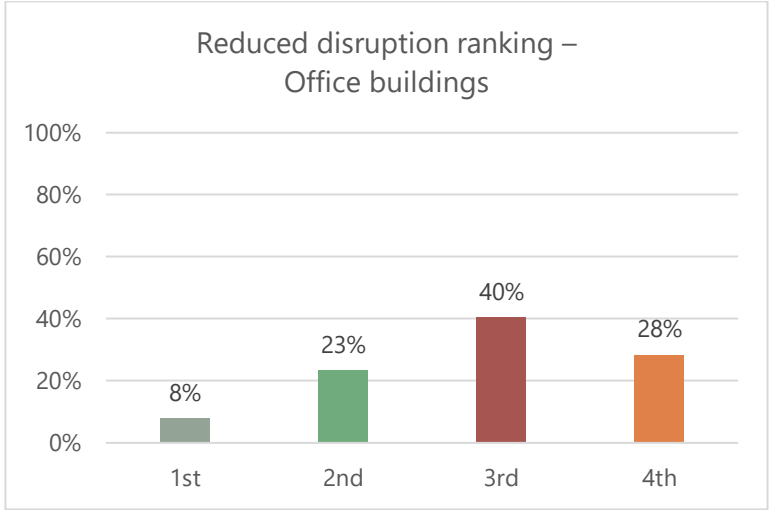



*Figure 14. Distribution of respondent rankings for the reduced disruption attribute (office buildings; n=504)*

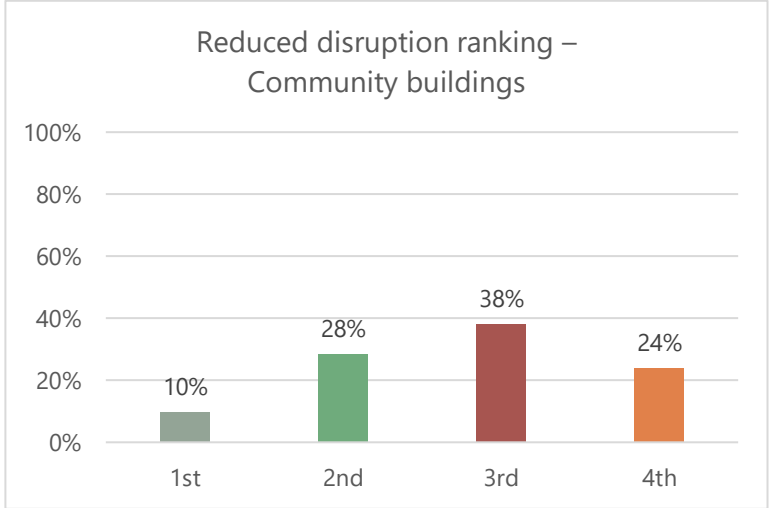



*Figure 15. Distribution of respondent rankings for the reduced disruption attribute (community buildings; n=506*

## 3.4 Reduced damage

The reduced-damage building performance attribute ranked slightly below reduced disruption (2nd most frequent, 3rd overall when weighted).

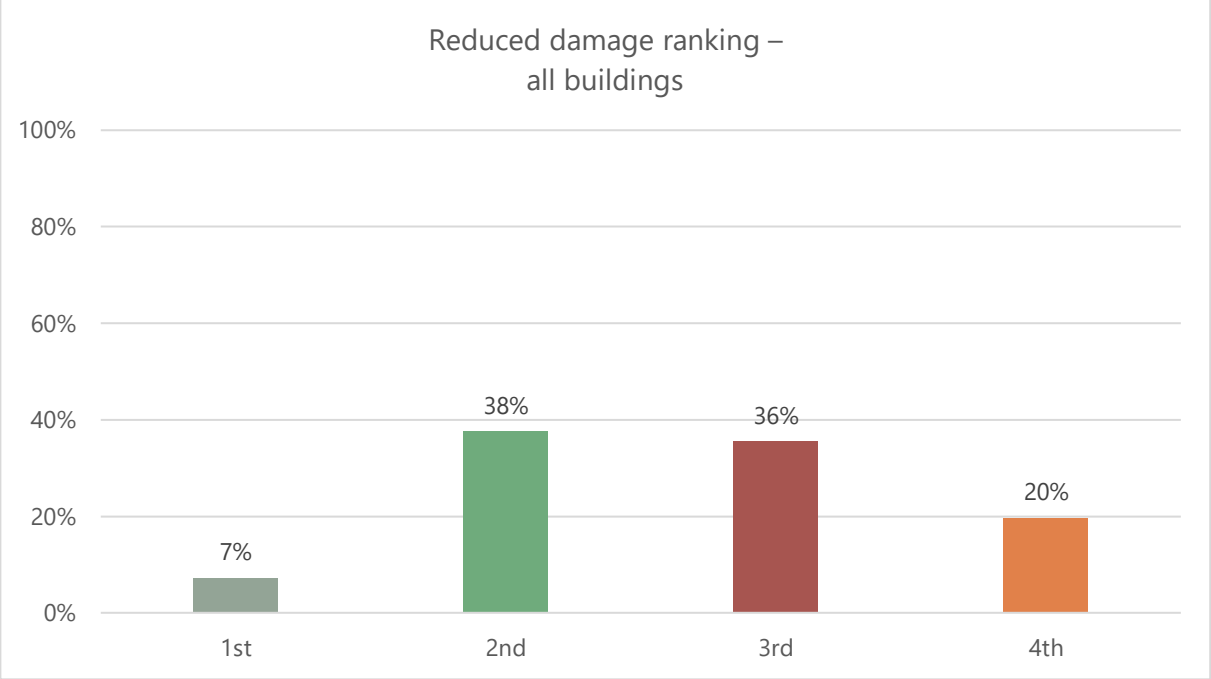



*Figure 16. Distribution of respondent rankings for the reduced damage attribute (all building-use types; n=2033)*

This result is also revealed for each of the four surveys individually (Figures 17-20).

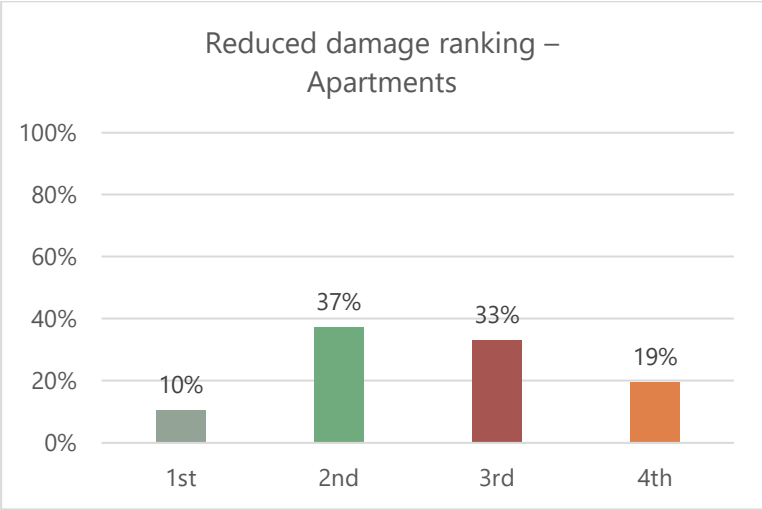



*Figure 17. Distribution of respondent rankings for the reduced damage attribute (apartments; n=519)*

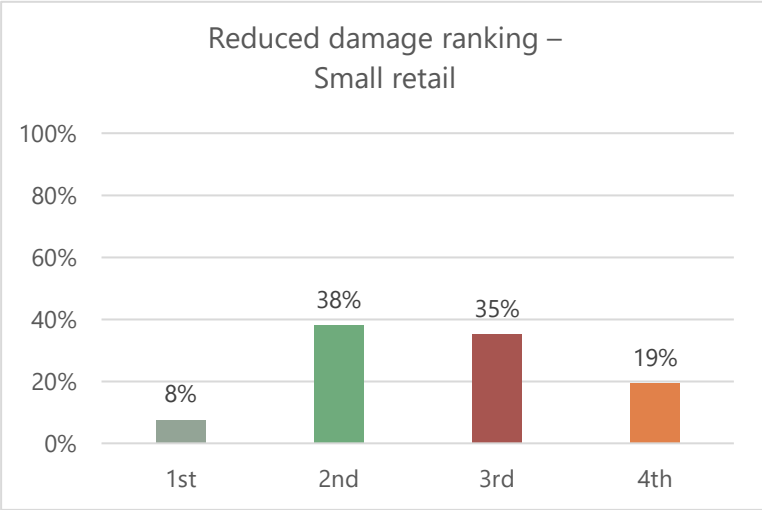



*Figure 18. Distribution of respondent rankings for the reduced damage attribute (small retail; n=504)*

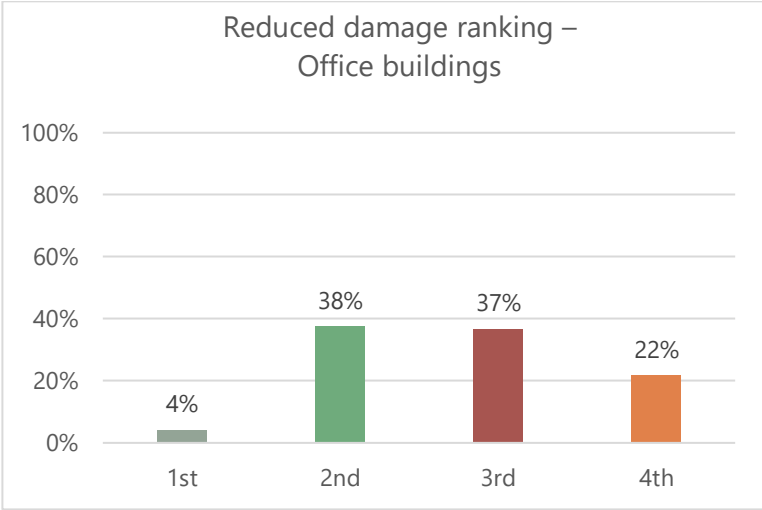



*Figure 19. Distribution of respondent rankings for the reduced damage attribute (office buildings; n=504)*

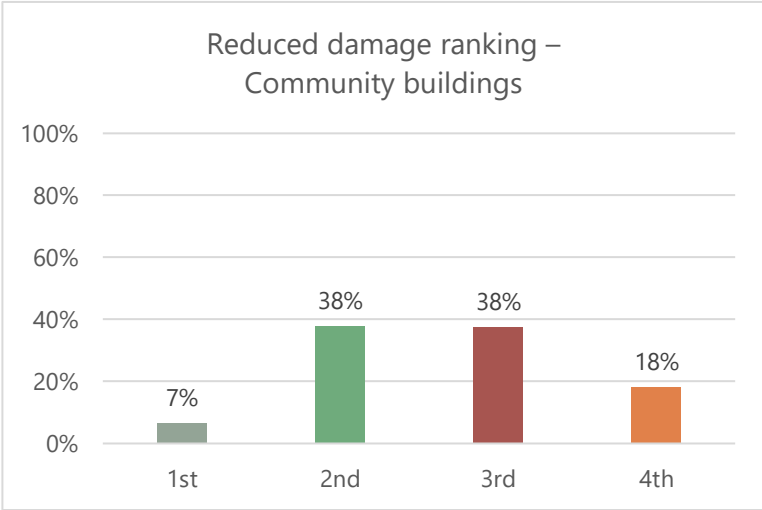



*Figure 20. Distribution of respondent rankings for the reduced damage attribute (community buildings; n=506)*

## CONSISTENT ATTRIBUTE RANKINGS FOR ALL BUILDING-USE TYPES

The graphs above show virtually identical distributions of attribute rankings across three building-use types. Office buildings differ slightly in that there is a lower willingness to pay tax, and this exception is discussed in the next section.

We are confident these findings are robust. These research findings are consistent with the qualitative findings in the Resilient Buildings Project (Brown et al., 2022) which also focused on the general building stock. Given the consistent results across all four surveys, we did not pursue further quantitative analysis on what factors explain variations in respondents' preferences for buildings' seismic performance.

Instead, we focused our available resources on exploring the factors driving differences in attitudes to willingness to pay taxes and sharing the burden of cost, as discussed in the next two sections.

# 4 Willingness to pay tax

## 4.1 Overall

In the following graphs we show how respondents ranked willingness to pay tax to fund seismic improvements. Figures 21-24 shows for each building use type the percentage of respondents that ranked willingness to pay (WTP) tax first (highest) through to fourth (lowest) relative to the other seismic performance attributes. Note that the lower ranking of the attribute means people are more reluctant to pay taxes. The graphs are 'U-shaped', meaning that a significant minority (20-25%) of respondents have a low willingness to pay tax to fund seismic strengthening, whereas more than 40% of respondents think that tax is the least important attribute and are willing to pay more tax to achieve better building seismic performance.

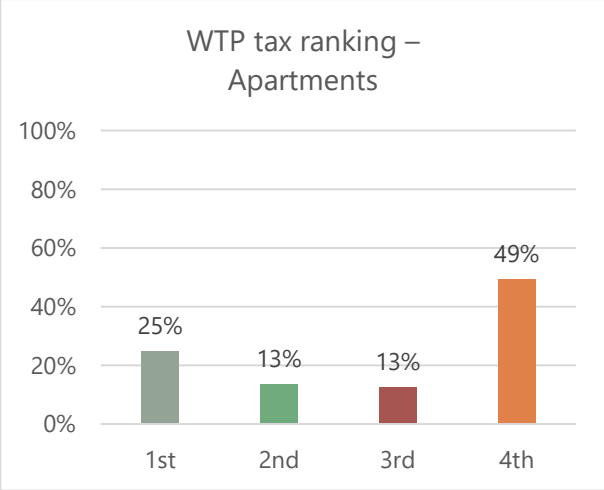



*Figure 21. Distribution of respondent rankings for the WTP tax attribute (apartments; n=519)*

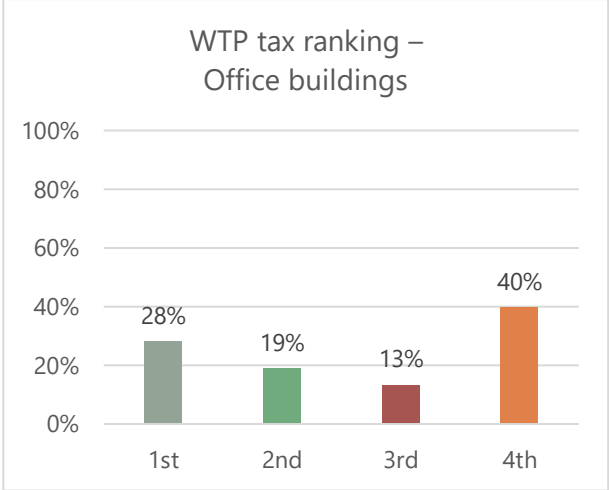



*Figure 23. Distribution of respondent rankings for the WTP tax attribute (office buildings; n=504)*

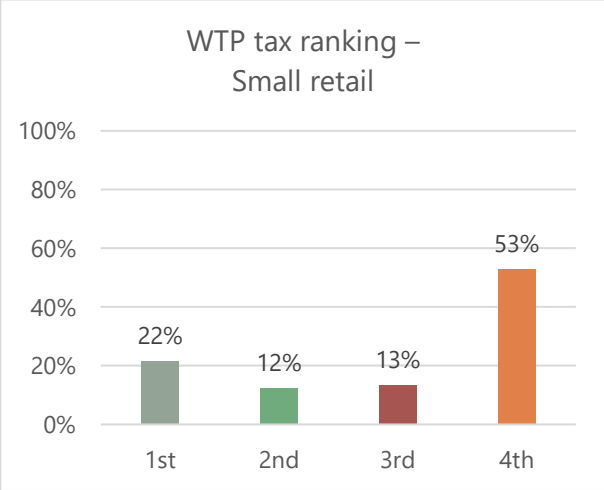



*Figure 22. Distribution of respondent rankings for the WTP tax attribute (small retail; n=504)*

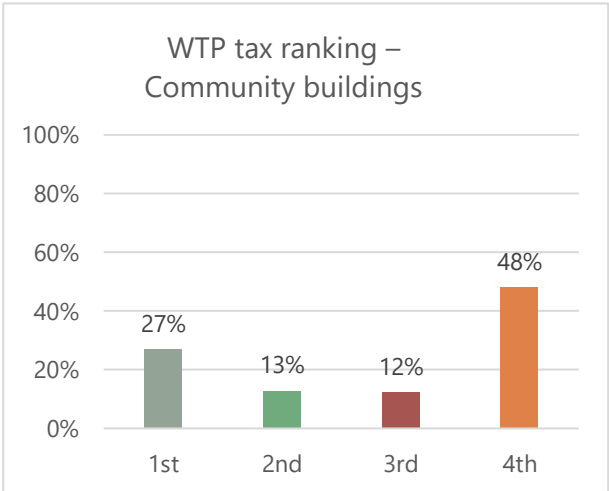



*Figure 24. Distribution of respondent rankings for the WTP tax attribute (community buildings; n=506)*

The similarity in the shapes of the graphs show willingness to pay tax is consistent across the four building-use types surveyed:

- Around half of respondents ranked tax fourth (lowest priority), showing some significant willingness to pay increased tax.
- The U-shape shows willingness to pay tax ranks first for a substantial minority of people (>30%) (these respondents favour less tax over other attributes: life safety, reduced damage and reduced disruption).
- Building-use type matters: there is higher willingness to pay taxes for apartments and small retail, moderate for community buildings and lowest for office buildings.

The detailed analysis of the implicit tax valuation (technically the utilities underpinning the willingness to pay) confirmed that willingness to pay is affected by building use. This analysis confirms that people are willing to pay 12.5% more tax to reduce risk to life, damage and disruption on apartments compared to office buildings. Similarly, people are willing to pay significantly more tax to improve the seismic performance of small retail than community buildings.

Overall, the surveys suggest some willingness to pay taxes to contribute to improving the performance of existing buildings, but the willingness to pay varies significantly by building-use type.

## 4.2 Impact of earthquake likelihood

The DCE survey scenario was based on expert advice that there is a 60% chance of a major (magnitude 7 or above) earthquake in the next decade. As discussed above, we included supplementary questions based on 40% and 80% chances respectively.

The survey responses suggest that willingness to pay tax for seismic strengthening is not very sensitive to the likelihood of earthquakes. This is consistent with the view from behavioural economics and psychology that people are not naturally equipped to think statistically (Kahneman, 2011) and the findings from a range of New Zealand research on natural hazard risk (e.g. Miranda et al., 2023).

There are two striking features from the results shown in Figures 25 and 26 below:

1. The dominant single response (20-50% of respondents) is that they would not change their willingness to pay despite the earthquake likelihood increasing or decreasing by 20%.
2. The responses are asymmetric: respondents were more likely to increase their willingness to pay tax with an increase in earthquake likelihood than to decrease contributions due to a decrease in earthquake likelihood.

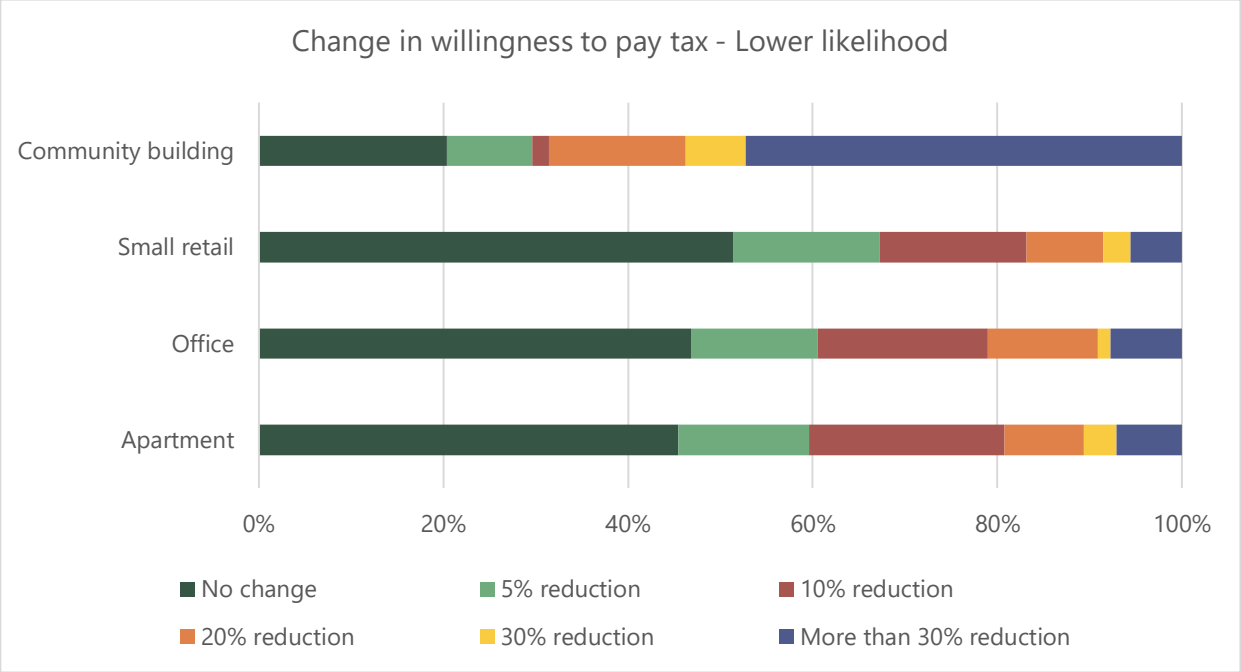



*Figure 25. Respondent preference for paying less tax if earthquake likelihood was lower (all buildings; n=2033)*

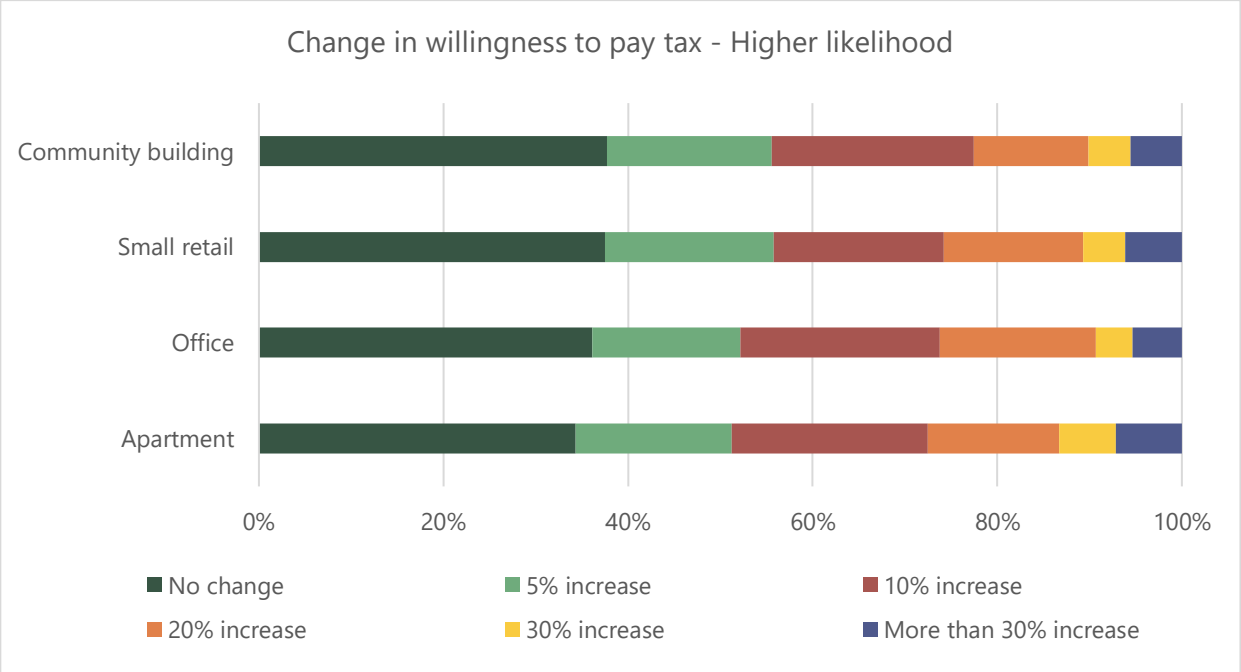



*Figure 26. Respondent preference for paying more tax if earthquake likelihood was higher (all buildings; n=2033)*

## 4.3 Factors influencing willingness to pay tax

When we reviewed the descriptive statistics for the results across the surveys, we found significant variation in willingness to pay tax within some demographic groups or groups with common environment factors. For example, willingness to pay tax was highly variable within each age group as shown in Figure 27 below. The results suggest a lower willingness to pay in the older age groups.

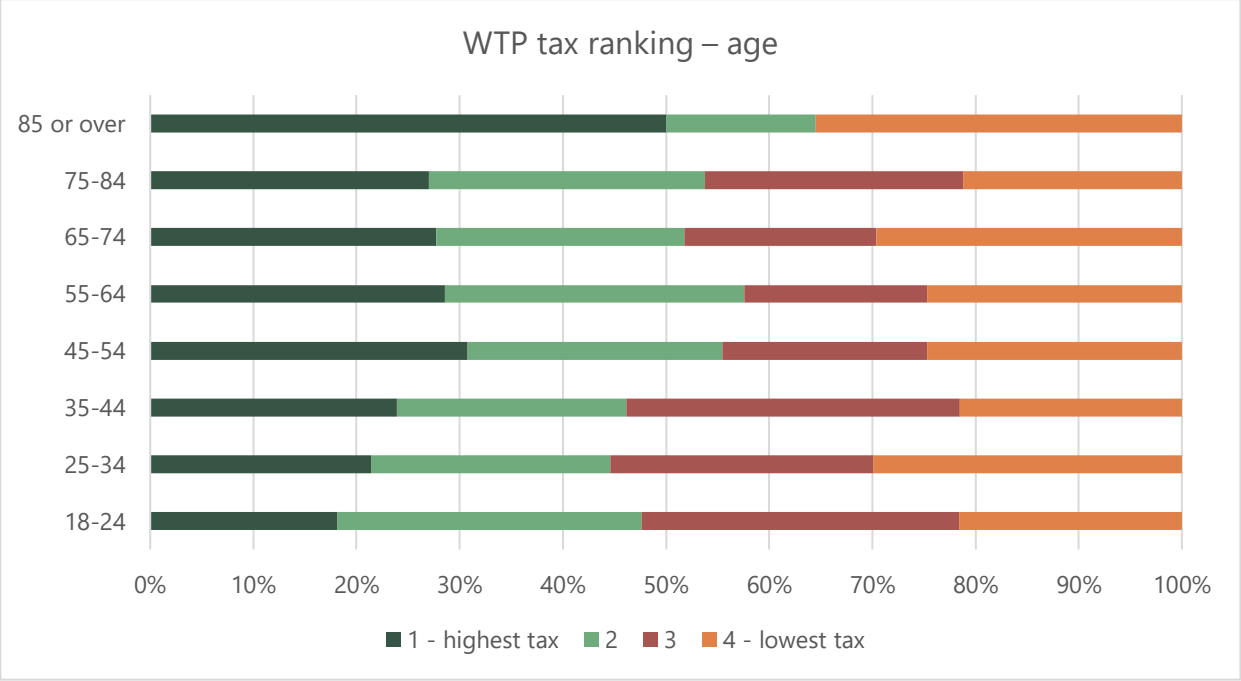



*Figure 27. Distribution of willingness to pay tax attribute by age group (all buildings; n=2033)*

We wanted to explore how much willingness to tax is affected by:

- environment factors: seismic risk zone, setting (urban, regional centres, rural)
- socio-demographic characteristics: gender, age, ethnicity, total income, dependents under 18, property ownership
- likelihood of earthquakes
- lived experience of earthquakes.

To do this we applied non-parametric tests to see if the difference of mean preference weight on willingness to tax between groups is statistically significant. Appendix D presents the analysis undertaken and the findings relating to willingness to pay in greater detail.

In summary, we used two main analytical techniques: partial multinomial logistic regression and cluster analysis.[5] As the DCE survey is based on ordinal (ranking) not cardinal (unit value)

[5] Fractional multinomial logistic regression is applied for decision-making data analysis of data that are in fraction form and all the alternatives add up to 1. The data produced by the 1000minds software is in the form of preference weights between all alternative choices that add up to 1. To assess the significance of differences between socio-demographic groups, a Fractional Multinomial Logistic Regression (FMLR) is applied. The FMLR model applied uses the quasi-maximum likelihood estimator which is standard for multinomial models (Papke and Wooldridge 1996)

rankings, partial multinomial logistic regression is used which compares one cohort (such as those aged 18-24) with all other cohorts (those aged over 24).

Some statistically significant differences did emerge in each survey that were not consistent. For example, some variables had a significant effect in some surveys but not others, Only three variables – age, gender and property ownership – were consistently associated with significant differences in attitudes to paying tax. For example, females and younger people (18-24) and non-homeowners had statistically significant lower willingness to pay taxes than the rest of the population in three of the four surveys.

The main finding from the regression analysis is that most of the variation in people's willingness to pay tax is independent of their socio-demographic characteristics and environment variables. It is possible this reflects an omitted variables problem – including more variables may help explain some variation. But given the range of variables included and the care taken in their selection, we think this is unlikely.

Moreover, when there was a significant effect, the size of the effect varied depending on the building-use type. For example, age is a stronger variable for apartments and small retail, but weak in office and community buildings. Gender plays a stronger role in apartments and minimal in small retail buildings, and none in offices. Notably, neither seismic hazard zone nor living environment (urban, regional or rural) had a significant influence on burden-of-cost perceptions.

Overall, what this analysis suggests is there is significant variation in willingness-to-pay tax preferences within each demographic group or those with common environment factors. Given the range of factors included, this suggests that the variation in these preferences reflects underlying differences in what people value. This conclusion is not inconsistent with other New Zealand studies using DCE – see Gill and Rolfe (2023) for similar findings on factors driving difference in attributes underpinning the value of the naval frigate force.

# 5 Burden of cost

## 5.1 Overall responsibility for cost

The burden-of-cost questions were included in each of the four surveys, so the survey results below represent n=2033 survey responses. Across all seven building-use types combined, the results show strong support for building owners having primary responsibility for the cost of building remediation but with significant minority support for some tax funded assistance (Figure 28).

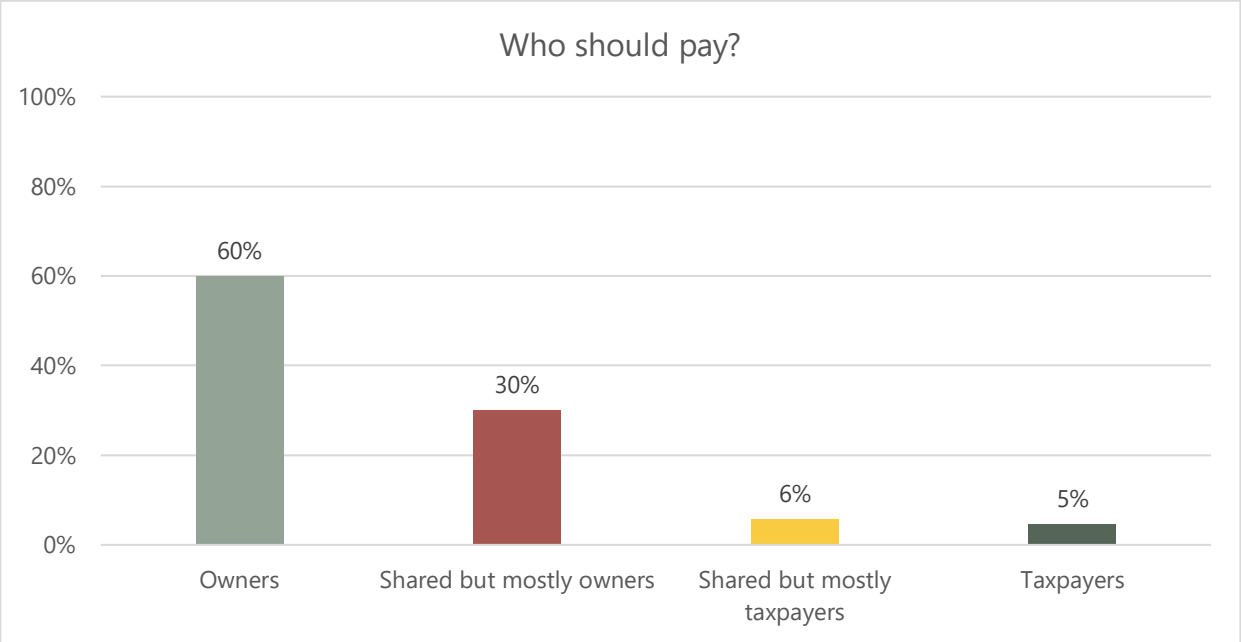



*Figure 28 Preferences for who should bear the cost of seismic remediation (all buildings; n=2033) rounded to whole number.*

These responses suggest strong majority support for funding being the sole responsibility of owners, followed by the main responsibility of owners, with only low support for sole or mainly tax-funded assistance.

Figure 29 looks at where the prime responsibility for earthquake strengthening should lie across all building-use and ownership types combined. It combines participant responses for "owners" and "shared but mostly owners" and compares this to the response for “taxpayers” and “mainly taxpayers”. Almost 90% of respondents indicated that building owners should have prime responsibility.

Figure 30 cuts the responses a different way. It contrasts the responses which support building owners having sole responsibility with those who support some level of tax-funded assistance. Although there was majority support (60%) for building owners having sole responsibility for seismic strengthening costs, there was substantial minority support (40%) for some tax-funded assistance.

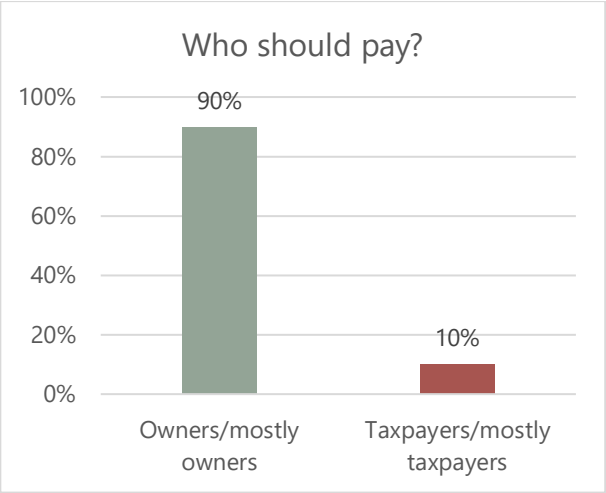



*Figure 29. Survey respondent preferences for who should pay for seismic strengthening costs – all/mostly owners or all/mostly taxpayers (all building purposes; n= 2033)*

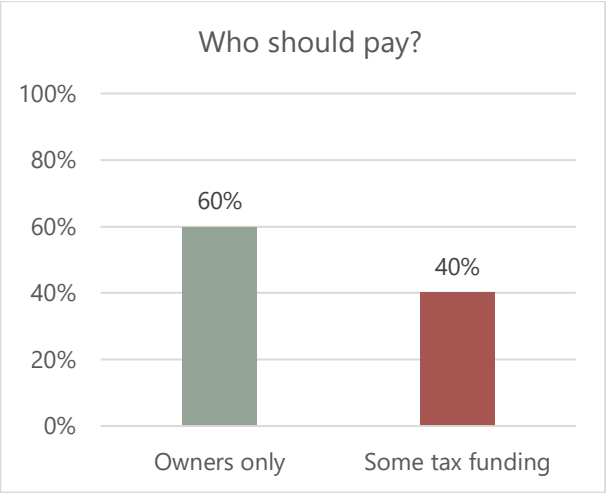



*Figure 30. Survey respondent preferences for who should pay for seismic strengthening costs – sole owners or some tax funding (all building purposes n= 2033)*

## 5.2 Burden of cost by building-use type

The discussion of the burden of cost to date has focused on all building purposes combined. The graphs below show how the strength of support for building owners' sole responsibility for burden of cost varies by building-use type.

Figure 31 shows how a building's use type (including both ownership and use) affects the split between preferences for building owners' sole responsibility and some tax funding. In summary there is:

- Majority support for the sole owner's responsibility for almost all building purposes.
- There is greatest support for some taxpayer contributions for private (individually owned) residential apartments and medical facilities at 49%.

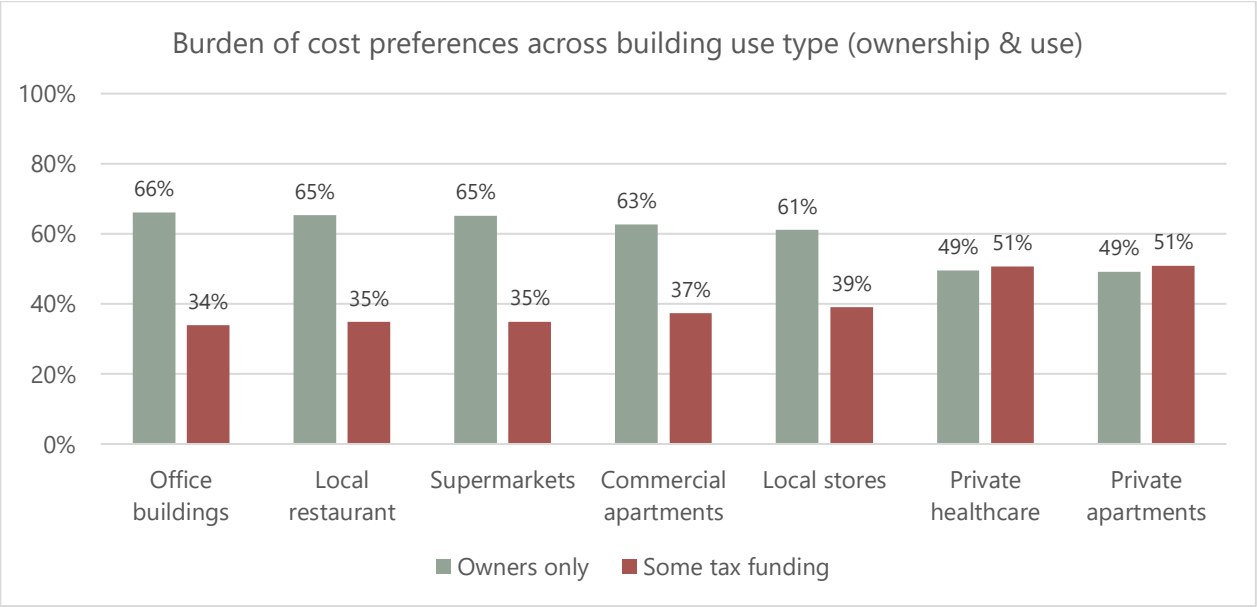



*Figure 31. Survey respondent preferences for burden of cost – owner only or some tax funding (all building purposes; n= 2,033)*

The range in the burden allocation by building purpose (shown in brackets) includes:

- The majority felt building owners should solely (49-65%, across 7 building-use types) or mainly (35-41%) pay for earthquake strengthening.
- Building owner sole responsibility was highest (65%) for office blocks and restaurants, lowest (49%) for private (individually owned) residential apartments and private health facilities.
- Low support for sole (3-10%) or main (3-9%) tax funding.
- But some support for some form of tax-funded assistance (35-51%).

## 5.3 Rationale for burden-of-cost perceptions

The survey concluded with a question on "Do you have any comments you'd like to share?". The text analysis summary, provided below, reinforced the survey findings above:

- The dominant sentiment was building owners should bear primary or complete responsibility for strengthening their own buildings, especially commercial property owners who profit from these assets.
- There was significant resistance to using general taxation to fund private building improvements.
- However, there is recognition that protecting life safety is paramount, and some respondents acknowledge the need for government support, particularly for small businesses and apartment owners who might struggle with costs.
- The comments reflect tension between individual responsibility and collective action in addressing seismic risks, with financial affordability concerns being particularly acute given the current economic climate and cost-of-living pressures.

To triangulate the survey responses, we utilised the interviews in the associated project on Remediation Behaviours (ResOrgs and JCDR, 2025) to explore in more detail the rationale for different responses to questions of who should bear the cost. In line with the survey results, all of the interview participants (N= 46) stated that the cost of seismic retrofit should either fall entirely on the building owner or should be shared but with the owner bearing most of the cost. The only trend based on building-use type was that owner-occupied residential apartments received more support for cost sharing than any of the other building-use types.

### REASONING FOR BUILDING OWNERS BEARING MOST OF THE COST

Many interviewees suggested that building owners should have some responsibility to pay for seismic strengthening because of their ownership responsibilities and associated financial benefits. They reasoned that as owners profit from the buildings through rental income and/or property value appreciation, they should also accept the risks and responsibilities, including the costs of managing the risk.

It was also suggested that owners should bear the cost because they may be able to partially recover the costs of strengthening by raising rental prices.

Others argued that things like earthquake strengthening are simply the costs of doing business, and that taxpayer money should not be available to commercial operators that make a profit.

There was also concern that the country cannot afford to have taxpayers contributing to private building upgrades.

The idea of "private buildings, private cost" was expressed extensively, with the principle that responsibility should fall with whoever benefits from building value.

### REASONING FOR COSTS TO BE SHARED BUT MOSTLY ACCRUING TO BUILDING OWNERS

Interviewees who suggested a shared approach to the cost of seismic strengthening reasoned that the principle of “greater good” applies. They highlighted that strengthening benefits society broadly through increased public safety.

Many interviewees suggested that while owners should bear most of the cost it might be unrealistic to expect all owners to be able to take on the entire cost, proposing that government assistance in some form may be necessary to solve the problem.

Regulatory changes were also a considerable factor in support of shared costs. Interviewees expressed that for buildings that had already been brought up to Code, the government should bear some responsibility for the costs if they change the Code/standards. Some reasoned that if regulations changed after someone purchased a building, they might be due more support than those who knew about the changes when they purchased.

Building use and criticality were noted by many as important factors. Building holding services like Hato Hone St John Ambulance that provide a public good might be deserving of more support. The fact that they are also not a primarily profit-driven organisation was also seen as justification for taxpayer support.

Heritage buildings were also mentioned as deserving of taxpayer support, as they are often seen to provide some kind of public good outside of their primary function. For buildings that are of local or national interest, interviewees recognised that a failure to upgrade could cause demolition of culturally significant areas, also justifying public-funding mechanisms.

Owner-occupied residential apartments were identified as most likely to need a shared-cost model. Many interviewees highlighted that certain challenges these owners face justify providing more support, such as multi-owner environments making decision-making complex, and financial considerations for individuals being different from those of commercial companies.

### URBAN VS REGIONAL CONSIDERATIONS.

Regional centres were considered more deserving of assistance due to the notion that the expense of strengthening could prove detrimental to a small town, particularly where property values and/or rental prices may be significantly less than those in urban areas. However, it was also noted that buildings in regional areas may also present less risk to people because of smaller populations.

Other economic factors were also considered to justify financial support for regional buildings. For instance, it was noted that higher-valued buildings in urban areas are more likely to be strengthened, whereas lower-valued buildings in regional areas might be sold or abandoned.

## 5.4 Central vs local government tax funding

In response to whether central government or local government tax money should contribute towards seismic risk strengthening, 30% of survey respondents had no preference. Of the remaining 70%, two-thirds supported general (central government) tax funding and one-third local government rates funding.

People who supported some level of taxpayer funding in the interviews undertaken for the associated MBIE-sponsored project on Remediation Behaviours (ResOrgs and JCDR, 2025), generally preferred central-government funding over local-ratepayer funding. The main reasons for this preference included:

- National policy should have national funding.
- The cost would be spread across more people.
- Building performance in earthquakes benefits the country as a whole.
- Smaller towns might not have sufficient resources.
- National funding ensures consistency.

Those favouring local ratepayer funding suggested that the local communities who benefit from buildings should bear the costs, particularly for heritage buildings and/or other buildings that have strong public significance to local communities.

## 5.5 Drivers of attitudes to burden of cost

Support for owners' responsibility and tax funding varies by socio-demographic and other characteristics. A regression analysis identified a range of statistically significant characteristics that explain differences in preferences for allocating burden of cost. The variables that were most consistently significant are listed below in rank order – starting with variables that were significant for five building-use types down to a cutoff at three building-use types.

1. Older individuals are more likely to put responsibility for burden of cost on owners for business apartments, office, supermarkets, local grocery stores, local restaurants than the 18-24 year-old age group.
2. Non-property investment owners are less likely to put responsibility on owner-occupied apartments and private health facilities; and they are more likely to put responsibility on owners for business apartment, offices, supermarket, local stores and private health.
3. Females are less likely than males to put responsibility on owners for business apartments, offices, supermarkets and local restaurants. Females are more likely than males to put responsibility on owners for private apartments, private health buildings and local stores.
4. People with no dependents living with them are less likely to put responsibility on owners for business apartments, and owners for offices and supermarkets.

The main finding from the regression analysis is that most of the variation in people's preferences for allocating responsibility for burden of cost is independent of their socio-demographic characteristics and environment factors. This is consistent with the analysis of the

willingness to pay reported above. Appendix D shows that some variables had a statistically significant effect some of the time (people with no children). Only 3 variables – age, gender and property ownership – were consistently associated with significant differences in attitudes to cost burdens across a range of tests. Notably, neither seismic hazard zone nor living environment (urban, regional or rural) had a significant influence on burden-of-cost perceptions.

# 6 Conclusions and future directions

The research brief raised three main research questions:

- Which seismic-performance attributes are most important?
- What is New Zealanders' willingness to pay?
- Where should the burden of cost lie?

It is evident from all four surveys that life safety is the primary seismic-performance attribute that New Zealanders desire in their buildings; and reduction in damage and disruption are of secondary importance.

There is some societal willingness to pay tax to fund improved seismic performance in a range of building-use types although this is lowest for offices.

When we asked about burden of cost, a majority of respondents felt that building owners should solely be responsible for paying the cost of seismic remediation. Though there was low support for sole (5%) or main (6%) tax funding, there was substantial minority support for partial tax-funded assistance (40%).

Support for owners having sole responsibility varied notably by building-use and ownership type. Support for sole owners' responsibility was particularly strong for commercial purposes such as office blocks and restaurants (65%). In contrast, it was much lower for social functions such as private apartments and private health facilities (49%).

There are three important caveats or limitations to this analysis that could be productively addressed in subsequent research.

The first limitation is the lack of structured data on commercial returns from investment in earthquake strengthening across a range of building-use types and locations. This study's survey data on willingness to pay tax and burden of cost both point to a preference for tax-funded support for non-commercial purposes over commercial purposes. The interview data suggested that this is because landlords can recover the costs via increased rental yields.

Empirical work (Filippova et al 2017) suggests that although an earthquake risk premium exists for office accommodation in Wellington, there is no corresponding commercial return in Auckland. New Zealand evidence on any earthquake risk premium in other centres or building-use types is also lacking.

Whether any risk premium that might exist is adequate to cover the costs of building remediation is also unknown. So, though the survey data presented in the report suggests that there a social licence for partial tax-based funding for non-commercial purposes, it is not clear that the exclusion of commercial functions has a robust foundation in market realities. Nor is it clear that any earthquake premium is adequate to recoup the costs of earthquake strengthening over time through increased rental streams from commercial investments.

A parallel research project by BECA (2025) – Economic Analysis of New Zealand's Earthquake Prone Building System – finds that the social returns to New Zealand from strengthening

earthquake-prone buildings are predominantly generated by the reduction of disruption to function. Reduced deaths and injuries and damage to buildings and their contents, while important, play a lessor role that varies across the earthquake event. Reductions in damage and direct disruption are the main commercial benefits to building owners to offset the costs of building remediation. Indirect benefits from reduced wider social disruption (including injuries and deaths) do not accrue to the building owner. In addition, unless the building owner is also the occupier, they are unlikely to capture or value the major benefits due to improved life safety from their investment in earthquake related upgrades.

Accordingly, a key area for future research and policy design is to achieve greater alignment between commercial and social returns. Specifically looking at who bears the risk, i.e. who is exposed to the seismic risk, who bears the cost (of remediating buildings), and who benefits from the remediation. However, how to achieve that goal is beyond the scope of this current study.

The second limitation of the present study is that it is unclear the extent to which survey respondents fully understood the risk of building disruption and the implications for the different stakeholders. Many respondents had not experienced a significant earthquake and may not understand, for example, the importance of some community buildings in emergency response or of reducing displacement of apartment dwellers in the aftermath of an earthquake. They also may not understand the economic impact of large-scale disaster recovery and who bears the cost for this. Similarly, participants may not have appreciated the potential for building owners to pass on remediation costs to tenants or customers. Our results reflect public perceptions; they should be balanced with expert analysis of risk to New Zealand Inc.

The third limitation is that the survey did not explore willingness to pay for strengthening heritage buildings. Heritage buildings were out of scope for this research because they include a wide range of building-use types and functions and we were concerned that the burden on respondents considering heritage issues would undermine the validity of the research findings (see Aigwi et al 2023 for some recent NZ evidence). Research to achieve greater understanding of New Zealanders' willingness to pay for the retention of heritage building would be a useful companion study to this one.

Overall, the data in the surveys is consistent with a social license for some tax-funded partial contributions to achieve improved seismic performance of some building-use types.

# 7 References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# Appendix A: Literature Scan

We commissioned a two-pronged approach to search for academic research on building earthquake risk looking for references on burden of cost and societal willingness to pay, and with a particular emphasis on DCE.

The search strategy employed Google Scholar to conduct a systematic literature scan using keywords including "Discrete Choice Experiments," "Societal Willingness to Pay," "Seismic Retrofitting," and "Seismic Risk Premium," with secondary searches exploring hedonic pricing studies and qualitative approaches to seismic preferences in comparable jurisdictions. We focused on published academic research in refereed journals and excluded 'grey' practitioner studies.

With respect to DCE approaches to willingness to pay, we identified two Italian studies on residential accommodation (D'Alpaos & Bragolus 2020, 2022) as part of our initial research design. So, we explored the references cited by D'Alpaos & Bragolus and also looked for more recent citations of their work.

D'Alpaos et al 2020 acknowledged the absence of studies using DCE to evaluate WTP for seismic retrofitting, and our own literature scan confirmed this.

Nonetheless, we found some research on willingness to pay for earthquake resilience in general (Chou et al., 2022; Sarin, 1983), and some around willingness to pay for other mitigation strategies such as for the electricity grid (Hotaling et al., 2021). As a result, we expanded our search to other hazards and mitigation strategies. In brief we found:

- Lots on willingness to pay for different types of mitigation, such as ranking preferences for different retrofitting options (Azimi & Asgary, 2013; Olschewski, 2013)
- Some literature around willingness to pay for hazard insurance – e.g. flooding (Glatt et al., 2019; Simmons et al., 2002)
- Some research around WTP for Property Level Flood Protection (PLFP), not using DCE – often surveys (Owusu et al., 2013; Kazmierczak & Bichard, 2010)
- Some studies around WTP for urban green space using DCE (Davies et al., 2023).

However, these studies did not speak directly to the research questions at hand.

Scanning the literature on who should bear the cost of seismic mitigation / retrofit revealed a significant gap. Most studies focus on who currently bears the cost rather than exploring alternative funding models. The question of who *should* bear the cost is noticeably absent.

Building owners currently shoulder the financial burden of earthquake strengthening in New Zealand, with 90% of interviewees in one study describing retrofit costs as excessive and unfairly placed solely on property owners (Egbelakin et al., 2014). While some jurisdictions like China have experimented with full government funding (which strains public finances) (Zhang et al., 2022), owners across multiple countries express frustration at being held responsible for natural disaster mitigation beyond their control (Ministry of Business Innovation and Employment, 2021).

This literature raises questions about whether approaches based on sole owner responsibility are adequate. Researchers canvassed various alternative mechanisms including grants, subsidies, insurance warranties, and development incentives (Zhang et al., 2022), However comprehensive analysis of optimal cost-sharing arrangements remains limited.

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# Appendix B: The DCE approach

The point of difference for the stated-preference approach is that it uses a carefully designed survey to explore the general public's willingness to pay increased taxes to fund improvements in buildings' seismic performance. This technique involves a discrete choice experiment (DCE) (McFadden 1973) in which respondents are asked via a survey to express their preferences by choosing between two or more multi-attribute alternatives (Johnston et al 2017). DCEs are based on Lancaster's theory of consumer demand, where the value of a good is derived from the fundamental attributes of the good (Lancaster 1966). The advantage of this approach is the ability to measure citizens stated WTP tax to fund improved building performance. Note DCE is often used to assess individual willingness to pay but the technique is also applicable to assessing societal willingness to pay through changes in taxation.[6]

We used the 1000minds software, an online DCE survey platform. DCE surveys were used to elicit the public's preferences by having them repeatedly choose between two hypothetical scenarios with respect to the building performance where the scenarios were described according to two performance related attributes at a time and involving a trade-off.

From each participant's answers to such questions (~30 per person), the software determines weights on the attributes, representing their relative importance to the person. The software can be thought of as converting each participant's survey responses into their individual utility function.

## Survey design

Four parallel DCE surveys were administered simultaneously to explore people's stated WTP for the building seismic performance for different building-use types: apartments, small retail, offices, and community buildings. We used a survey research company (Dynata) with a large base of clients who are rewarded for computer-based surveys. The research company sent the surveys out to a mixture of respondents to ensure that the samples were broadly representative of New Zealand's socio-economic characteristics by age, gender and region.

Each DCE survey involved ~30 pairwise comparisons plus some questions about people's socio-demographic and environment characteristics. The survey had an internal consistency test involving two repeated questions. We excluded those whose responses were contradictory (possibly because they carelessly or randomly answered the questions) and re-sampled.

In effect, the software estimates a cardinal utility function (i.e. a measurable function) for each person that is consistent with their responses to the questions. Each level for each attribute is given a weight: the lowest-ranked level for each attribute gets a weight of zero, and the sum of weights across the attributes = 1 (100%).

[6] see the discussion at https://www.1000minds.com/conjoint-analysis/what-is-conjoint-analysis#marginal-wtp

# Survey questions

This DCE was designed to examine the trade-offs participants are willing to make across various levels of four possible building seismic-performance attributes. The non-tax attributes reflect the main dimensions of performance identified by previous NZ research – life safety, damage and disruption. A tax attribute – i.e. "Increase in your tax for earthquake strengthening" – was also included in the DCE to enable relative values of the other building seismic-performance attributes, in terms of willingness to pay or accept, to be estimated.

All of the building seismic-performance attributes and the tax attribute were defined on three levels, ranging from lowest ranked ('worst' possible) to highest ranked ('best' possible).

The attributes were:

| **Risk to life** | |
|---|---|
| High | High (i.e. likely to be some deaths and & many injuries) |
| Medium | Medium (i.e. likely to be some injuries, low chance of deaths) |
| Low | Low (i.e. very low chance of deaths or injuries) |

| **Risk to of damage to buildings and content** | |
|---|---|
| High | High (i.e. expensive damage, needing major repair or rebuild) |
| Medium | Medium (i.e. likely to be some serious damage) |
| Low | Low (i.e. very little damage, at most a few superficial cracks) |

| **Risk to lengthy disruption to building use** | |
|---|---|
| High | High (i.e. unusable for a long time) |
| Medium | Medium (i.e. some loss of function, but still usable) |
| Low | Low (i.e. immediately usable) |

| **Increase in your tax for earthquake strengthening** | | | |
|---|---|---|---|
| **Community building** | **Small retail** | **Apartments** | **Offices** |
| $20 per year | $25 per year | $65 per year | $65 per year |
| $5 per year | $5 per year | $15 per year | $15 per year |
| No increase | No increase | No increase | No increase |

The survey questions were tested using a three-track approach with initial development, cognitive testing of a pilot survey followed by full roll out.

The survey was implemented using 1000minds software[1] which implements the PAPRIKA[2] method (Hansen and Ombler 2008). Respondents are presented with a series of discrete choices and asked to make a choice.

Each choice requires the respondent to confront a trade-off between the two attributes contained in the question (assuming the other attributes are the same). Comparing only two building seismic-performance attributes at a time keeps this exercise as simple as possible. The wording of the attributes and levels was intended to be as accessible and understandable as possible. Figure B1 shows an example of the choices that participants are presented with in the survey.

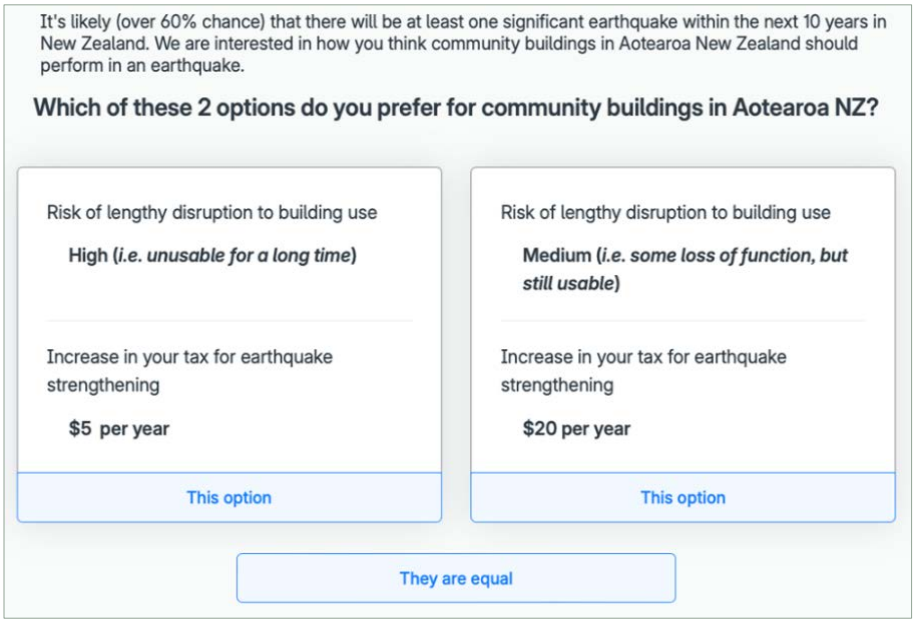



*Figure B1: Example of a DCE trade-off question in the survey*

Central to the efficiency of the PAPRIKA method is the method's exploitation of the mathematical and hence logical properties of additive "multi-criteria value models", including the transitivity property[3]. Each time a respondent answers a question – i.e. ranks a pair of options; all other options that can be pairwise ranked are identified and eliminated. Then a new question is chosen for the participants. In other words, the software adapts as the person answers their questions, such that this type of DCE is known as *adaptive* DCE.

PAPRIKA's adaptivity ensures that the number of trade-off questions each respondent is asked is minimised – here 29, on average – but all possible options are pairwise ranked, either explicitly or implicitly. Consistency tests were applied to selected questions as a quality check. Finally, from the respondent's explicit pairwise rankings, the software uses linear programming techniques to derive weights (known as 'part-worth utilities' in the DCE literature) for each attribute, representing their relative importance to the respondent. As well as weights for each individual respondent, the weights are averaged across all respondents.

A major strength of the PAPRIKA method is that a set of weights is generated for each individual respondent, in contrast to most other DCE methods, which produce aggregated data only. This individual-level data permits a cluster analysis (Späth 1980) to be performed, enabling any 'clusters' of respondents with similar patterns of weights to be identified. It also means that it is possible to infer intermediate points between, say, "marginally increased" and "significantly increased" using interpolation techniques.

[1] https://www.1000minds.com/

[2] PAPRIKA is an acronym for Potentially All Pairwise Rankings of all possible Alternatives. PAPRIKA was developed by 1000minds to make decisions as cognitively easy as possible while remaining scientifically robust. For more information visit: https://www.1000minds.com/paprika

[3] Transitivity is easily illustrated as follows. For example, if option X is ranked ahead of option Y and also Y is ranked ahead of option Z, then, by transitivity, X must be ranked ahead of Z – and so the PAPRIKA method eliminates this third pair of options and any other pairs implied by transitivity, thereby saving the respondent from being asked any such (redundant) questions pertaining to these implied rankings.

# Appendix C: Survey questions

**Your Priorities for [Building-use Type] Performance in an Earthquake**

This survey is about earthquake resilience of [BUILDING-USE TYPE] in Aotearoa New Zealand. Tell us your priorities between life safety, damage, building use, and willingness to pay for strengthening.

Your responses in this survey will directly inform the current government review of how New Zealand manages earthquake risk in existing buildings, to ensure the system is effective, workable, and proportionate.

Your participation is voluntary, and you are free to withdraw from the project at any time before you complete the survey. All responses provided in this survey are anonymous.

The survey should take approximately 20 minutes to complete.

This research has been commissioned from Dynata by ResOrgs for the Ministry of Building, Innovation and Employment (MBIE).

*Your feedback is invaluable, as our research findings rely entirely on your input, by completing this survey you are agreeing to provide honest and accurate responses.*

*To ensure data quality, we will review responses during and after the survey. If responses are incomplete or inconsistent, we may disqualify you from the survey.*

*This project has been evaluated by peer review and judged to be low risk. If you have any concerns about the ethical conduct of this research that you wish to raise other than with the organisations conducting this research, please email Massey University Human Ethics: humanethics@massey.ac.nz*

**To start with, a few questions about yourself**

To make sure we have a good mix of New Zealanders, all questions require an answer. Your answers are completely anonymous.

Which NZ region have you lived in the most in the last 12 months? *

- Northland
- Auckland
- Waikato
- Bay of Plenty
- Gisborne
- Hawke's Bay
- Taranaki
- Manawatu-Wanganui
- Wellington
- Tasman
- Nelson
- Marlborough
- West Coast

- Canterbury
- Otago
- Southland
- Outside New Zealand

Which of the following best describes where you have lived most in the last 12 months? *

- Large urban centre (*more than 100,000 people*)
- Medium sized centre (*1,000 to 100,000 people*)
- Rural area (*less than 1,000 people*)

What is your age group? *

- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65-74
- 75-84
- 85 or over

Which gender do you most identify with? *

- Female
- Male
- Another gender

From all sources of income (excluding loans), what was your total income in the last 12 months (before tax)? *

- $30,000 or less
- $30,001 – $50,000
- $50,001 – $70,000
- $70,001 or more
- Prefer not to say

Which ethnic group do you most identify with? *

- New Zealand European
- Māori
- Pacific Islander
- Asian
- Other

Are you the sole/shared carer for any children aged under 18? *

- Yes
- No

Do you own property? (Tick any options that apply) *

- Own home
- Residential investment property

- Commercial property
- Other
- None

Have you or your close family or friends directly experienced a damaging earthquake? *

- Yes
- No

**DISCRETE CHOICE EXPERIMENT**

*Participants are presented with a scenario and given a set of options to choose from. The options are based on a set of pre-defined attributes. The 1000minds software creates options for participants based on their prior choices until a clear ranking of attributes is arrived at.*

*The attributes are:*

| ***Risk to life*** | |
|---|---|
| *High* | *High (i.e. likely to be some deaths and & many injuries)* |
| *Medium* | *Medium (i.e. likely to be some injuries, low chance of deaths)* |
| *Low* | *Low (i.e. very low chance of deaths or injuries)* |

| ***Risk to of damage to buildings and content*** | |
|---|---|
| *High* | *High (i.e. expensive damage, needing major repair or rebuild)* |
| *Medium* | *Medium (i.e. likely to be some serious damage)* |
| *Low* | *Low (i.e. very little damage, at most a few superficial cracks)* |

| ***Risk to lengthy disruption to building use*** | |
|---|---|
| *High* | *High (i.e. unusable for a long time)* |
| *Medium* | *Medium (i.e. some loss of function, but still usable)* |
| *Low* | *Low (i.e. immediately usable)* |

| ***Increase in your tax for earthquake strengthening*** | | | |
|---|---|---|---|
| ***Community building*** | ***Small retail*** | ***Apartments*** | ***Offices*** |
| *$20 per year* | *$25 per year* | *$65 per year* | *$65 per year* |
| *$5 per year* | *$5 per year* | *$15 per year* | *$15 per year* |
| *No increase* | *No increase* | *No increase* | *No increase* |

**The scenario is:**

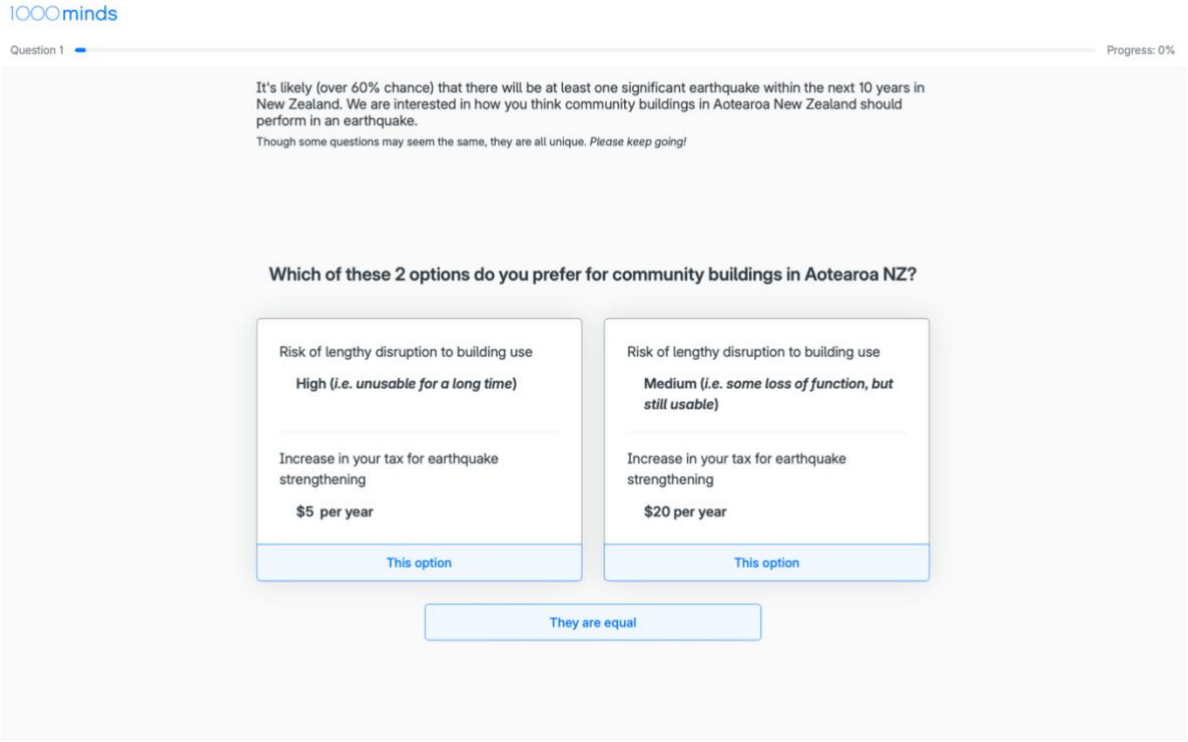
It's likely (over 60% chance) that there will be at least one significant earthquake within the next 10 years in New Zealand. We are interested in how you think [BUILDING-USE TYPE] in Aotearoa New Zealand should perform in an earthquake.

**QUESTION format**

Though some questions may seem the same, they are all unique. *Please keep going!*

**Which of these 2 options do you prefer for [BUILDING-USE TYPE] in Aotearoa NZ?**

*Screen shot of example choice:*




**We now have questions about who should pay for earthquake strengthening of different building types.**

For each of the following types of building, please select who you think should pay for earthquake strengthening.

Who should pay for the earthquake strengthening of owner-occupied *apartments*? *

- Apartment owners
- Taxpayers
- Shared but mostly apartment owners
- Shared but mostly taxpayers

Who should pay for the earthquake strengthening of apartments owned by *commercial businesses*? *

- Apartment building owners
- Taxpayers
- Shared but mostly building owners
- Shared but mostly taxpayers

Who should pay for the earthquake strengthening of private *office buildings*? *

- Office building owners
- Taxpayers
- Shared but mostly building owners
- Shared but mostly taxpayers

Who should pay for the earthquake strengthening of privately-owned *health facilities* (e.g. local medical centres)? *

- Building owners
- Taxpayers
- Shared but mostly building owners
- Shared but mostly taxpayers

Who should pay for the earthquake strengthening of *supermarkets*? *

- Building owners
- Taxpayers
- Shared but mostly building owners
- Shared but mostly taxpayers

Who should pay for the earthquake strengthening of local *grocery stores* (e.g. dairies)? *

- Building owners
- Taxpayers
- Shared but mostly building owners
- Shared but mostly taxpayers

Who should pay for the earthquake strengthening of local *restaurants*? *

- Building owners
- Taxpayers
- Shared but mostly building owners
- Shared but mostly taxpayers

If taxpayer money is used for earthquake strengthening, who should cover most of the cost? *

- General taxpayers
- Local ratepayers
- No preference

**Almost done!**

You answered questions about your priorities of four key attributes for community buildings in an earthquake. Based on your responses, here is how these priorities rank for you, from most to least important.

Does this ranking of the community building and tax attributes seem about right to you?

- Yes
- No

If not, how is it different from how you feel about the attributes?

Imagine the chance of an earthquake within the next 10 years is less likely (40% chance). How much would your willingness to pay taxes for earthquake strengthening *reduce* by?

- No change
- 5% reduction
- 10% reduction
- 20% reduction
- 30% reduction
- More than 30% reduction

Imagine the chance of an earthquake within the next 10 years is more likely (80% chance). How much would your willingness to pay taxes for earthquake strengthening *increase* by?

- No change
- 5% increase
- 10% increase
- 20% increase
- 30% increase
- More than 30% increase

Overall, how did you find understanding this survey?

- Difficult
- Reasonably difficult
- Reasonably easy
- Easy

Do you have any comments you'd like to share? Please write them here:

# Appendix D: Willingness to pay additional tax

## Regression and cluster analysis

The first phase of the analysis highlighted the notable variation in New Zealanders' willingness to pay additional tax to fund seismic strengthening. For example, the willingness to pay tax attribute was the least important attribute for the majority but the most important for a significant minority (30%).

We undertook Fractional Multinomial Logistic Regression analysis of each of the four surveys to determine whether any demographic or environment characteristics of respondents could explain the differences in people's views.

### FRACTIONAL MULTINOMIAL LOGISTIC REGRESSION

The data produced by the 1000minds software is in the form of preference weights between all alternative choices that add up to 1. To assess the difference between each choice's preference weight, and between demographic groups, a Fractional Multinomial Logistic Regression (FMLR) is applied. Fractional multinomial logistic regression is applied for decision-making data analysis of data that are in fraction form and all the alternatives add up to 1, and so it is an expansion of the multinomial logit to fractional responses. This model is applicable for data that are a percentage of a budget, or fractions of a population. The FMLR model applied uses the quasi-maximum likelihood estimator. The quasi-maximum likelihood function is a standard for multinomial models (Papke and Woolridge, 1996).

### READING THE RESULTS

The Coefficients of the FMLR model show the value of difference between choices and/or between demographic groups. A negative sign means a lower likelihood of choosing an alternative, and a positive means a higher likelihood of choosing that choice, over the base choice. The way the FMLR models show its results is that it chooses a base choice (one of the choices) and compares the other choices compared to base choice, by each subgroup of a demographic group – e.g. how choice A (base choice) compares to B by Gender (male versus female).

The P value of the result shows if the difference is statistically significant. A statistic is considered significant if it fulfils a confidence interval in the range 90-99%. The confidence interval is interpreted as the confidence level that the result is true for the sample. The results that have a (*), (**), (***) are statistically significant at 90%, 95%, and 99% respectively. The report only shows results that are statistically significant because if they do not fulfil the confidence level threshold, then the results mean that there are no significant differences between choice and by socio-demographic factors.

The FMLR applied uses base choice (highlighted in the table below) such as WTP tax male, and those aged 18-24 as the base demographic subgroups. The results shown are all compared to the base mentioned above.

### STATISTICALLY SIGNIFICANT RESULTS

The following tables show the main findings from the FMLR analysis of willingness to pay tax in the four surveys. We undertook additional analysis, including removing certain variables such as urban, living environment, hazard region, and a combination of them. However, the results were not materially different and are not reported here. Note that for gender we asked respondents whether they identified as male, female or another gender. Because of the small numbers, we combined another gender with female to create a non-male grouping.

### APARTMENTS

| **Tax choice as base** | **Life** | **Damage** | **Disruption** |
|---|---|---|---|
| | Coefficient | | |
| 18-24 | | | |
| 25-34 | -1.202 | -0.531 | -0.172 |
| 35-44 | -0.247 | -0.189 | -0.238 |
| 45-54 | -0.250 | -0.093 | -0.089 |
| 55-64 | -0.408** | -0.282* | -0.288* |
| 65+ | -1.132 | -0.008 | 0.041 |
| Male | | | |
| Non-Male | 0.375*** | 0.358*** | 0.253*** |
| New Zealand European | | | |
| Māori | -0.157 | -0.153 | 0.500 |
| Pacific Islander | -0.031 | 0.020 | 0.057 |
| Asian | -0.920 | -0.197 | 0.055 |
| Other | -0.221 | -0.061 | -0.063 |
| Mixed ethnicity | -0.326* | -0.275* | -0.262* |
| Child | | | |
| No | 0.137 | 0.460 | 0.049 |
| $30,000 or less | | | |
| $30,001-$50,000 | 0.202 | 0.252* | 0.292** |
| $50,001-$70,000 | 0.177 | 0.207 | 0.227* |

| | | | |
|---|---|---|---|
| $70,001 or more | 0.286** | 0.286** | 0.230* |
| Prefer not to say | -0.061 | -0.027 | 0.050 |
| Homeowner | | | |
| No | 0.228** | 0.245** | 0.211** |
| Property Investment | | | |
| Commercial property | -0.082 | -0.642 | -0.153 |
| Other | 0.008 | -0.162 | -0.256 |
| Residential and commercial | 0.627*** | 1.26*** | 1.13*** |
| Residential and other | 0.935*** | 1.13*** | 0.664** |
| None | -0.041 | -0.073 | -0.195 |
| Earthquake experience | | | |
| No | 0.003 | -0.313 | 0.019 |
| Hazard Region | | | |
| Medium | -0.011 | -0.023 | 0.070 |
| High | -0.353 | -0.346 | -0.148 |
| Living environment | | | |
| Regional Regional | -0.074 | -0.047 | -0.086 |
| Rural | -0.178 | -0.134 | -0.120 |
| Urban | | | |
| Urban other | 0.369 | 0.320 | 0.148 |
| Regional | omitted due to collinearity | | |
| Rural | omitted due to collinearity | | |
| Seismic | | | |
| High other | 0.554 | 0.416 | 0.354 |
| Medium Urban | -0.549 | omitted due to collinearity | |
| Medium Other | omitted due to collinearity | 0.067 | 0.123 |
| Low | -0.054 | -0.044 | -0.035 |

In summary, though most of the social and environment variables included were not statistically significant, a handful of variables were. These results include:

- People aged 55-64 put greater weight on Life/Damage/Disruption than 18-24 year olds than on Tax (significant)
- Non-Male put greater weight on Tax than Life/Damage/Disruption than male (significant)
- NZ European put greater weight on Tax than Life/Damage/Disruption than mixed ethnicity group (significant)
- Higher income put greater weight on Tax than on Life/Damage/Disruption than the lowest income group (significant)
- Non-homeowner put greater weight on Tax than Life/Damage/Disruption than Homeowners (significant)
- Those living in Rural put less weight on Tax than those living in Urban (significant)

OFFICES

| Life | Damage | Disruption |
|---|---|---|
| 0.337*** | 0.308** | 0.165 |
| 0.047 | -0.026 | -0.073 |
| -0.127 | -0.069 | -0.108 |
| 0.235 | 0.16 | 0.107 |
| 0.226 | 0.257 | 0.303** |
| | | |
| 0.078 | 0.037 | 0.089 |
| | | |
| -0.306** | -0.217 | -0.34** |
| -0.332* | -0.334* | -0.179 |
| -0.148 | -0.082 | -0.065 |
| 0.075 | 0.026 | 0.062 |
| 0.258 | 0.311* | 0.154 |
| | | |
| -0.026 | 0.019 | -0.032 |
| | | |
| 0.086 | 0.124 | 0.103 |
| -0.089 | -0.071 | -0.081 |
| 0.063 | 0.166 | 0.150 |
| -0.377** | -0.260 | -0.273* |
| | | |

| | | |
|---|---|---|
| 0.232** | 0.306*** | 0.250*** |
| | | |
| -0.749*** | -0.349 | 0.048 |
| -0.071 | 0.058 | 0.323 |
| -0.981*** | 0.236 | 0.645*** |
| -0.834*** | -1.04*** | -1.373*** |
| 0.031 | 0.681 | 0.352 |
| | | |
| -0.131 | 0.071 | 0.048 |
| | | |
| -0.081 | -0.071 | -0.062 |
| -0.152 | -0.324 | -0.315 |
| | | |
| 0.015 | 0.029 | 0.085 |
| 0.182 | 0.175 | 0.215 |
| | | |
| 0.292 | 0.448** | 0.406** |
| omitted due to collinearity | | |
| omitted due to collinearity | | |
| | | |
| 0.398 | 0.202 | 0.133 |
| -0.421 | -0.579* | -0.432 |
| omitted due to collinearity | omitted due to collinearity | omitted due to collinearity |
| -0.097 | omitted due to collinearity | -0.129 |

As with apartments, for offices a handful of variables are statistically significant while most of the socio-demographic and environment variables included were not. Moreover, a different mix of variables are statistically significant:

- People 25-34 put greater weight on Tax than 18-24 (significant)
- Non-homeowner put greater weight on Tax than Life/Damage/Disruption than Homeowners (significant)
- Those living in Rural put more weight on Tax than those living in Urban (significant)

### SMALL RETAIL

- Age groups older than 18-24 put greater weight on Life/Damage/Disruption than 18-24 than on Tax (significant)
- Male put greater weight on Tax than Life/Damage/Disruption than Non-male (significant)
- Māori put greater weight on Life/Damage/Disruption than Tax compared to NZ European (significant)
- Non-homeowner put greater weight on Tax than Life/Damage/Disruption than Homeowners (significant)
- High hazard region put greater weight on Life/Damage/Disruption than on Tax (significant)
- Urban other put greater weight on Tax than Urban Auckland (significant)

### COMMUNITY BUILDINGS

- Male put greater weight on Tax than Life compared to Non male (significant)
- Rural put greater weight on Life/Damage/Disruption than on Tax compared to Urban (significant)

For completeness we have included the results for small retail and community buildings below.

| Small retail | | | | Community building | | |
|---|---|---|---|---|---|---|
| Life | Damage | Disruption | | Life | Damage | Disruptio |
| | | | | | | |
| | | | | | | |
| -0.155 | -0.094 | -0.183 | | 0.155 | 0.174 | 0.118 |
| -0.264 | -0.373** | -0.324** | | -0.08 | 0.002 | 0.104 |
| -0.277 | -0.283 | -0.274* | | -0.207 | -0.147 | 0.003 |
| -0.460** | -0.430** | -0.352** | | -0.115 | -0.114 | 0.049 |
| -0.541*** | -0.373** | 0.164 | | -0.254 | -0.088 | 0.083 |
| | | | | | | |
| 0.204** | 0.173** | 0.199** | | 0.207** | 0.129 | 0.089 |
| | | | | | | |
| -0.358* | -0.188 | -0.383** | | -0.169 | 0.128 | -0.02 |
| -0.623* | -0.352 | -0.11 | | -0.493 | -0.269 | -0.133 |
| -0.300** | -0.181 | -0.119 | | -0.370*** | -0.316*** | -0.229** |
| -0.398** | -0.443*** | -0.312** | | 0.239 | 0.201 | 0.225 |

### CLUSTER ANALYSIS

The cluster analysis identified four clusters grouped around those with highest tax weighting (e.g. those with the lowest WTP tax) to lowest tax weighting.

**Apartments**

- Highest Tax weighting: male***, 55-64, equal earthquake experience, medium hazard region, rural, medium urban
- Lowest tax weighting: Non-male***, 65+, earthquake experience, medium hazard region, medium sized population, urban other, medium urban

**Offices**:

- Highest tax weighting: male, 45-54***, no earthquake experience**, medium hazard region, medium sized population, urban Auckland, low seismic
- Lowest tax weighting: male, 65+***, no earthquake experience**, low hazard region, rural, medium urban

**Small retail**:

- Highest tax weighting: male**, 35-44*, no earthquake experience, low hazard region, medium size population, urban Auckland***, high urban
- Lowest tax weighting: non-male**, 25-34*, earthquake experience, high hazard region, large urban, urban other***, low seismic

**Community buildings**:

- Highest tax weighting: male, 45-54, no earthquake experience, medium hazard region, rural, high urban
- Community building lowest tax weighting: non-male, 25-34, earthquake experience, high hazard, large urban, urban other, high other.

# Appendix E: Regression and cluster analysis of burden of cost

Appendix D summarised the analysis of willingness to pay for seismic strengthening found in four parallel DCE surveys with each focused on one building-use type – apartments, offices, small retail and community buildings – to address the first two research questions. We reported on the use of cluster and regression analysis to explore what were the drivers of differences in attitudes to willingness to pay taxes.

In this appendix we present a similar analysis for the survey questions on the burden of cost. The burden-of-cost section of the survey used conventional closed-ended questions and explored a wider range of building purposes. We split apartments into owner-occupied and commercially owned, distinguished supermarkets from local grocery stores (e.g. dairies), and added community health centres and local restaurants.

Because the burden of cost questions were identical, all four survey results can be combined (N=2033). Detailed regression results are available on request.

The regression analysis identified a range of characteristics that appeared to be statistically significant in explaining differences in preferences for allocating burden of cost. These are listed below ranked from those that were significant for the most building purposes (5 purposes out of 7) to least (1 purpose of 7).

- Individuals older than the 18-24 group were more likely to put responsibility on Owners for Business Apartments, Office, Supermarket, Local Store, Restaurant than the 18-24 group
- Non-property investment owners less likely to put responsibility on Owners for Privately (individually) owned Apartment and Health; and more likely on Owners for Business (Commercially owned) Apartment, Office, Supermarket, and Local Store
- Non-Male less likely than male to choose Owners for Business (commercially owned) Apartment, Office, Supermarket, Restaurant
- Non-Male more likely than male to choose Owners for Private (individually owned) Apartment, Health Building, and Local Store
- People with no dependents less likely to put responsibility on Owners for Business (commercially owned) Apartments, and are more likely to put responsibility on non-owners for Office and Supermarket
- Individuals older than the 18-24 group less likely to put responsibility on Owners than the 18-24 group for Private (individually owned) Apartments and health buildings
- Non-Homeowner more likely to put responsibility on Owners for Office and Non-Owners for Supermarkets
- People with No Earthquake experience more likely to put responsibility on Non-owners for Private (individually owned) Apartments
- People living in medium hazard region are more likely to put responsibility on Non-owners for Private (individually owned) Apartments.

- People living in Rural areas are more likely to put responsibility on Owners for Business (commercially owned) Apartments.

Another way of cutting the data review is by building purpose e.g. private (individually owned) apartments, supermarkets etc. In summary, the key characteristics of people likely to assign the burden of the costs to owners as opposed to taxpayers for particular purposes are:

- More likely private apartment owners: 18-24, non-male, property investment owners, no earthquake experience, medium hazard region
- More likely commercial apartment owners: older groups, male, dependents, non-property investment owners, urban area
- More likely private office owners: older groups, male, dependents, non-homeowner, non-property investment owners
- More likely owners of private health providers: 18-24, non-male, property investment owners
- More likely supermarket owners: older groups, male, dependents, homeowner, non-property investment owners,
- More likely local store owners: older groups, non-male, non-property investment owners,
- More likely local restaurant owners: older groups, male.

The table below shows the results from the Chi-square test to assess whether the proportion of people choosing owners' responsibility compared to non-owners are significantly different across the purposes. It suggests age, gender, home ownership, other property ownership and earthquake experience are significant variables. Notably, environment factors such as seismicity and living environment (urban, regional, rural) do not appear important.

| Chi2 (p value) | Apartment | Business apartment | Office | Health | Supermarket | Local Store | Restaurant |
|---|---|---|---|---|---|---|---|
| for owners vs non owners | | | | | | | |
| Age | 0.057* | 0*** | 0.004*** | 0*** | 0*** | 0*** | 0*** |
| Gender | 0.003*** | 0.002*** | 0*** | 0*** | 0*** | 0*** | 0*** |
| Ethnicity | 0.428 | 0.065* | 0.644 | 0.188 | 0.015** | 0.221 | 0.013** |
| Child | 0.759 | 0.583 | 0.018** | 0.421 | 0.001*** | 0.194 | 0.165 |
| Income | 0.979 | 0.598 | 0.64 | 0.397 | 0.171 | 0.068* | 0.298 |
| Homeowner | 0.104 | 0.004** | 0.004*** | 0.003*** | 0*** | 0*** | 0*** |
| Prop investment | 0.194 | 0.029** | 0.005*** | 0.588 | 0.305 | 0.252 | 0.075* |
| Earthquake experience | 0.02** | 0.034** | 0.02** | 0.032** | 0.104 | 0.025** | 0.058* |
| Hazard region | 0.797 | 0.768 | 0.565 | 0.064* | 0.933 | 0.995 | 0.875 |
| Living environment | 0.202 | 0.017** | 0.164 | 0.102 | 0.508 | 0.219 | 0.3 |
| Urban | 0.277 | 0.041** | 0.077* | 0.003*** | 0.479 | 0.16 | 0.094* |
| Seismic | 0.221 | 0.231 | 0.459 | 0.657 | 0.593 | 0.175 | 0.451 |

The cluster analysis identified four clusters:

1. Non-owners for health, mid-point for private (individually owned) apartment owners, and owners for the rest
2. Non-owner for private (individually owned) apartment and mostly owners for the others, especially health
3. Choose mostly non-owners across all building-use types
4. In the middle point of owners and non-owners across building-use types.

The characteristics of the clusters are shown below:

**Cluster 1:** equal male-non-male*** proportion, more 25-34*** and 65+***, equal on earthquake exp**, high hazard region, medium size environment, regional*, high other seismic

**Cluster 2:** Male***, 45-54***, earthquake experience**, medium hazard region, rural*, medium other seismic

**Cluster 3:** Non-male***, 18-24**, earthquake experience**, hazard region equal, large urban, urban other*, medium urban

**Cluster 4:** Male, 45-54*** and 55-64**, no earthquake experience**, low hazard region, rural*, low seismic.

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