MASTER

Green facades

What is the willingness of Dutch homeowners of land-based dwellings to implement a green façade?

van den Bosch, C.J.M. (Kees-Jan)

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Graduation project – 7Z45M0

C.J.M. van den Bosch
1017859

Supervisors:

Ir. S.J.E Maussen MRE (Main supervisor)
Prof. Dr. T.A. Arentze
Ir. R.P. van Dongen

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General information:

Student name:	Cornelis Johannes Maria van den Bosch
Student number:	1017859
Masters:	Architecture, Building and Planning, track Urban Systems and Real Estate (USRE)
University:	Eindhoven University of Technology
Course code:	7Z45M0
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Abstract

Greenery can mitigate the negative effects of climate change. However, space to implement this greenery is getting scarce especially in urban environments (as a result of urbanisation). Combining the need for greenery and the lack of horizontal space feeds into the possibility of adding greenery vertically. However, these vertical spaces (e.g. facades) are often owned by private parties, thus the implementation of green facades requires the willingness of these parties. This research provides new information regarding the willingness of Dutch home-owners of land-bound dwellings to implement a green façade and the influence of context variables on the willingness. A stated choice experiment was conducted to measure the preferences of Dutch home-owners regarding a green façade. The experiment was constructed using a non-orthogonal design, resulting in highly correlated attributes. Therefore, a Multiple Correspondence Analysis (MCA) was conducted to translate the non-orthogonal data into orthogonal data. This data is then used in a Multinomial Logit (MNL) model, including 140 respondents and showing that a green façade is preferred over a non-green façade. A Mixed Logit (ML) model showed that there is heterogeneity regarding the willingness to implement a green façade and the types of green facades and that this heterogeneity is caused by differences in age, education level, attitude towards a green façade and the amount of greenery present in the neighbourhood. Integrating the preferences and the willingness to implement a green façade, personal characteristics, and context variables can help municipalities and policy makers in general to strengthen the effect of their stimulating policies regarding green facades. Thereby potentially increase the amount of implemented green façades.

Keywords:

Green facades, stated choice experiment, theory of planned behaviour, multinomial logit model, mixed logit model, multiple correspondence analysis, non-orthogonal data.

Preface

This report is written as the master thesis of the master Urban Systems and Real Estate (USRE) at the Eindhoven University of Technology (TU/e). This report discusses the willingness to implement a green façade and the conversion of non-orthogonal data into better interpretable data.

The first part of the report is dedicated to an subject that is close to my field of interest. Improving the existing urban fabric so that it can handle climate change and improve the livability. Implementing a green façade could play a part in achieving this goal. The second part of this report elaborates the steps taken to go from raw (non-orthogonal) data to a better interpretable data form. These steps needed to be taken due to a human-error. This error occurred when choosing a orthogonal design were I misread the part that showed that the specific design chosen should not be used in this case, which resulted in non-interpretable results. However, through many errors and failed outputs a better interpretable model was created.

I would like to thank my supervisors, Theo Arentze, Robert van Dongen, and Stefan Maussen. Theo Arentze and Robert van Dongen for their great guidance and help during the search for a solution for the many failed outputs and Stephan Maussen for given insight into the practical relevance from the 'real world'. In addition, I would like to thank my family and friends for their support during my graduation period. Especially the members of the so-called 'stilte ruimte'; Bregje Schulten, Sander Troost, Dennis Andreoli, Diane Nelissen, Joppe van Veghel, and Stefan Aalbersberg thanks for the great conversations, brainstorm sessions and the well-deserved interludes!

Special thanks to Sander Troost for helping with the distribution of the flyers, Dennis Andreoli for his input regarding the research methodologies, Bregje Schulten for her input regarding the writing of this report, and finally the coffee machine of Study association SERVICE!

I hope you enjoy reading this thesis.

Kees – Jan van den Bosch

Eindhoven, December 2022

Summary

Climate change puts stress on the urban environment. These stresses could be mitigated by adding greenery. However, space is often lacking in existing urban areas and is increasingly becoming scarcer due to urbanisation. Combining the need for greenery and the lack of horizontal space feeds into the possibility of adding greenery vertically. However, these vertical spaces (e.g. facades) are often owned by private parties, thus the implementation of green facades requires the willingness of these parties.

Gaining knowledge about whether Dutch home-owners are willing to implement a green façade and what influences their decision will help gain insights for municipalities, architects, and property developers. In addition, the preference of the type of green façade and context variables such as the perceived noise disturbance have not been covered by the scientific literature. Therefore, the objective of this research was to get insight in the preferences of Dutch home-owners of land-bound houses in regards to the type of green façade, the pricing of the green façade, and the effectiveness of governmental policies. The research aims to answer the following main research question:

What is the willingness of Dutch home-owners of land-bound dwellings to implement a green façade?

First a literature study was conducted to collect information about the potential effects of green facades and the influence of personal characteristics on the willingness to implement a green façade. The study resulted in a list of important aspects that influence the willingness to implement a green façade. Namely, the investment cost, the maintenance cost, the maintenance frequency, energy savings potential, biodiversity improvement, and the time it takes to reach the final image. Secondly, information was gathered about the Theory of Planned Behaviour. This theory is used as a theoretical framework throughout this research to understand the psychological processes that lead to choices. The theory describes that the choice is influenced by: the attitude, the subjective norm, and the perceived behavioural control.

The information from the literature was used to create a survey which included a choice experiment and several closed-end questions to test the willingness of Dutch home-owners of land-bound dwellings to implement a green façade. This experiment consisted out of eight choice-sets per respondent, each having two hypothetical alternatives and a 'neither one' option. The experiment was constructed using an experimental design that included eight attributes with multiple levels. Namely, *'type of green façade', 'investment cost', 'maintenance cost', 'maintenance frequency', 'time it takes to reach the final image', 'size of the wall', 'improved biodiversity',* and *'energy savings'*. A non-orthogonal fractional factorial design was used to create 16 alternatives, which were randomly divided over eight choice-sets. The closed-end questions were used to gain information regarding the socio-demographics, and statements regarding the attitude, social norm, and perceived behavioural control. Were the statements such as; 'green facades are common in my neighbourhood' were scale-questions ranging from totally disagree to totally agree (5 levels).

The gathered data was then used to conduct a descriptive analysis on the socio-demographics. The survey received 170 complete responses. The descriptive analysis showed that the sample population did not represent the Dutch population accurately as its distribution of frequencies is not in-line with the WoON2018 data. People aged between 55 and 64, higher educated, and wealthier were overrepresented in the data sample.

The data of the choice experiment needed to be transformed as the experimental design used was non-orthogonal. This resulted in several attributes being highly correlated with each other. Therefore, a Multiple Correspondence Analysis (MCA) was conducted to transform the non-orthogonal data into

orthogonal dimensions. After which the transformed data was used as input for both a Multinomial Logit Model (MNL) and Mixed Logit models (ML).

MNL model was conducted to find the utility that respondents gave to a certain green façade, while the ML model was estimated to test whether there was heterogeneity within the sample population regarding certain green facades.

The MNL model indicated that '*a non-green façade*', *'a green façade that is the most expensive & most environmental', 'a green façade with (20%) energy savings & a high maintenance frequency', 'a green façade with a medium to high maintenance frequency'*, and '*a green façade with a high maintenance cost*' were statistically significant at the 1 percent level. It can be concluded that all the dimensions that have a statistically significant coefficient have a negative coefficient. The goodness-of-fit of the MNL model was poor as the McFadden's rho^2 adjusted was 0.136. This could indicate that there is heterogeneity within the data.

Therefore, a Mixed Logit model was conducted as it allows for random taste variations. The results indicated that there is no heterogeneity over the sampled population regarding '*a green façade with (20%) energy savings & a high maintenance frequency', 'a green façade with a medium to high maintenance frequency*', *'a green façade with an average maintenance cost*', and '*a green façade with a high maintenance cost*'. However, the '*non-green façade*', '*a green façade that is the least expensive & fastest to reach the final image'*, *'a green façade that has a medium to high investment cost & takes the longest to reach the final image*', and *'a green façade that is the most expensive & most environmental'* have heterogeneity over the sampled population. Thus indicating that respondents have a different opinion about the size of the utility for those specific dimensions.

The answers to the closed-end questions regarding the attitude, social norm, and perceived behavioural control were analyzed. Regarding the attitude, the vast majority of the Dutch home-owners is worried about climate change and sees human processes as a cause of it. Furthermore, the majority of the home-owners is positive regarding the potential benefits of green facades and the aesthetics of it. Nevertheless, the vast majority of the home-owners has not considered implementing a green façade. Green facades are not common and are not the subject of conversation, which is negative regarding the perceived social norm. The perceived behavioural control of the home-owners is rather positive, as the majority is financially able to buy a green façade and can handle the added maintenance. In addition, the majority feels in control over the desired effect as they see the positive effect of an implemented green façade even when no other green façade is implemented. However, the information regarding green facades is unknown to the majority of the home-owners.

From the context statements the following conclusions could be drawn from the statements regarding the context. Heat stress leads to a decreased productivity, and to a lesser extent sleep problems and sweating. However, not to headaches. Noise disturbance has a negative effect on sleep, productivity, and increases annoyance. Furthermore, the majority of the home-owners is unaware of available stimulating policies (e.g. subsidies) regarding green facades. In addition, the majority did receive information about improving the sustainability of their dwelling but this information did not include the possible effects of green façades.

To find out whether the heterogeneity found in the Mixed Logit model within the dimensions is influenced by socio-demographics, context variables, the general attitude, social norm, or perceived behavioural control is tested by estimating additional ML models. The ML model outperformed the MNL model, 0.329 compared to 0.136. In addition, the goodness-of-fit measured by adjusted McFadden rho^2 is satisfactory. The results of the additional ML models indicated that Dutch home-owners of land-bound dwellings are more likely to choose a green façade compared to a non-green façade. In general the heterogeneity within the '*non-green façade'* is caused by socio-demographics. While the heterogeneity within '*a green façade that is the least expensive & fastest to reach the final image*' is caused by different age groups and the general attitude towards a green façade. The heterogeneity within *'a green façade that has a medium to high investment cost & takes the longest to reach the final image"* is also caused by age. While the heterogeneity within *'a green façade that is the most expensive & most environmental*' is caused by the existing amount of greenery in the neighbourhood.

To conclude, green facades can mitigate the negative effect of climate change and urbanisation. These facades can improve the air-quality, reduce the (city)noise, increase biodiversity, and positively influence the urban heat island effect. In addition to the larger scale influences of a green façade, the indoor climate can be improved. Green facades can stabilise the internal temperature of a house, which positively influences the energy consumption and the thermal comfort.

Dutch home-owners of land-bound dwellings are more likely to choose for a green façade than a non-green one. However, the willingness is influenced by education and age, individuals aged between 35 and 44 years old or individuals with a masters' degree are less likely to choose for a green façade than individuals aged 18 to 34 or individuals with a secondary vocational education. The willingness to implement a certain green façade is influenced by age, general attitude towards a green façade and the amount of greenery present in the neighbourhood.

The more green facades are implemented, the greater the potential benefits. Therefore, policymakers and home-owners should aim to implement more green facades to mitigate the negative effects of climate change (especially in urban areas). Furthermore, the municipalities should invest in distributing information regarding the potential benefits of green facades as well as the availability of subsidies and municipalities should focus on areas that have hardly any green as individuals within these areas are more likely to choose a green façade as these individuals have the greatest benefit of implementing a green façade, as it substantially adds to the amount of greenery present.

Future research should focus on getting a larger sample that is better representative for home-owners in the Netherlands, both in terms of socio-demographics as the geospatial distribution. In addition, a stated choice experiment regarding the willingness to implement a green façade based on an orthogonal design is highly recommended. To get a better understanding of the effects of individual attributes on the willingness to implement a green façade. This would potentially result in a better answer regarding the research questions. Conducting a Latent Class Model to group individuals is also of interest, as it potentially could be used to target individual groups differently. Adding a monetary value to the research by means of Willingness to Pay, would increase the knowledge gained and potentially find bottlenecks or solutions for the implementation of green façades. Lastly, future research could focus on the relation between knowledge (information about improving the sustainability of their dwelling) and the choices regarding green facades. To potentially increase the effectiveness of these governmental tools regarding the implementation of green facades.

Samenvatting

Klimaatverandering zet de stedelijke omgeving onder druk. Deze druk kan worden verlicht door groen toe te voegen. Ruimte ontbreekt echter vaak in bestaand stedelijk gebied en wordt door de verstedelijking steeds schaarser. De combinatie van de behoefte aan groen en het gebrek aan horizontale ruimte leidt tot de potentie van het toevoegen van verticaal groen. Deze verticale ruimtes (bijv. gevels) zijn echter vaak eigendom van private partijen, zodat de implementatie van groene gevels de bereidheid van deze partijen vereist.

Kennis vergaren over de vraag of Nederlandse huiseigenaren bereid zijn om een groene gevel te implementeren en wat hun beslissing beïnvloedt, zal helpen inzichten te verwerven voor gemeenten, architecten en projectontwikkelaars. Daarnaast zijn de voorkeur van het type groene gevel en contextvariabelen zoals de ervaring van geluidshinder niet aan bod gekomen in de wetenschappelijke literatuur. Daarom is het doel van dit onderzoek inzicht krijgen in de voorkeuren van Nederlandse huiseigenaren van grondgebonden woningen met betrekking tot het type groene gevel, de prijsstelling van de groene gevel en de effectiviteit van het overheidsbeleid. Het onderzoek beoogt de volgende hoofdonderzoeksvraag te beantwoorden:

Wat is de bereidheid van Nederlandse huiseigenaren van grondgebonden woningen om een groene gevel toe te passen?

Een literatuurstudie werd uitgevoerd om informatie te verzamelen over de mogelijke effecten van groene gevels en de invloed van persoonlijke kenmerken op de bereidheid om een groene gevel te implementeren. De studie resulteerde in een lijst van belangrijke aspecten die de bereidheid om een groene gevel te implementeren beïnvloeden. Namelijk, de investeringskosten, de onderhoudskosten, de onderhoudsfrequentie, het energiebesparingspotentieel, de verbetering van de biodiversiteit en de tijd die nodig is om het eindbeeld te bereiken. Ook werd er informatie verzameld over de Theorie van Gepland Gedrag (Theory of Planned Behaviour). Deze theorie wordt in dit onderzoek gebruikt als theoretisch kader om de psychologische processen die tot keuzes leiden te begrijpen. De theorie beschrijft dat de keuze wordt beïnvloed door: de attitude, de subjectieve norm en de ingeschatte beheersing van gedrag (zelfeffectiviteit)(perceived behavioural control).

De informatie uit de literatuur is gebruikt om een enquête op te stellen met een keuze-experiment en een aantal gesloten vragen om de bereidheid van Nederlandse huiseigenaren van grondgebonden woningen om een groene gevel te implementeren te testen. Dit experiment bestond uit acht keuzesets per respondent, elk met twee hypothetische alternatieven en een 'geen van beide' optie. Het experiment werd opgezet aan de hand van een experimenteel design met acht attributen elk met meerdere levels. Namelijk, '*type groene gevel*', '*investeringskosten*', '*onderhoudskosten*', '*onderhoudsfrequentie*', '*tijd die nodig is om het eindbeeld te bereiken*', '*grootte van de bedekte gevel*', *'verbeterde biodiversiteit'* en '*energiebesparing*'. Een niet-orthogonaal fractioneel factorial ontwerp werd gebruikt om 16 alternatieven te creëren, die willekeurig werden verdeeld over acht keuzesets. De gesloten vragen werden gebruikt om informatie te verkrijgen over de sociaal-demografische gegevens en informatie over stellingen gaande over de attitude, de sociale norm en de zelfeffectiviteit met betrekking tot groene gevels. Deze stellingen zoals "groene gevels zijn gebruikelijk in mijn buurt" waren schaalvragen met als schalen totaal niet mee eens, niet mee eens, neutraal, mee eens en totaal mee eens.

De verzamelde gegevens werden vervolgens gebruikt voor een beschrijvende analyse van de sociaal-demografische gegevens. De enquête ontving 170 volledige antwoorden. Uit de beschrijvende analyse bleek dat de steekproefpopulatie de Nederlandse bevolking (woningeigenaren) niet nauwkeurig weergaf, aangezien de verdeling van de frequenties niet overeenkwam met de WoON2018-gegevens. Mensen tussen de 55 en 64 jaar, hoger opgeleid en rijker waren oververtegenwoordigd in de steekproef.

De gegevens van het keuze-experiment moesten worden getransformeerd omdat de gebruikte experimenteel design niet-orthogonaal was. Dit had tot gevolg dat verschillende attributen sterk met elkaar gecorreleerd waren. Daarom werd een Multiple Correspondence Analysis (MCA) uitgevoerd om de niet-orthogonale gegevens om te zetten in orthogonale dimensies. Waarna deze orthogonale dimensies gebruikt werden als input voor zowel een Multinomiaal Logit (MNL) model als een Mixed Logit (ML) model.

Het MNL-model werd uitgevoerd om het nut te vinden dat de respondenten aan een bepaalde groene gevel gaven. Terwijl het ML-model werd geschat om te testen of er binnen de steekproefpopulatie heterogeniteit bestond met betrekking tot bepaalde groene gevels.

Het MNL-model gaf aan dat *'geen groene gevel'*, '*een groene gevel die het duurst en het meest milieuvriendelijk'*, '*een groene gevel met (20%) energiebesparing en een hoge onderhoudsfrequentie'*, '*een groene gevel met een gemiddelde tot hoge onderhoudsfrequentie'* en '*een groene gevel met hoge onderhoudskosten*' statistisch significant waren. Geconcludeerd kon worden dat alle dimensies met een statistisch significante coëfficiënt een negatieve coëfficiënt had. Het model is niet goed instaat om keuzes te voorspellen, aangezien de aangepaste McFadden's rho² 0,136 bedroeg. Dit zou erop kunnen wijzen dat er heterogeniteit bestaat binnen de gegevens.

Daarom werd een Mixed Logit (ML) model uitgevoerd omdat dit model willekeurige smaakvariaties toelaat. De resultaten gaven aan dat er geen heterogeniteit bestaat over de steekproefpopulatie wat betreft '*een groene gevel met (20%) energiebesparing en een hoge onderhoudsfrequentie*', '*een groene gevel met een gemiddelde tot hoge onderhoudsfrequentie'*, '*een groene gevel met gemiddelde onderhoudskosten'* en *'een groen gevel met hoge onderhoudskosten'*. De '*geen groene gevel*', '*een groene gevel die het minst goedkoopst is en het snelst het eindbeeld bereikt*', '*een groene gevel die middelhoge tot hoge investeringskosten heeft en het langst nodig heeft om het eindbeeld te bereiken'* en '*een groene gevel die het duurst is en het meest milieuvriendelijk'* vertonen echter heterogeniteit over de steekproefpopulatie. Dit wijst erop dat de respondenten voor die specifieke dimensies (groene gevels) verschillen van mening wat betreft de grote van het nut.

De antwoorden op de gesloten vragen over de attitude, sociale norm en zelfeffectiviteit werden geanalyseerd. Wat de attitude betreft, is de overgrote meerderheid van de Nederlandse huiseigenaren bezorgd over klimaatverandering en zien zij menselijke processen als een oorzaak daarvan. Verder is de meerderheid van de huiseigenaren positief over de potentiële voordeel van groene gevels en de esthetiek ervan. Toch heeft de overgrote meerderheid van de huiseigenaren niet overwogen een groene gevel te implementeren. Groene gevels zijn niet gebruikelijk en zijn geen onderwerp van gesprek, wat negatief is voor de sociale norm. De zelfeffectiviteit van de huiseigenares is iets positief, aangezien de meerderheid financieel in staat is een groene gevel aan te schaffen en het bijkomende onderhoud aan zegt te kunnen. Bovendien voelt de meerderheid zich in controle over het gewenste effect, aangezien zij het positieve effect van een groene gevel zien, zelfs wanneer er geen andere groene gevel wordt geïmplementeerd. De informatie over groene gevels is echter onbekend bij de meerderheid van de huiseigenaren.

Uit de stellingen omtrent de context variabelen konden de volgende conclusies worden getrokken. Hittestress leidt tot een verminderde productiviteit en in mindere mate tot slaapproblemen en overtollig zweten. Echter niet tot hoofdpijn. Geluidsoverlast heeft een negatief effect op de slaap, de productiviteit en leidt tot irritatie. Verder is de meerderheid van de huiseigenaren niet op de hoogte van mogelijk beschikbare stimulerende reguleringen (bijv. subsidies) met betrekking tot groene gevels. Daarnaast heeft de meerderheid wel informatie ontvangen over het verbeteren van de duurzaamheid van hun woning, maar in deze informatie werden de mogelijke effecten van groene gevels niet meegenomen.

Om na te gaan of de in het ML-model gevonden heterogeniteit binnen de dimensies (groene gevels) wordt beïnvloed door sociaal-demografische factoren, contextvariabelen, de algemene attitude, de sociale norm of de zelfeffectiviteit worden aanvullende ML-modellen te schatten. Het ML-model presteerde beter dan het MNL-model, 0,329 vergeleken met 0,136. Bovendien laat de aangepaste McFadden's rho² zien dat het model goed instaat is om te voorspellen. De resultaten van de aanvullende ML-modellen geven aan dat Nederlandse huiseigenaren van grondgebonden woningen vaker voor een groene gevel kiezen dan voor geen groene gevel. Over het algemeen wordt de heterogeniteit binnen de '*geen groene gevel'* veroorzaakt door sociaal-demografische factoren. Terwijl de heterogeniteit binnen '*een groene gevel die het minst duur en het snelst het eindbeeld bereikt*' wordt veroorzaakt door verschillende leeftijdsgroepen en de algemene houding tegenover een groene gevel. De heterogeniteit binnen '*een groene gevel die gemiddeld tot hoge investeringskosten heeft en het langst nodig heeft om het eindbeeld te bereiken*' wordt ook veroorzaakt door leeftijd. Terwijl de heterogeniteit binnen '*een groene gevel die het duurste en meest milieuvriendelijke is*' wordt veroorzaakt door de bestaande hoeveelheid groen in de buurt.

Kortom, groene gevels kunnen het negatieve effect van klimaatverandering, vooral binnen stedelijk, verzachten. Deze gevels kunnen de luchtkwaliteit verbeteren, het (stads)geluid verminderen, de biodiversiteit vergroten en het hitte-eilandeffect positief beïnvloeden. Naast de grootschalige effecten van een groene gevel kan ook het binnenklimaat worden verbeterd. Groene gevels kunnen de binnentemperatuur van een huis stabiliseren, wat een positieve invloed heeft op het energieverbruik en het thermisch comfort.

Nederlandse huiseigenaren van grondgebonden woningen kiezen vaker voor een groene gevel dan voor een niet-groene gevel. De bereidheid wordt echter beïnvloed door opleiding en leeftijd, personen tussen de 35 en 44 jaar of personen met een masterdiploma kiezen minder vaak voor een groene gevel dan personen tussen de 18 en 34 jaar of personen met een middelbare beroepsopleiding. De bereidheid om een bepaalde groene gevel toe te passen wordt beïnvloed oor leeftijd, de algemene houding ten opzichte van een groene gevel en de hoeveelheid groen die in de buurt aanwezig is.

Hoe meer groene gevels worden toegepast, hoe groter de potentiële voordelen. Daarom moet beleidsmakers en huiseigenaren streven naar meer groene gevels om daarmee de negatieve effecten van klimaatverandering te verzachten (vooral in stedelijke gebieden). Verder zouden de gemeenten moeten investeren in de verspreiding van informatie over de potentiële voordelen van groene gevels en de beschikbaarheid van subsidies en gemeenten zouden zich moeten richten op gebieden die nauwelijks groen hebben, omdat de kans groter is dat mensen in die gebieden voor een groene gevel kiezen. Deze mensen het meeste voordeel hebben bij de implementatie van een groene gevel, omdat deze de hoeveelheid aanwezig groen aanzienlijk vergroot.

Toekomstig onderzoek moet zich richten op het verkrijgen van een grotere steekproefpopulatie die beter representatief is voor de huiseigenaren in Nederland, zowel wat betreft sociaal-demografisch als de geografische spreiding. Daarnaast is een stated choice experiment met betrekking tot de bereidheid om een groene gevel toe te passen op basis van een orthogonaal ontwerp zeer aan te bevelen. Zodat een beter inzicht verkregen kan worden wat betreft de effecten van individuele kenmerken op de bereidheid om een groene gevel te implementeren. Dit zou mogelijk leiden tot betere antwoorden op de onderzoeksvragen. Het uitvoeren van een Latent Class Model om individuen te groeperen kan ook interessant zijn, aangezien het mogelijk gebruikt kan worden om bepaalde groepen anders te benaderen. Het toevoegen van een monetaire waarde aan het onderzoek door middel van de Willingness to Pay, zou de opgedane kennis vergroten en mogelijk knelpunten of oplossingen naar voren brengen. Tot slot zou toekomstig onderzoek zich kunnen richten op de relatie tussen kennis (informatie over het verbeteren van de duurzaamheid van hun woningen) en de keuzes met betrekking tot de implementatie van groene gevels. Dit om mogelijk de effectiviteit van deze overheidsinstrumenten te vergroten.

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Terminology & Abbreviations

NBS	Nature Based Solutions: "*Actions to protect, sustainably manage, and restore* ***natural*** *or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (International Union for Conservation of Nature, 2021)* Nature Based Solutions: "*adaptations and risk mitigation measures provided or inspired by nature and continuously supported by natural processes." (European Commission, 2013).*
GW	Green wall: *green facades that have their roots on the ground and grow vertically against the wall (direct) or against a support system (indirect)* (Santi, Bertolazzi, Leporelli, Turrini, & Croatto, 2020)
LW	Living wall: *green facades that are constructed out of modular panels placed on substructures fixed to the walls* (Bustami, Belusko, Ward, & Beecham, 2018)
dB	*Decibel*
CWs	*Constructed wetlands*
TPB	*Theory of Planned Behaviour (Ajzen, 1991)*
MNL	*Multinomial Logit model*
ML	*Mixed Logit model*
MCA	*Multiple Correspondence Analysis*
LCM	*Latent Class model*
WTP	*Willingness to pay*

1. Introduction

Climate change puts stress on the urban environment. These stresses could be mitigated by adding greenery. However, space is often lacking in existing urban areas and is increasingly becoming scarcer due to urbanisation. Combining the need for greenery and the lack of horizontal space feeds into the possibility of adding greenery vertically. However, these vertical spaces (e.g. facades) are often owned by private parties, thus the implementation of green facades requires the willingness of these parties.

Within this chapter the scope, research gap, and research objective are elaborated. The findings of these three aspects are translated into research questions. Finally, the practical relevance and the academic relevance of this research is discussed.

1.1. Scope

The majority of the houses in the Netherlands are owner-occupied (CBS, n.d.) and are largely land-bound (e.g. no apartments)(CBS, 2016). Therefore, the implementation of green facades or green roofs only happen when the homeowners are willing to. The willingness to implement a green roof has recently been studied in the Netherlands by De Louw (2021) and Wijnberg (2021), many more have studied the willingness to implement a green roof across the world (Netusil, Lavelle, Dissanayake, & Ando, 2022; Sarwar & Alsaggaf, 2020; Teotónio, Cruz, Silva, & Morais, 2020; Zhang, Fukuda, & Liu, 2018). However, the willingness to implement a green façade has not yet been studied in the Netherlands, creating a research gap. Furthermore, the focus of this research is on existing buildings. The Netherlands has just past its 8 millionth dwelling in 2021 (CBS, 2021a). Making the urban environment more adaptive to climate change starts with the existing built environment. Therefore, the scope of this research is narrowed to existing land-bound home-owner dwellings.

1.2. Research gap

The preferences of Nature-Based Solutions (NBS), adaptations and risk mitigation measures provided or inspired by nature and continuously supported by natural processes (European Commission, 2013), have been covered in terms of green roofs (Louw, 2021; Sarwar & Alsaggaf, 2020) and urban greening on the street level (Fruth et al., 2019). The literature also discusses the point of view of residents towards green infrastructure and how it can be used to tackle climate change (Derkzen, van Teeffelen, & Verburg, 2017). Several co-benefits of implementing NBS were found by Hérivaux & Le Coent (2021), in order of importance, landscape conservation, air quality improvement, climate change mitigation, local temperature regulation and biodiversity conservation.

Several aspects of green facades are already covered in the scientific literature. Mainly about the effects of such systems on the energy usage (Kenai, Libessart, Lassue, & Defer, 2021), thermal performance (Daemei, Shafiee, Chitgar, & Asadi, 2021), the cooling effect provided by green facades (Convertino, Vox, & Schettini, 2021), and the improvement of air quality (Farooq & Kamal, 2020).

Various studies have researched the willingness to pay for NBS. What was found is that citizens are willing to pay for residential developments which benefit from greener infrastructure (on the condition that it improves flood risk management, better recreational value and the enhancement of habitat (Kumar, Roquette, & Lerner, 2012). However, the increased costs of development would outweigh the additional income made by the private sector developer (Wild, Henneberry, & Gill, 2017). Even though the hedonic pricing method has shown that greenery (tree cover and parks) have a positive correlation with the housing price (Luttik, 2000; Schilling & Logan, 2008). Therefore, the implementation of a green façade is not financially feasible just yet. A case study in the French Mediterranean found that residents were already willing to pay €140,- to €180,- a year on average, via tax increase, for NBS development (Hérivaux & Le Coent, 2021). According to Vollmer et al. (2015)

monetary valuation was strongly determined by socioeconomic characteristics of the respondents, while preferences were affected by the information intervention. However, Derkzen et al. (2017) concluded that environmental education cannot increase public support for climate adaptation measures.

The preference of the type of green façade have not been covered by the scientific literature. Including this in this research fills that gap in the scientific literature. Furthermore, there is a literature gap in the preference of the price per square meter concerning green facades. Lastly, there are contradictions within the scientific literature about the effects of knowledge with regards to the effects of NBS and more specifically green facades. Studying this more specifically for the Netherlands could result in a better understanding of the effectiveness of policies used within the Netherlands to increase the amount of façade greening. Furthermore, the influence of context variables, such as; the amount of greenery present, the perceived noise disturbance, perceived heat stress and availability of stimulating governmental policies, on the willingness to implement a green façade has not been covered by the scientific literature.

The desire to increase the amount of green facades on private land has to coexist with a behavioural change by the homeowners themselves. Therefore, the Theory of Planned Behaviour is used as a framework within this research.

1.3. Research objective

The research objective is to get insight in the preferences of Dutch homeowners of land-bound houses in regards of the type of green façade, the pricing of the green façade and the effects of context variables. All in all, to get insight in the willingness to implement a green façade. The research can potentially also distinguish differences between socio-demographic groups on their willingness to implement a green façade.

Recommendations can be formed from the results for municipalities in regards to the effectiveness of governmental stimulations. Architects and property developers can use the results in their favour for future implementation of green facades.

1.4. Research questions

The aim of this research is to analyse the willingness of Dutch home-owners to implement a green façade. To achieve this, the following main research question needs to be answered;

What is the willingness of Dutch home-owners of land-bound dwellings to implement a green façade?

In relation to the willingness to implement a green façade, several other aspects are of key interest. These are covered by the following sub-questions, in which information is gathered concerning demographics, the possible effects of green facades, differentiation between different kinds of green facades and their attributes. Furthermore, several context variables are taken into account, such as; the effects of stimulating governmental policies, perceived noise disturbance, perceived heat stress, and the perceived amount of greenery present in the area. This research aims to analyse these aspects further by answering the following sub-questions:

1. *To what do home-owners find the most important advantage of a green façade?*
2. *To what extent is the willingness of implementation of a green façade influenced by the type of green façade, the maintenance price, the price, sound insulation, heat insulation, energy savings potential, and biodiversity level?*
3. *To what extent is there a relation between the demographic of the home-owners (e.g. education level, income and age) on the willingness to implement a green façade?*
4. *Is there a relation between the perceived noise disturbance, the perceived heat stress in the neighbourhood, the perceived greenery present in the neighbourhood, the availability of stimulating governmental policies and the willingness to implement a green façade?*

Answering the first sub-question gives insight in what advantage of a green façade is seen as most important. This could be used to potentially use these advantages as tools to stimulate the willingness to implement a green façade. The second sub-question gives insight in the willingness to implement a green façade based on the different types of green facades and their attributes, resulting in a potential overview of the best version of a green façade to implement. The goal of the third sub-question is to see if demographics have an influence on the willingness to implement a green façade. The fourth sub-question concerns the influence of context variables; the perceived noise disturbance in the neighbourhood, the perceived heat stress in the neighbourhood, the perceived amount of greenery present in the neighbourhood, and the availability of stimulating governmental policies on the willingness to implement a green façade. These four context variables are included to see their influence on the willingness to implement a green façade. For example for the possible effects of existing greenery on the willingness to implement a green façade, e.g. are respondents in greener areas more likely to implement a green façade?

1.5. Research practical relevance

The practical relevance of this research is the potential to mitigate climate change and create more sustainable and adaptive cities. The latter is of importance due to the growth of these cities (urbanisation) and with that the increase of city climate aspects (e.g. heat stress & water stress). Gaining the knowledge about the implementation of green facades gives insights for municipalities, architects, and property developers. Municipalities know there policies/legislations are known by the inhabitants. If that is not the case, than possible recommendation can be drawn up. Property developers (including architects) can use the gathered information in future developments. If green facades are desired by home-owners, then adding green facades in future developments could enhance the potential success of these developments. Furthermore, implementing a green façade during the design phase makes the implementation easier compared to already existing dwellings.

1.6. Research academic relevance

The academic relevance of this research is the filling up of the existing research gap. As mentioned before, no research has been conducted on the preference of Dutch home-owners in regards to green facades. Furthermore, the combination of the preferences of Dutch home-owners, their willingness to pay, and the influence of contextual variables has not been covered by existing scientific literature. Therefore, this research can give the scientific community a clear image of what the willingness of Dutch home-owners of land-bound dwellings is to implement green facades.

1.7. Report structure

The report is structured as follows. Chapter 2 describes the results from the literature study on climate change and urbanisation, followed by literature about green facades; costs, policies, bottlenecks, potential- benefits and disadvantages of a green façade. And the theory behind the theoretical framework used in this report. Chapter 3 discusses the research method, including the structure of the experimental design, data collection, data preparation and background information on the used analysing methods. Chapter 4 elaborates the results from the analysis about the data distribution, demographical data, statements regarding the theoretical framework, context variables and a ranking of the possible benefits of a green facade. The results from the models is discussed in chapter 5, including a MNL model of the raw data, a restructuring of the data by means of an MCA followed by a second MNL model and a ML model. Chapter 6 will conclude the report by giving answers to the research questions, provide recommendations, discusses the limitations of this research and recommendations for future research.

2. Literature review

In this chapter the already existing scientific literature about urbanisation, climate change, and green facades is covered. The main focus of this chapter is to explain the potential of the implementation of a green façade as well as the benefits and disadvantages of green facades in general and the theory behind the theory of planned behaviour that is used as a theoretical framework throughout this research.

2.1. Urbanisation & Climate change

Urbanisation is an ongoing process, 55 percent of the world's population lived in urban areas in 2018 and this share is prospected to rise to 68 percent by 2050. However, urbanisation levels vary between geographical locations. In North America 82 percent are urban dwellers, Latin America 81 percent, Europe's urbanisation level is at 74 percent, and Asia is currently around 50 percent. Africa is the least urbanised region in the world with 43 percent (United Nations, 2019).

In the Netherlands the trend of urbanisation is also visible. Especially the Randstad, which has a higher growth rate than the rest of the Netherlands (Kooiman et al., 2016). Urbanisation has coexisted with the hardening of the environment, in other words the permeability of the area has decreased by the use of non-permeable materials (e.g. concrete and buildings). This has resulted in (urban) water-related problems, such as pollution, water shortages and flooding (Nguyen et al., 2019), heat problems (Vautard et al., 2020), and makes urban areas the most vulnerable human habitat in regards to the consequences of climate change (Francesch-Huidobro et al., 2017).

The effects of climate change are already visible in the Netherlands, as its weather patterns are changing. The annual precipitation increased with roughly 26 percent between 1910 and 2013. Furthermore, the weather conditions have intensified (KNMI, 2014)**.** The Netherlands has always been prone to flooding. Currently 59 percent of the Netherlands is prone to flooding, of which 26 percent is situated below sea level. 55 percent is protected by dikes, dunes and water barriers (e.g. the Oosterscheldekering and the Maeslantkering), leaving 4 percent unprotected. The economic heart of the Netherlands is located at the west of the country in the so-called 'Randstad', this area is prone to both flooding from the sea but also from the rivers. In the future the risk of flooding will increase due to both climate change and soil subsidence. (Kaufmann et al., 2016)

Another change is the increase of average temperature in the Netherlands, by 1.1 degrees Celsius over the last three decades (KNMI, 2021). On top of that, the temperature during heatwaves has increased with 3 degrees since 1900, according to Vautard et al. (2020). The latter is also responsible for extra death, mostly among elderly older than 80 years, according to Centraal Bureau voor de Statistiek (CBS) (CBS, 2020a). Urban areas can be significantly warmer than (surrounding) rural areas. This phenomenon is called urban heat island effect (UHI) and originates from the accumulation of heat within urban areas due to modification of the land surfaces (e.g. urban construction) (Solecki et al., 2005) and human activities (Yang, Qian, Song, & Zheng, 2016). Key characteristics of the UHI effect is the increased temperature during the night, which can be linked to the type of surface. Urban areas consist of largely non-permeable materials (e.g. concrete, asphalt, stone, and brick). These materials absorb a larger proportion of (short-wave) solar radiation compared to the suburbs and rural lands (e.g. more greenery and softer materials). The stored energy within the materials is then reradiated out during the night. (Solecki et al., 2005) According to Steeneveld et al. (2011) the UHI effect in Dutch cities on hot summer days is 5.3 degrees Celsius. Causing the temperature to rise above 27.7 degrees Celsius more frequently and with that effecting the population negatively on their health and productivity. Sleeping problems (Altena, Baglioni, Sanz-Arigita, Cajochen, & Riemann, 2022), heavy sweating and headaches are also effects of heat waves (Kinnaleth & Sarin, 2022).

2.2. Green facades

Urbanisation and climate change have multiple effects on the (urban) environment. These have a direct effect on the livability and the sustainability of the urban environment. The importance of climate mitigations is more and more accepted and translated into strategies to create so-called climate adaptive cities or sponge cities (Nguyen et al., 2019). The Dutch water management follows a three step approach, capturing, storing, and draining the water, which is similar to the principles of the sponge cities (Dai et al, 2018). The idea is that precipitation should be captured at the place where it fell instead of directly discharging it via the sewage system. The latter should only be conducted when the water storages are overwhelmed (Commissie Waterbeheer, 2000). Additionally, adding greenery to the city provides benefits ranging from added biodiversity, air quality improvement, local temperature regulation and landscape conservation (Hérivaux & Le Coent, 2021)

2.1.1. Green walls & Living walls

There are two types of green facades respectively (visualized in Figure 1). Namely, green walls (GW) and living walls (LW). GWs come in two forms; 'Direct' GWs are self-clinging climbers attached to the external wall (no air cavity) and 'Indirect' GWs (or Double-skin GWs) are self-clinging climbers using a support system (with air cavity)(Bustami et al., 2018; Hunter et al., 2014; Jim, 2015; Ottelé et al., 2011; Pérez et al., 2011; Santi et al., 2020). The LW is constructed out of plants, containers or substrates and (most often) irrigation systems. These walls do not have any climbing plants but plants that do not have their own support system (e.g. herbs or shrubs). These are grown using mineral wool slabs or containers containing natural soil and/or light-weight artificial growing mediums. (Bustami et al., 2018; Jim, 2015; Ottelé et al., 2011; Pérez et al., 2011; Santi et al., 2020)

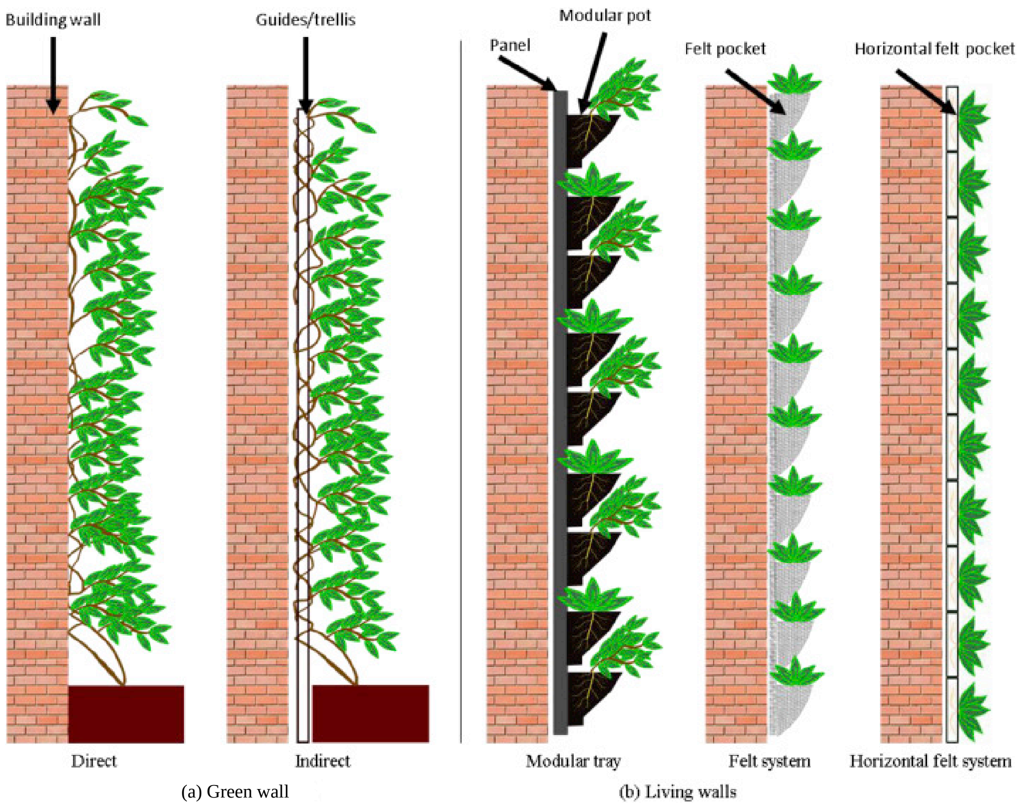


Figure 1 Possible GW and LW (Bustami et al., 2018)

2.1.2. Implementation costs and maintenance costs

Green walls direct climbing plants for the base of the façade: 30 – 45 €/m², (indirect: 40 -75 €/m²). When planter boxes are added the price rises significantly, from 100 to 150 €/m² for plastic up to 800 €/m² for zinc-coated steel. Living walls rage from 400 to 1200 €/m² depending on systems conception and material used. (Perini & Rosasco, 2013) Green wall systems, both green walls and living walls have an in-service life of 50 years. However, the maintenance differ between the two. The majority of green walls need maintenance once a year, in terms of pruning. Living walls on the other hand need replacements of approximately 5 percent – 10 percent of the plants every year. Furthermore, living walls often require irrigation systems which need replacement every seven and a half years as a result of salt crystallization. (Perini & Rosasco, 2013) The average maintenance costs for a green façade is 5,57 euro/m²/year, this amount increases to 18.98 euro/m²/year for a living wall according to Manso et al. (2021).

2.1.3. Dutch policies/subsidies

Within the Netherlands a substantial part of the municipalities offers subsidies to stimulate the installment of (green) sustainable measures (Sempergreen, n.d.). However, the amount of municipalities that actually grant a subsidy for the installment of a green façade is rather limited. From the top 5 largest cities in the Netherlands only Amsterdam (Overheid.nl, 2021b) and Rotterdam (Rotterdam, 2022) grant subsidy for green facades. The other three cities are still working on subsidies for green facades. Rotterdam set its requirements for a subsidy rather strict, starting only from 20 m² of added green (Rotterdam, 2022). These subsidies cover a maximum of 50 percent of the total investment and often less. Additional requirements need to be met as well, such as the period that the green façade needs to be standing (often 5 to 7 years), that 50 percent of the added plants need to be indigenous to that area, that the green façade should be visible from a public street (Utrecht, n.d.), and/or that a minimum amount of added green surface area is required (Overheid.nl, 2021a; Rotterdam, 2022).

2.1.4. Preferences, drivers and bottlenecks of homeowners

Preferences and drivers for homeowners to choose for a green façade are constructed based on literature study. This resulted in the following. First, the adaptation of green facades in the market is rather low. The main criticalities are according to Riley (2017); (1) high investment and maintenance costs, (2) certified commercial simulation models are not available, (3) no uniform experimental data available, and (4) the lack of a constructive standard. The high investment cost is also seen as a restricting factor during the Green Wall Conference in 2014, where many experts pointed out that the so-called 'ignition point' of the living wall would be at approximately half of their current costs. (*Green Wall Conference 2014*, 2014)

2.1.5. Benefits

Thermal comfort & Energy usage

GW and LW can reduce the consumption of heating or air-conditioning. The latter was proven to be reduced by 80 percent by Mohamed-Amine et al. (2021) in a case study in France. They also concluded that a green wall in winter is not recommended, because the radiation of the sun can then be used to reduce the energy consumption for heating, this is supported by He et al. (2017). Therefore, Mohamed-Amine et al. (2021) recommends the use of deciduous plants to exploit the advantages of a green façade to the fullest, both in summer and in winter. Bass & Baskaran (2003) found that the shading effect of vertical greenery reduces the energy used for cooling with approximately 23 percent in Santa Barbara (USA). Additionally, the energy used by fans can be reduced with 20 percent which results in a total of 8 percent reduction in annual consumption of energy. They added that the reduction of energy consumption used by air-conditioning is closer to or above 30 percent in cities like Vancouver and St. Johns.

Yoshimi & Altan (2011) found that the green façade stabilized the indoor air temperature by mitigating daytime solar heating and by insulating the wall at night, this effect was noticeable in both hot and cold climates. This stabilization of the indoor temperature also results in the energy saving caused by GW and LW. Several studies have concluded that GW and LW save energy by reducing the need for cooling and heating (Coma et al., 2014; Di & Wang, 1999; Kontoleon & Eumorfopoulou, 2010; Widiastuti et al., 2018), found that 28 percent reduction in the peak cooling load could be achieved by covering the west-facing wall with self-climbing plants. Another study, conducted by Price (2010), found that the building cooling load could be brought down by a maximum of 28 percent in a temperate climate.

Dinsdale et al. (2006) stated that the cold winter winds play a decisive role in the reduction of the indoor temperature, even when the buildings are airtight. This is a consequence of the reduced effectiveness of the regular insulation. Using GW or LW to protect the building from these winds can reduce the heating demand by 25 percent. These findings are supported by Besir & Cuce (2018). Furthermore, Bass & Baskaran (2003) found that the negative effects of having vegetation in winter (due to reduced sun radiation reaching the exterior wall, as stated by Mohamed-Amine et al. (2021) can be offset by the reduction of the wind speed and the stagnant air between the vegetation and the exterior wall (cavity).

Ottelé (2011) calculated the added heat insulation by green facades. He found that implementing a GW on top of an existing wall with an insulated cavity can lead to an added heat insulation of 3 percent, if a LW is chosen than the added heat resistance is 14 percent. The effect of implementation of both GW and LW is larger when the existing wall is not insulated, almost 16 percent for GW and 123 percent for LW respectively.

Noise canceling

Hard surfaces within the urban environment reflect sounds instead of absorbing them (Dunnett & Kingsbury, 2008). Noise nuisance due to traffic in urbanised areas is a serious problem. In the year 2000, it was estimated that 44 percent of the population of the European Union was exposed to traffic noise levels higher than the threshold for onset of negative health effect set by the World Health Organization (den Boer & Schroten, 2007). This exposure to noise can have several effects, sleep disturbance (Gidlöf-Gunnarsson et al., 2016), reduced productivity (Kawada, 2011), cardiovascular disorders, cognitive impairment, and above all annoyance (WHO, 2011).

Plants, the substrate and the air cavity (if existing) can be used as sound insulation by means of absorption, reflection and deflections. Additionally, the plants and the substrate block sounds with lower and higher frequencies respectively (Dunnett & Kingsbury, 2008). Therefore, green facades (GW and LW) can have a positive effect on the sound insulation. Azkorra et al. (2015) found that a LW had a weighted sound reduction index of 15 dB and therefore concluded that green walls (GW & LW) have a significant potential for sound insulation. The latter is supported by Wong et al. (2010), they found that the sound absorption coefficient of green facades is one of the highest compared with other furnishings and building materials. A study conducted by Pfoser et al. (2017) resulted in the findings of a sound reduction of 5 dB after the implementation of a GW.

Air quality

Vegetation is an efficient sink for particulate matter (Abhijith et al., 2017; Fowler et al., 1989)**,** especially the leaves. According to Ottelé et al. (2010), the leaves can absorb significant quantities of health-damaging particles from the atmosphere and with it improve the air quality. Plants are considered to be natural filters of the air, absorbing the carbon dioxide from the air and replacing it with oxygen (Timur & Karaca, 2013) in a process called photosynthesis (Othman & Sahidin, 2016). The roots of the plants can remove particles from the soil (e.g. volatile organic compounds (VOCs) and xylene) (Wolverton et al., 1989) significantly reducing the concentration of toxins near the GW or LW (Loh, 2008).

Vertical vegetation in street-canyons offers the biggest benefits in regards to street-level air quality, bigger than for instance green roofs. Analyses resulted in a decrease of 40 percent in NO_2 and 60 percent for PM_{10} at street-level by implementing a green wall. (Pugh et al., 2012)

Several studies indicated that GW and LW significantly reduce the amount of $PM_{2.5}$ (Vera et al., 2021; Viecco et al., 2021, 2018) and PM_{10} (Pugh et al., 2012; Viecco et al., 2018). PM_{10} and $PM_{2.5}$ stands for particulate matter, these are inhalable particles smaller than 10 micrometers and smaller than 2.5 micrometers respectively (EPA, 2021).

Urban heat island

Vegetation can reduce the UHI through evapotranspiration cooling or directly by shading heat-absorbing surfaces (McPherson, 1990). Surface temperatures of different vertical greenery systems have been observed since 1996 at the University of Toronto and it consistently showed that vertical vegetated areas are cooler than (light-colored) brick, walls and black surfaces, which are common in urban areas (Bass & Baskaran, 2003). The same is visible in Germany, where Wilmers (1988) found that the surface temperature of a vertical vegetated wall was 10 degrees Celsius cooler than a bare wall in September. In Autumn, the temperature difference between a bare wall and a double-skin green façade in the Netherlands is approximately 2.7 degrees Celsius (Perini et al., 2011).

Widiastuti et al. (2018) conducted a thermal analysis between the GW and LW. They found that the LW reduced the outdoor temperature by 3.0 degrees Celsius and the GW by 1.2 degrees Celsius. Additionally, the LW also produced the cooling effect faster. Possible reasons are that the substrate helps with cooling the air and the higher foliage density of a LW compared to a GW. A study conducted by Wong et al. (2010) found that the GW can function as an insulation for the building façade, the system can significantly reduce the wall temperature of the external wall by up to 12 degrees Celsius. Pérez et al. (2011) also concluded that a double-skin GW creates a microclimate, characterized by lower temperatures and higher humidity levels. This characteristic of a GW creates the possibility to mitigate temperatures in urban canyons, creating 'human-friendly' levels in regards to the temperature (Alexandri & Jones, 2008)**.**

Water

GW and LW can filter rainwater and with that improve the water quality (Wong et al., 2010). GW and LW can be seen as constructed wetlands (CWs), which utilizes the purification functions conjoined to the natural ecosystem to decrease water pollution (Zhao et al., 2020). Integrating CWs in urban environments is often limited due to their large land requirement. However, GW and especially LW have all the major components of CWs and can therefore perform the functions of CWs in wastewater treatment and all without requiring a large land area due to the vertical nature (Zhao et al., 2019). LW have been proven effective in removing nutrients and organic pollutants from greywater (Gattringer et al., 2016). Furthermore, Lau & Mah (2018) found that LW can be effectively used as urban drainage systems to mitigate storm water runoff, especially in spatially restricted metropolitan areas.

Biodiversity

GW and LW have proven beneficial for the biodiversity on a local scale. Simplistic flora assemblages provide habitats for invertebrates (Francis & Lorimer, 2011) and shelter resources, food and nesting for birds (Chiquet et al., 2013)**.** GW and LW can also support the biodiversity by fulfilling the function of being a 'stepping stone' or 'corridor' to ease movement of animals (Angold et al., 2006; Tian & Jim, 2011).

Aesthetics

Wong et al. (2010) found that vertical greenery (GW) were seen as improvements in regards to the aesthetical appearance of the building. Additionally, visual encounters with vegetation can reduce stress and anxiety (Ulrich, 1979). Sheweka and Magdy (2011) added that the visual and physical contact with plants can improve the recovery rate of patients and increase the resistance to illnesses. Jing et al. (2021) found that a higher level of greenery visible from the street in urbanised areas can be associated with a lower fear of neighbourhood crime.

LW offer a more creative potential compared to GW and thereby increase the aesthetical appeal, according to Perini and Ottelé (2014). Houses with some form of integrated vegetation are according to White & Gatersleben (2011) *"more preferred, beautiful, restorative, and had a more positive affective quality than those without"*.

Economic benefits

Well-designed and well-maintained green roofs and walls increase the value of real estate, especially if they create extra outdoor living space (Bade et al., 2011). Peck et al. (1999) assumed that the increase in real estate value for a green wall would be equal to that of a 'good tree cover' and estimated that the value of real estate increased with 6- to 15 percent. Real estate increased 3.9 percent in value due to presence of hedges or green walls in Quebec (Canada), according to Des Rosiers et al. (2002). Luttik (2000) observed 3000 housing transaction in eight regions in the Netherlands and compared them on the presence of greenery and water. She concluded that houses are valued up to 28 percent more when located in a green environment.

2.1.6. Disadvantages

Risk of fire

Greenery (e.g. green roofs and green walls) can be seen as a fire hazard (Manso et al., 2021). However, the fire performance of such systems are generally very resistant to ignition. This is a result of the moist within these plants (which is normally available to keep them alive). However, the green systems might have a higher fire risk when the green wall dries out (especially when no irrigation system is integrated). (DCLG, 2013)

Tests conducted by Department for Communities and Local Government (2013) have shown that the material used as growing medium within living walls cannot be ignited, even when it is completely dried out. However, other materials of which a living wall is constructed can ignite. Therefore, some guidelines for implementing a green façade regarding fire prevention are: perform regular maintenance (Dvorak, 2011), remove dry and dead plants (Dvorak, 2011), moisturise the substrate (City of Sydney, 2010), apply a selection of plants that are more resistant (e.g. grasses and sedums)(Breuning, 2008) and avoid fire spread by having areas with no vegetation or growing medium (Dvorak, 2011).

Animals

Adding green facades has the benefit of increasing the biodiversity. However, next to the desired animal species also some non-desired animal species (so-called pest organism) will find their way to the green spaces as well (Lõhmus & Balbus, 2015). Increasing the amount of urban greenery, combined with its interconnectivity will draw certain animals. For example the tick (Estrada-Peña, 2002, 2003), mosquitos (Shackleton et al., 2016), and rodents (Meerburg, Singleton, & Kijlstra, 2009; Patergnani et al., 2010) (e.g. rats (de Cock & Maas, 2021)). These animals can cause damage due to gnawing, spread allergens, and potentially transmission of zoonotic pathogens (Lõhmus & Balbus, 2015).

Pollen allergens

Greenery can create allergic reactions to pollen. Especially in urban vegetation that is often characterized by an (over)abundance of a limited amount of specific species (Casares-Porcel & Cariñanos, 2011). On top of that, trees are used within the urban fabric as additives along avenues or as sound barriers. Placing them in close proximity to each other result in a reduction of air currents, which else would dilute the pollen (Vos et al., 2013). These trees release their pollen simultaneously and in combination with the reduction of air currents significantly influence the local micro-environmental conditions (Casares-Porcel & Cariñanos, 2011). Burney et al. (1997) estimated that in Europe up to 35 percent of the young adults have antibodies to pollen, resulting in considerable costs in terms of sick leave and drugs (D'Amato, Liccardi, & Frenguelli, 2007).

2.1.7. Conclusion benefits & disadvantages

Implementing a green façade has the benefit of stabilizing the internal temperature, effecting both the energy usage and the thermal comfort positively. Green facades also has an influence on the environment in close proximity to the green façade. Improving the air quality, reducing the noise, increase biodiversity, and positively influence the urban heat island effect. Aesthetically, the green facades influence it positively as well. Resulting in added value to the dwelling.

However, some disadvantages to a green façade need to be taken into account as well. In dry periods the risk of fire can be of concern and the increase in biodiversity can also be negative aspect. The latter due to undesired animals (e.g. rats) being drawn to the green façade. Additionally, adding greenery can increase the amount of pollen in the proximity. Which can increase the nuisance for people with pollen allergens.

The limited amount of municipalities that grand subsidies as well as the strict regulations for the ones that actually give grands, both can have a negative impact on the implementation rate of green facades. Additionally, the high investment costs, cost for maintenance, the frequency of the maintenance all have a negative effect on the willingness to implement a green façade.

Important aspects for making a decision on implementing a green façade are; investment cost, maintenance cost, energy savings potential, biodiversity improvement, and the time it takes to reach the final image. Making a decision is a result of psychological choice processes, to understand these processes the Theory of Planned Behaviour (TPB) is used as a framework (Section 2.2).

2.2. Theory of Planned Behaviour

In this study the Theory of Planned Behaviour (TPB) is used as a theoretical framework to understand choice behaviour. TPB is the prolonged version of the Theory of reasoned action (TRA) (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975). Both theories provide information about the motivational influences on behaviour. However, Ajzen (1985, 1991) added the term 'perceived behavioural control' to take into account situations where the respondents did not have complete volitional control.

Both theories are based around the individual's *intention* to conduct a given act or behaviour and is based around the general rule that the higher the individuals intention for a certain act or behaviour the more likely the act or behaviour is performed (Ajzen, 1991). Translating this to the subject of this study, the intention becomes the willingness/readiness of the respondent to implement a green façade.

The intention is influenced by three predictors. Namely, attitude towards the behaviour or act, the subjective norm, and the perceived behavioural control. The theory predicts that a positive attitude towards a behaviour or act, favourable social norms and, a high level of perceived behaviour control are the best predictors for forming a behavioural intention. This behavioural intention in turn leads to a performed behaviour or act. (Ajzen, 1991)

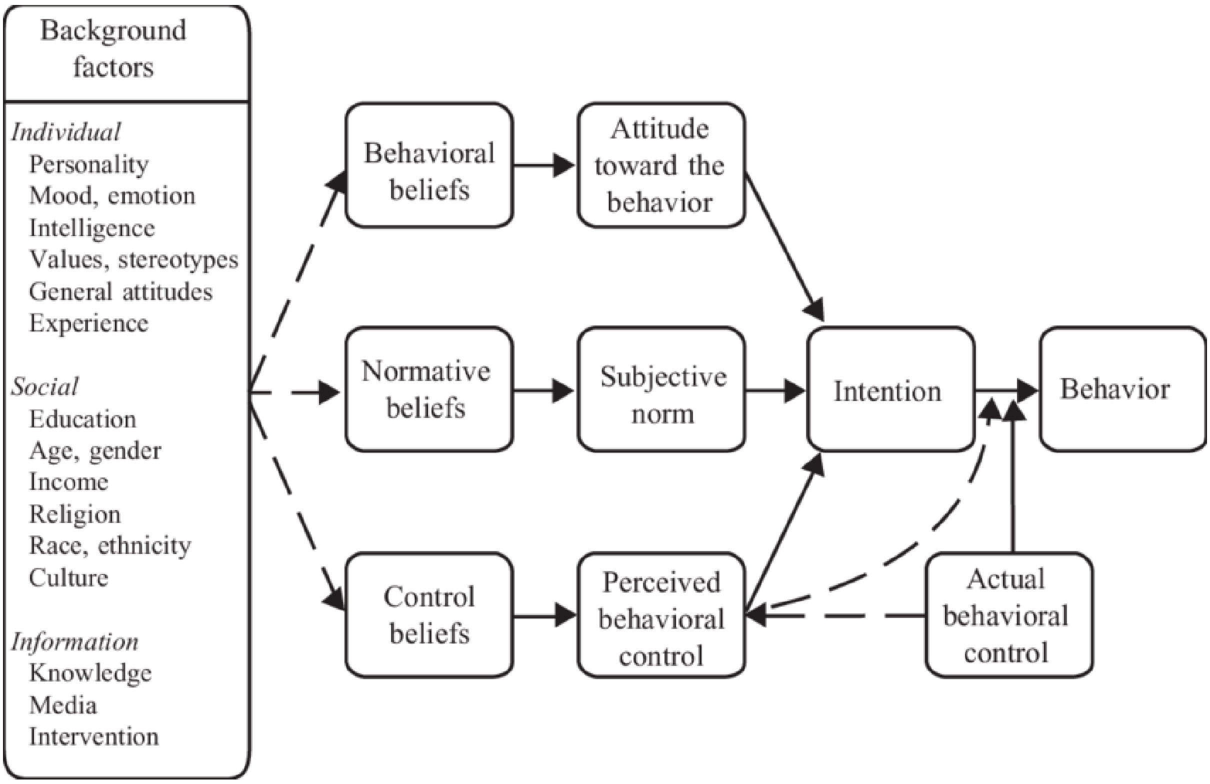


Figure 2 The theories of reasoned action and planned behaviour (Ajzen & Fishbein, 2005)

Figure 2 visualizes a more elaborate version of the TPB by Ajzen & Fishbein (2005). It shows that the three predictors of intention are influenced by so-called beliefs, which are in turn influenced by background factors. These background factors include a wide variety of cultural, personal, and situational factors, such as the differences between men and women, educated and uneducated, shy and outgoing but these factors might be affected by the availability of information, the social environment, and the physical environment (e.g. context variables). (Ajzen & Fishbein, 2005)

Ajzen (1991) mentioned that the model can be extended if important determinants are identified. He stated it as follows: *"The theory of planned behavior is, in principle, open to the inclusion of additional predictors if it can be shown that they capture a significant proportion of the variance in intention or behavior after the theory's current variables have been taken into account (p. 199*)". Numerous researchers have extended the model. For instance the extension by taking into account the environmental concerns of the respondent (Paul, Modi, & Patel, 2016)**.**

The theoretical framework of TPB has successfully been used in several environmental researches, about a wide variety of subjects. From fuel-efficient cars (Nayum & Klöckner, 2014)**,** to sustainable food consumption (Vermeir & Verbeke, 2008), to the willingness to pay for an urban park (López-Mosquera, García, & Barrena, 2014), to the willingness to implement green roofs (Louw, 2021).

The three predictors of intention, attitude towards the behaviour or act, the subjective norm, the perceived behavioural control, and the contextual variables are elaborated further in this chapter.

Attitude

The first predictor of intention, the attitude towards the behaviour or act, is about the individual's beliefs regarding the behaviour or act. Does it contribute positively or negatively to that person's life? (Ajzen, 1985)

In general, people have beliefs about an object based on the association of certain attributes of that object. These attributes become the possible outcomes of an action or the possible costs for an action, when translating the general rule to an behavioural attitude. These attributes are already been valued negatively or positively and therefore the attitude towards a behaviour is automatically formed. (Fishbein & Ajzen, 1975)

Petty & Briñol (2010) state that attitudes refer to the opinion of people regarding people (including themselves), objects, places, and issues. People will chose the option that they like the most, approve most strongly or find most favourable.

The attitude towards environment is often described as difficult (Heberlein & Wisconsin, 1981) and they noted that: *"The environment as an object is constantly present and has multiple sub-objects which do not, as individual objects, represent the totality. We have attitudes about specific objects in the environment such as pine trees, a particular river, the Rocky Mountains, etc. The environment is an experiential object, but no one experiences 'the environment' as a whole, but rather separate distinct aspects of the environment. (p.243)."* Dunlap, Jones & Micelson (2002) mentioned three broad trends regarding environmental problems. First, the problems are less localized and less visible, making people awareness more dependent on the media or other information sources. Secondly, the source of the problems as well as the solutions to the problems are seen as inherently related to complex social processes. Lastly, the continuing emergence of such problems, which are often seen as interrelated, likely gives greater credence to more general notions of environmental deterioration and ecological destruction. The latter made broad concepts about the environment (e.g. environmental problems, ecological deterioration) more meaningful attitude object for the public than a couple of decades ago. Eagly and Kulesa (1997) mentioned that the first two trends make the study of environmental studies harder due to more complex processes of forming attitude towards environmental issues and less dependency on personal experiences. Making attitudes more likely to be interrelated with attitudes towards other issues (e.g. governmental roles).

Capstick et al. (2014) mentioned that people do not feel worried or interpret climate change and its impacts as a threat. This can be attributed to vagueness of the responsibility of climate change for particular problems. But also informational context and the psychological distance for the problems (Steg & De Groot, 2019).

Steg & Vlek (2009) defined pro-environmental behaviour as “behaviour that harms the environment as little as possible, or even benefits the environment”. However, Steg & De Groot (2019) added that the behaviour is not solely or by definition motived by environmental goals. These pro-environmental behaviours can be conducted by people without the intention of improving the environment, for instance due to habitual behaviour (e.g. turning off the tap when brushing your teeth) or behaviour that is motived by other goals, such as cycling instead of driving because it is healthier and cheaper.

Demographics influence pro-environmental behaviour (Blankenberg & Alhusen, 2019; Whitmarsh & O’Neill, 2010). Several researchers found that women demonstrate higher pro-environmental behaviour than men (Hunter, Hatch, & Johnson, 2004; Longhi, 2013; Sánchez, López-Mosquera, & Lera-López, 2016; Zelezny, Chua, & Aldrich, 2000). However, men show more external behaviours in regards to pro-environmental behaviours, such as participating in environmental groups and reading environmental materials (Johnson, Bowker, & Cordell, 2004). Age influences PEB negatively (McCluskey, Durham, & Horn, 2009), which can be explained by the less active behaviours by elderly people (Wright, Caserta, & Lund, 2003). Longhi (2013) adds that PEB is at the lowest level when people start families, due to restrictions on time and money. Furthermore, the larger the household the lower the PEB (Clark, Kotchen, & Moore, 2003; Johnson et al., 2004; Longhi, 2013). Household income also influences the PEB, increase of energy emissions, greenhouse gas emissions is directly related to an increase in household income (Ala-Mantila, Heinonen, & Junnila, 2014; Moll et al., 2005). However, higher income households are more likely to pay for green electricity (Clark et al., 2003; Zorić & Hrovatin, 2012). Poorer individuals also tend to demonstrate more PEB, by taking public transport and reduce heating expenses (Longhi, 2013). On the contrary, higher income and educated people are more likely to conduct water savings practices (Berk, Schulman, McKeever, & Freeman, 1993). Education is correlated with more awareness and interest in environmental issues (Johnson et al., 2004; Longhi, 2013) and increases the PEB (Johnson et al., 2004). Franzen & Meyer (2010)**)** found that education influences environmental concerns by increasing the knowledge, which in turn increases the likelihood of PEB (Hines, Hungerford, & Tomera, 1987; Pothitou, Hanna, & Chalvatzis, 2016). On the contrary, conflicting information and lack of knowledge are hurdles to PEB (Lorenzoni, Nicholson-Cole, & Whitmarsh, 2007)

The PEB can be influenced by optimism bias or unrealistic optimism, according to Steg & De Groot (2019). Sharot (2011) defined optimism bias as “*the difference between a person’s expectation and the outcome that follows. If expectations are better than reality, the bias is optimistic and if reality is better than expected, the bias is pessimistic.*” In relation to climate change, this optimism bias can be that the person beliefs the negative impacts of climate change will occur at some other time and somewhere else. The latter is called psychological distance (Trope & Liberman, 2010).

Subjective norm

The second predictor of intention, the subjective norm, is defined as “the perceived social pressure to perform or not to perform the behaviour” (Ajzen, 1991). Cialdini (2003) elaborates this by subdividing the subjective norm in two types of norms: perceptions of which behaviour or act are generally approved or disapproved (injunctive norms) and perceptions of which acts or behaviours are generally conducted (descriptive or behavioural norms). The subjective norm represents the feeling of an individual regarding the social pressure of a given behaviour. Ultimately, the higher the positive subjective norm regarding a given behaviour, the more likely the intention for the given behaviour is positive (Ajzen, 2002; Mimiaga et al., 2009)

Both attitudes and (subjective) norms contribute significantly to the intention of certain actions (Bowman & Fishbein, 1978; Davidson & Jaccard, 1979; Hom, Katerberg, & Hullin, 1979). However, in general attitudes outperform (subjective) norms on influencing the intention (Cialdini, Petty, & Cacioppo, 1981).

Behaviours that are socially accepted are hard to change (Jackson, 2005; Lorenzoni et al., 2007). Therefore, if car use is socially accepted than the social norm negatively influences the PEB (Steg, Vlek, & Slotegraaf, 2001). On the contrary, if being green is socially accepted then the social norm positively influences the PEB (Welsch & Kühling, 2018).

Furthermore, climate change is often referred to as being a 'wicked' problem due to its complex interdependencies in society that effect climate change and the difficulty to find solutions (Hulme, 2009; Levin, Cashore, Bernstein, & Auld, 2007; Turnpenny, Lorenzoni, & Jones, 2009). Carley & Christie (2000) mentioned that a clear component of a 'wicked' problem is that the cumulative impacts of collective action are unknown or not clear. This phenomenon is closely related to a social dilemma within the social psychology. Dawes (1980) defined social dilemmas as situation were individual action results in improved personal outcomes. However, if a majority of people conduct the same action, the outcome would be undesirable for all.

Perceived behavioural control

The third predictor of intention, the perceived behavioural control (PBC) refers to the perception of people regarding the ease or difficulty of performing the behaviour or act. It reflects past experiences as well as anticipated impediments and obstacles (Ajzen, 1991).

Ajzen & Madden (1986) referred to the perceived behavioural control as a function based on control beliefs and perceived power. The latter is asked using the following statements; 'I can buy a green façade, if I want to', 'I can handle the added amount of maintenance of a green façade', and 'I have the information to be able to implement a green façade'. The latter refers to the individual opinion of the importance of the resources and opportunities in achieving the behavioural outcomes. Whereas the control beliefs are defined as the perceived absence or presence of resources and opportunities to ease the execution of a specific behaviour. Madden, Ellen, & Ajzen (1992) added that the perceived behavioural control of a person in the TPB should be greater when he or she has significant resources and opportunities.

Sparks et al. (1997) pointed out that PBC reflect both inner control factors, such as self-efficacy, and external perceived difficulty factors. In other words, perceived product availability (Sparks & Shepherd, 1992) and perceived consumer effectiveness (Roberts, 1996). The perceived product availability is defined as the consumers feeling of easiness to obtain/consume a certain product. The intention of a person to buy a (sustainable) product can be hampered. Even though, the consumer has a high motivation to buy a (sustainable) product, due to the low perceived availability of the product (Vermeir & Verbeke, 2006). Perceived consumer effectiveness is defined by Roberts (1996) as the extent to which the consumer can contribute to a solution of a problem by his or hers own personal efforts, this is asked using the following statement: 'There is no point in realizing a green façade, if no one else is realizing one'. Having a high perceived consumer effectiveness is a must for consumers to consume (sustainable) products (e.g. green facades) and to express their positive attitudes towards these products.

The lack of behavioural actions in regards to climate change has been found to be a result of a lack of perceived behavioural controls, according to Lorenzoni et al. (2007). Behaviour did not change for people directly influenced by climate-related events, such as flooding (Lorenzoni et al., 2007). Car drivers are more concerned in regards to climate change than individuals that are non-drivers. Car drivers demonstrated that reducing the car use (change of behaviour) would be beneficial. (Stradling et al., 2008) However, car use is still increasing (CBS, 2020b). Furthermore, having children is positively related to the concern for climate change. Even though the awareness regarding climate change is rather high, acknowledging the possible individuals impact, the experience of an climate-related event, or the consideration of the effects of climate change on one's children will not lead to change in behaviour. (Norton & Leaman, 2004)

Lorenzoni et al. (2007) added that a coping mechanism based on denial, caused by misperceptions, in order to reduce the feeling of guilt and thereby justify the inactive behaviour. The perception that barriers to behaviour exists are affected by the failure of imagining the impacts of climate change, both on a personal level as on others, along with failing to see the link between personal activities (e.g. energy usage) as a cause of climate change.

Contextual forces

High-cost behaviours, such as adding a green façade, are probable to be strongly influenced by contextual forces (Stern, 2000). However, the relation between actual behaviour and the contextual forces are heavily mediated by personal variables (Black, Stern, & Elworth, 1985). Jansson et al. (2009) argued that the perception of contextual forces combined with how these perception influence actual behaviour might be more relevant than an objective measure of the contextual forces.

Conclusion

The theory of planned behaviour (TPB) will be used as the theoretical framework within this research. The theory is based around the individuals *intention* to conduct an act or behaviour, which in turn is influenced by three predictors. Namely, attitude towards the behaviour or act, the subjective norm and, the perceived behavioural control. Furthermore, climate change is seen as a 'wicked' problem due to its scale and volatility, reducing the ability of people to see the effects of their own actions in regards to climate change. Additionally, contextual forces are at play, especially with high-cost behaviours such as the implementation of a green façade. The perception of these contextual forces and how these influence the actual behaviour might be more interesting than the objective measure of the contextual forces itself.

2.3. Conclusion

Urbanisation and climate change are ongoing processes, the latter can be mitigated using permeable materials. As space is increasingly limited due to urbanisation, adding permeable materials can be done vertically (e.g. green facades). There are two types of green facades; green walls and living walls. Prices range from 30 to 1200 €/m² and between 5,50 and 19 €/m²/year for maintenance. Municipalities that grant subsidies regarding green facades are rather limited and often with strict requirements.

The high investment cost and maintenance cost are seen as the restricting factors for implementing green facades.

Potential benefits of a green façade are; stabilizing the internal temperature, energy savings, increasing the thermal comfort, improving air-quality, reducing noise, increasing biodiversity, positively influence the urban heat island effect, and added value of the dwelling. Potential disadvantages are; the risk of fire (during dry periods), increasing biodiversity (undesired animals e.g. rats), and increase the amount of pollon in the proximity.

Important aspects for making a decision on implementing a green façade are: investment cost, maintenance cost, energy savings potential, increased biodiversity, and time it takes to reach the final image.

The theory of planned behaviour is used as a framework throughout the research as a decision is a result of psychological choice processes. The theory is based around the individuals intention to conduct an act or behaviour, which is in turn influenced by three predictors; attitude towards an act or behaviour, perceived social norm, and perceived behavioural control. Furthermore, context variables are at play, especially because implementing a green façade is a high-cost behaviour.

3. Research method

This chapter discusses the research method used in this report and is structured as follows. First, the conceptual model used is described. Second, the experimental design is elaborated focussing on the survey design and the construction of the choice experiment. Third, the data collection and preparation is discussed. Followed by the background information for the data analyses.

3.1. Conceptual model

The conceptual model, visualized in Figure 3, shows the four different categories that influence the willingness to implement a green façade. These are; socio-demographics, prior knowledge, context variables, and the Theory of Planned Behaviour. These groups are chosen based on the conducted literature study. First, the socio-demographic have been studied by multiple researchers. Who found that socio-demographics have an influence on the willingness to implement things, such as a green façade. These differences can be seen between age, gender, level of education, and household income. Secondly, prior knowledge. The literature stated that prior knowledge about a subject/or product increases the chances of implementation. Therefore, this is included into the concept model. Third, context variables, these are added to the model to see if context has an influence on the willingness to implement a green façade. This aspect has not yet been covered by scientific literature and therefore adds to the already existing literature. The three previously mentioned categories are influence the three predictors of the Theory of Planned Behaviour. The theory predicts that a positive attitude towards a behaviour or act, favourable social norms and, a high level of perceived behaviour control are the best predictors for forming a behavioural intention (Ajzen, 1991). Including this into the research makes it possible to see the effects of these three aspects on the willingness to implement a green façade. Lastly, the intention as a result from the Theory of Planned Behaviour is coupled with the different attributes and attribute levels of a green façade to finally derive the willingness to implement a green façade is.

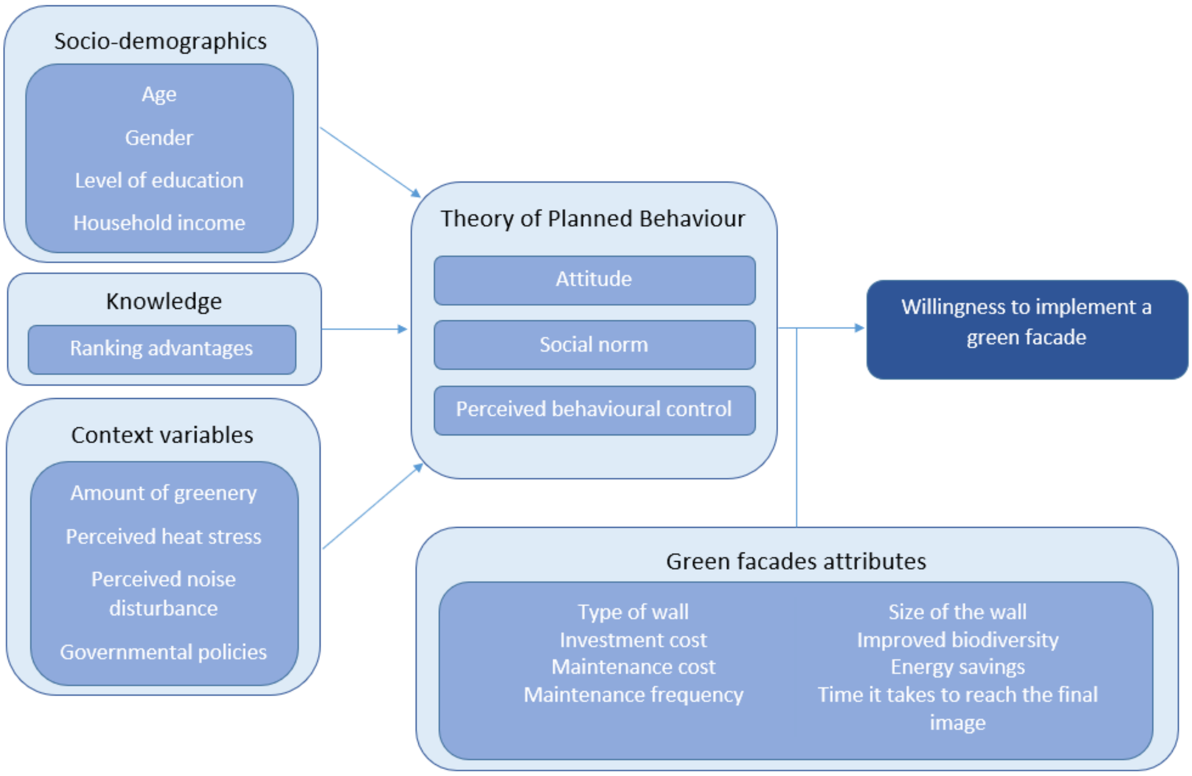


Figure 3 Concept model

3.2. Experimental design

The research aims to understand the willingness to implement a green façade by Dutch home-owners of land-bound dwellings. This will be studied using a survey that includes a Stated Choice experiment. An explanation of the design of the survey is elaborated below, followed by the data collection.

3.2.1. Survey design

The survey consists of two parts, first the closed-end questions followed by the stated choice experiment. To start with the closed-end questions, these are used for the gathering of demographic data, regarding; age, gender, education, and household income. The received data will be used to map the demographical influences on the preference of a green façade. Furthermore, the respondents are asked about the type of dwelling (e.g. rowhouse, apartment etc.) and whether they rent or own the dwelling. These questions are used for two purposes. First, it enables the removal of any respondent who does not live in a land-bound dwelling or owner-occupied dwelling. Second, the willingness to implement a green façade can differ between house types. Additionally, the respondents are asked to fill in their postal code (not compulsory). This data will be used to map the distribution of the respondents on a map.

Furthermore, the respondents are asked several scale questions regarding their attitude, perceived social norm, and their perceived behavioural control. These three aspects are indicators for the intention according to the theory of planned behaviour (TPB), and are therefore of interest.

The general attitude towards climate change is asked. This is done by asking two statements (1) “I’m worried about the climate” and (2) “I’m concerned about the human processes that damage the climate”. The first statements gives insight in whether there is a general concern about climate change in general and the second statement gives insights whether the respondent sees climate change as a consequence of human activities. The latter is added because when someone does not see the human activities as a cause for climate change, than no action can be taken as climate change is not caused by humans.

The attitude towards potential benefits of a green façade are asked. These benefits are derived from the conducted literature study and focus on biodiversity, air-quality, reduction of the urban heat island effect and increased thermal comfort in the house (e.g. “green facades are beneficial for the biodiversity in the neighbourhood”). The answers to these statements give insight whether the benefits mentioned by the literature are also seen as benefits by the respondents.

Finally, again two more general statements about the attitude towards a green façade are stated. First, the benefit of a green façade to the neighbourhood and second whether the green façade are aesthetically pleasing. These give insight into the attitude on a more general scale regarding green facades.

Two statements, “I am thinking of implementing a green façade” and “Have you thought about implementing a green façade”, are asked to get a more insight in whether the implementation of a green façade is actually on people’s minds and if so how far in the process they are.

However, having a positive attitude towards green facades is only one of the three aspects for intention. Therefore, five statements regarding social norm and four statements regarding perceived behavioural control are also included.

If an act or behaviour is seen as positive within the social norm, than that act or behaviour is more likely to occur. Therefore, five statements are asked to find out whether implementing a green façade is seen as a positive social norm. The statements are about the commonness of green facades in the neighbourhood, by people the respondents know and by close friends of the respondents. If so, the social norm for a green façade could be seen as a positive. However, also the information about a green façade by means of mouth to mouth are an indication to the social perception of a green façade. Therefore, the statement "Others have alerted me to the possibility of implementing a green façade" is included. A positive social norm is seen as one of the key indicators for an act or behaviour according to the literature. However, people might see this differently and are therefore asked whether the respondents care what others think of green facades.

The perceived behavioural control is based on the ease of access of a behaviour or act and the effectiveness of such an act or behaviour, in this case whether a green façade is perceived to be accessible and effective. This is tested using four statements. Were the first statement is focussed on whether the amount of information required to implement a green façade is available (e.g. "I have the information to be able to implement a green façade"). Second and third statements are about the access to a green façade (monetarily and physically): "I can buy a green façade for my house, if I wanted to" and "I can handle the added amount of maintenance of a green façade". The last statement is about the effectiveness of a green façade, to give insight in whether individuals are seeing the point in realizing a green façade when no one else is implementing one ("There is no point in realizing a green façade, if no one else is realizing one").

In addition, several context questions are asked. These variables are included to see if a specific context influences the willingness to implement a green façade. Context variables used in this survey are:

- The amount of greenery present in the direct surroundings of the respondent.
- The perceived amount of noise disturbance present in the area.
- The perceived amount of heat stress present in the area.
- The availability of stimulating policies for the implementation of green facades.

The respondents will be asked about the context variables via several scale questions. The first context variable, the perceived amount of greenery present in the direct surroundings of the respondent, is visualized by a choice-set of 4 different levels of greenery (Figure 4).

Figure 4 Choice-set question: Perceived amount of greenery present in the direct surroundings.

The other context variables are asked by means of statements, to which the respondents have to state how much they agree or disagree with that statement. All these statements are concerning possible effects caused by these context variables according to the literature. The perceived amount of noise disturbance present in the area is asked using three statements, (1) 'Noise disturbance disturbs my sleep', (2) 'noise disturbance makes me annoyed', and (3) 'noise disturbance decreases my productivity'. In regards to the perceived heat stress in the neighbourhood four statements are asked; (1) 'during heat waves I sweat a lot at home', (2) 'during heat waves I have problems sleeping at night', (3) 'during heat waves I often have headaches at home', and (4) 'during heat waves I have problems with being productive'. The availability of stimulating policies are asked by three statements. The first statement is concerned with the general knowledge of such policies ('Does the municipality grant a subsidy for a green façade?'). While the other two statements are about the information that respondents have received regarding making their house more sustainable and whether information about green façades is given. The statements are as follows; 'Have you received information for making your house more sustainable?' and 'Have you received information for making your house more sustainable, including information about green façades?'. The answers to these statements are combined into an average value for 'governmental support', which is then used as an interaction variable to test its effects on the willingness to implement a green façade.

Further questions are about the experience of the home-owners regarding green facades. This is done by asking the respondents to rank the advantages of a green façade based on their importance. This question not only gives insight in the knowledge of the respondents, but it also gives information to the respondents about the numerous advantages that green facades have. The advantages are derived from the literature review. An overview of all the questions can be found in Appendix I.

Design Stated Choice experiment

The chosen experiment is a Stated Choice experiment. For the reason that different attributes of the subject can be weighed against one another based on the preferences. From which the willingness to implement a green façade can be determined.

The stated choice experiment includes eight questions, in which a choice-set is shown. Each choice-set includes two-options and a no choice option. The respondent is asked to choose the option that he or she desires the most. Every choice option is constructed out of eight attributes: type of green façade, investment cost, maintenance costs, maintenance frequency, size, improved biodiversity, energy savings, and the time it takes to reach the final image (Table 1).

- **Type of green façade**, consist out of two levels. A green wall and a living wall. These walls are different in terms of esthetic, investment costs, maintenance cost, and maintenance intensity. The type of green façade will be named as well as visualized. The latter to help the respondents visualize the different wall types.
- **Investment cost**, from the literature it is shown that the investment cost is one of the bottlenecks in regards of implementing a green façade. This attribute of a green façade is included to understand the influence the investment costs has on the willingness to implement a green façade. The investment cost consist out of four levels. Namely, (1) 950 euros, (2) 1500 euros, (3) 3000 euros, and (4) 4500 euros. These amounts are not the real investment costs of green facades, which are higher in the real world (especially for living walls). It is chosen to use arbitrary values to reduce the chances that the investment cost will overrule the other attributes and potentially the choice of implementing a green façade itself.
- **Maintenance costs**, according to the literature this is also seen as a bottleneck in the implementation of a green façade. Therefore, the maintenance costs are taken into account. This three level attribute (€50, €200, and €400 per year) could give insights in its influence on the choice as well as the potential willingness to pay by the respondents for a green façade.
- **Maintenance frequency**, next to the maintenance costs also the maintenance frequency can be effecting the willingness to implement a green façade. The frequency of maintenance ranges from monthly, 2 times per year, to 4 times per year.
- **Size**, this two level attribute, half and whole, is included to find the preference of the respondents in regards to the coverage of the façade. This attribute is also supported by visualization.
- **Improved biodiversity**, one of the key factors according to the literature and the one-on-one interviews making a decision regarding the implementing of a green façade. Adding a green façade improves the biodiversity. Therefore, this two level attribute is included in the stated

choice. Having the levels 'average' and 'a lot' as choice options. In which both levels provide spaces for births to nest, but the level 'a lot' adds food provision for animals to that.

- **Energy savings**, seen as one of the largest benefits of a green façade. The literature stated that energy savings due to the implementation of a living wall could reach 30 percent and a green wall up to 20 percent. These two percentages are therefore used for this attribute.
- **Time it takes to reach the final image**, green facades are constructed out of plants. These plants need to grow and different kind of walls need different sizes of plants. This ultimately results in different time periods to fully green the wall. For living walls this 'greening' time is almost direct or in at least a couple of months. Whereas, green walls, constructed out of climbing plants can take years before they fully cover the façade. Therefore, the effect of this 'greening' time on the willingness to implement a green façade is tested in this stated choice experiment. Consisting out of three levels; 'direct or in a couple of months', 2 years, and 4 years.

Table 1 Attributes and levels

Levels / attributes	**Type of green façade**	**Investment cost**	**Maintenance cost**	**Maintenance frequency**	**Size**	**Improved biodiversity**	**Energy savings**	**Time it takes to reach the final image**
0	Green wall	€950	€50	Monthly	Half	Average	20%	Direct or in a couple of months
1	Living wall	€1500	€200	2 times per year	Whole	A lot	30%	2 years
2	-	€3000	€400	4 times per year	-	-	-	4 years
3	-	€4500	-	-	-	-	-	-

Eight attributes, four of which have two levels, three have three levels, and one has four levels. These eight attributes combined with their levels result in a stated choice experiment with 1728 possible combinations. This ultimately means that a lot of respondents are needed, an amount which is not going to be reached by this survey. Therefore, a fractional factorial design is used. Translating the amount of attributes and their levels into the non-orthogonal basis plans by Addelman (1962). Therefore, 16 alternatives or profiles are needed to test the main effects (Table 2). This method makes it possible to include all the main effects of a factorial arrangement unaccompanied by correlation, if the interaction are insignificant according to Addelman (1962). This assumption is reasonable because the main effects explain the largest amount of variance in the response data.

Table 2 Non-orthogonal basis plan 3 (Addelman, 1962)

4 levels		3 levels	3 levels	3 levels		2 levels	2 levels	2 levels	2 levels
0		0	0	0		0	0	0	0
0		0	1	1		0	0	0	0
0		0	2	2		0	0	0	1
0		0	1	1		0	0	0	1
1		1	0	1		0	1	1	0
1		1	1	0		0	1	1	0
1		1	2	1		0	1	1	1
1		1	1	2		0	1	1	1
2		2	0	2		1	0	1	0
2		2	1	1		1	0	1	0
2		2	2	0		1	0	1	1
2		2	1	1		1	0	1	1
3		1	0	1		1	1	0	0
3		1	1	2		1	1	0	0
3		1	2	1		1	1	0	1
3		1	1	0		1	1	0	1

Translating the non-orthogonal design into the labelled levels results in Table 3.

Table 3 Overview of alternatives

Alternative nr.	**Investment cost**	**Time it takes to reach the final image**	**Maintenance frequency**	**Maintenance cost**	**Type**	**Size**	**Improved biodiversity**	**Energy savings**
1	€ 950,00	Direct or in a couple of months	Monthly	€ 50,00	Green wall	Half	Average	20%
2	€ 950,00	Direct or in a couple of months	2 times per year	€ 200,00	Green wall	Half	Average	20%
3	€ 950,00	Direct or in a couple of months	4 times per year	€ 400,00	Green wall	Half	Average	30%
4	€ 950,00	Direct or in a couple of months	2 times per year	€ 200,00	Green wall	Half	Average	30%
5	€ 1.500,00	2 years	Monthly	€ 200,00	Green wall	Whole	A lot	20%
6	€ 1.500,00	2 years	2 times per year	€ 50,00	Green wall	Whole	A lot	20%
7	€ 1.500,00	2 years	4 times per year	€ 200,00	Green wall	Whole	A lot	30%
8	€ 1.500,00	2 years	2 times per year	€ 400,00	Green wall	Whole	A lot	30%
9	€ 3.000,00	4 years	Monthly	€ 400,00	Living wall	Half	A lot	20%
10	€ 3.000,00	4 years	2 times per year	€ 200,00	Living wall	Half	A lot	20%
11	€ 3.000,00	4 years	4 times per year	€ 50,00	Living wall	Half	A lot	30%
12	€ 3.000,00	4 years	2 times per year	€ 200,00	Living wall	Half	A lot	30%
13	€ 4.500,00	2 years	Monthly	€ 200,00	Living wall	Whole	Average	20%
14	€ 4.500,00	2 years	2 times per year	€ 400,00	Living wall	Whole	Average	20%
15	€ 4.500,00	2 years	4 times per year	€ 200,00	Living wall	Whole	Average	30%
16	€ 4.500,00	2 years	2 times per year	€ 50,00	Living wall	Whole	Average	30%

Every respondent is asked eight choice questions. In addition to the choice questions also seven personal questions, eleven context questions, 19 statements about green facades and 1 ranking question are asked. Resulting in a total of 46 questions per respondent. In order to prevent order bias, four different versions were generated randomly. These versions are allocated to the respondent randomly by the software. An example of a choice set is visualized in Figure 5. Additional information about the design of the choice set can be found in Appendix I.

Characteristics	Alternative 1	Alternative 2
Type	 Green wall	 Living wall
Size	 Half	 Heel
Investment cost	€950,-	€4.500,-
Maintenance frequency	4 times per year	Monthly
Maintenance cost	€200,-	€200,-
Time it takes to reach the final image	4 years	2 years
Improved biodiversity	Average	Average
Energy savings	30%	20%

Which alternative would you prefer?

Choose one of the following answers

Alternative 1 | Alternative 2 | Neither one

Figure 5 Example of a choice-set question

Sample size

A minimum sample size (minimum number of respondents) is needed to make sure that the gathered data is suitable for an accurate data analysis. Orme (2019) stated a formula in which the minimum number of respondents can be calculated. The formula includes; the number of respondents (N), the number of tasks (T), the number of alternatives per task (A) (excluding the no-choice alternative), and the number of analysis cells (C) in other words the maximum number of levels in an attribute. (Orme, 2019)

Equation 1 Minimum sample size

$$\frac{NTA}{C} > 500$$

The number of tasks (T) of a respondent is 8, the number of alternatives per task (A) in a choice-set equals 2, and the number of analysis cells (C) equals 4. Substituting this information into formula results in 125. Therefore, a minimum of 125 respondents are needed.

3.2.2. Data collection

Data is collected via a survey that is distributed using social media platforms (e.g. LinkedIn), personal network (e.g. friends, family, and acquaintances), and through door-to-door flyering in mailboxes. All with the aim of generating a large amount of responses from different groups of home-owners. This to gather data that is representative for the group of home-owners of land-bound dwellings in the Netherlands. In other words the data collected should have a high external validity.

The survey was online from the 15th of March until 20th of April, 2022. A total of 238 respondents started the survey, of which only 170 respondents filled in the complete survey. 28 respondents (12%) stopped answering after the personal questions. However, the vast majority of the respondents who stopped before completing the whole survey stopped at the start of the stated choice tasks (17%). Possible reasons for this can be the fact that the chosen words to explain the stated choice tasks were too difficult, the survey was too long or the stated choice tasks were to complex. Only the ones that completed the survey were included into the data analysis.

3.2.3. Data preparation

Several respondents were removed from the data to prepare the data for analysis, even if they completed the complete survey. These were removed for one of three reasons; (1) they stated that there type of dwelling was not a ground-based dwelling (e.g. apartment), (2) they are renters, or (3) they filled out the choice experiment homogeneously. Therefore, the total respondents that are used in the data analysis resulted in 140. Exceeding the minimum required sample size.

Furthermore, to conduct statical analysis on the data, the data needed to be prepared. Because several variables within the survey are categorical variables. These variables need special treatment/recoding before they can be included into a regression model. In general, two types of coding are used: dummy coding and effect coding. Dummy coding turns the categorical variable into dichotomous variables (having the value zero or one). Creating new variables for each of the attribute levels within the categorical variable minus one. Therefore, a maximum of three dummy variables per attribute can be created because the attributes differ between 2 and 4 levels. These new variables are included in the regression equation and given specific coefficients. Dummy coding enables the comparison of the different levels to the base level of that attribute. Whereas, effect coding compares the levels to the grand mean. Making it possible to state the effects of each attribute level. Effect coding uses the rule that all values for the new variables must sum to zero. (Hensher, Rose, & Greene, 2005) Dummy coding is generally preferred over effect coding. However, according to Zhou (2020) effect coding is beneficial for the interpretation in multinomial logit models. Therefore, effect coding is chosen and used in this research. The effect coding of the attribute levels is visualized in Table 4.

Table 4 Effect coding attribute levels

Attributes	**ID**	**Level**	**A**	**B**	**C**
Type of green façade	0	Green wall	1		
	1	Living wall	-1		
Investment cost	0	€950	1	0	0
	1	€1500	0	1	0
	2	€3000	0	0	1
	3	€4500	-1	-1	-1
Maintenance cost	0	€50	1	0	
	1	€200	0	1	
	2	€400	-1	-1	
Maintenance frequency	0	Monthly	1	0	
	1	2 times per year	0	1	
	2	4 times per year	-1	-1	
Size	0	Half	1		
	1	Whole	-1		
Improved biodiversity	0	Average	1		
	1	A lot	-1		
Energy savings	0	20 percent	1		
	1	30 percent	-1		
Time it takes to reach the final image	0	Direct or in a couple of months	1	0	
	1	2 years	0	1	
	2	4 years	-1	-1	

Additionally, Limesurvey stores the data in a format called ‘wide format’. The statistical package Nlogit uses a data format called ‘long format’, in which a single respondent is not represented within one row, but by several rows. Each row represents a choice alternative (Hensher, Rose, & Greene, 2015). Therefore the data structure is transformed into a ‘long format’ using Pythoncode (Appendix II).

3.2.4. Data analysis background

The background of what type of data analysis used and how these analysis work is elaborated in this section. Starting with the descriptive statistics, followed by the theoretical explanation of a choice data analyse model, a multinomial logit model.

Descriptive analysis

Descriptive analysis is conducted to test if the research sample is a representative group. This is of importance because the interpretation and the usefulness of the research results are dependent on it. If the sample is not a representative group than the results can be biased. Therefore, the demographical data collected by the survey is compared to the WoON2018 data.

Choice analysis

Stated choice experiments (SCE's) are based around the theory of utility. This theory states that people are choosing their actions/products based on its utility and when a choice needs to be made between two options than the option with the highest utility will be chosen. In other words, the individual will chose the option that maximizes their overall utility. Also called 'utility-maximizing behaviour'. (Cascetta, 2009)

However, within SCE there are observed effect and unobserved effects at play. The latter influences the choice of the individual but these aspects are not covered by the choice experiment. Therefore, assumptions need to be made regarding the unobserved effects. One example is the distribution of the unobserved effects. (Manski, 1977) Utility (U_{iq}) is constructed out of structural utility (observable) and random utility (unobservable), where structural utility is denoted as V_{iq}. The random utility is also revered to as the error term and denoted as ε_{iq}. In which the 'iq' stands for a specific alternative *i* and decision maker *q*. (Hensher et al., 2015)

Equation 2 Utility

$$U_{iq} = V_{iq} + \varepsilon_{iq}$$

$U_{iq} = Utility\ value$

$V_{iq} = Structural\ utility\ (observed)$

$\varepsilon_{iq} = Random\ utility\ (unobserved)$

Utility is mainly calculated by the observable structural component, since the unobserved random utility is a stochastic error component. The structural utility is defined by Hensher et al. (2015) as:

Equation 3 Structural utility

$$V_{iq} = \sum_{n} \beta_n * X_{inq}$$

$V_{iq} = Structural\ utility\ (observed)\ of\ alternative\ i\ for\ respondent\ q$

$\beta_n = Weight\ of\ attribute\ n$

$X_{inq} = Score\ of\ alternative\ i\ on\ attribute\ n\ for\ individual\ q$

This distribution of a random component within the utility function comes in two forms. These are a multivariate normal distribution (commonly used in probit models) and a multivariate generalized extreme value (GEV) distribution (commonly used in logit models). The implementation of these two types result in different coefficients, as they have influence on the normalization process. The latter is needed to allow for estimations of the model as the discrete choice models only compare utility levels, making it impossible to obtain the scale of the utility functions out of the observed information.

One of the main differences between probit and logit models is how they are interpreted. First, the coefficients used in logit models are generally larger than in probit models. Second, logit models assume that every alternative has the same variance of the unobserved effects. Making the logit model easier to interpreted than probit models and therefore, the model that is generally used in discrete choice models (Long & Freese, 2001)(J.S. Long & Freese, 2006).

There are various types of logit models, such as the multinomial logit (MNL), the nested logit, and the mixed multinomial logit. MNL is the simplest of the three.

Multinomial logit (MNL)

The MNL model uses random (unobserved) components that are independently (covariates are zero) and identically (variances constant) Gumbel distributed (Labbé, Laporte, Tanczos, & Toint, 1998). The model calculates the probability of an alternative being chosen from a set of alternatives by an individual. Translated into a formula gives (Labbé et al., 1998):

Equation 4 Probability

$$P_{iq} = \frac{\exp(V_{iq})}{\sum_{i=1}^{I} \exp\,(V_{iq})}$$

$P_{iq} = Probability\ of\ alternative\ i\ for\ individual\ q$

$V_{iq} = Observed\ component\ of\ alternative\ i\ for\ individual\ q$

$V_{iq} = Observed\ component\ of\ the\ number\ of\ alternatives\ in\ the\ choiceset$

Log-likelihood ratio test

The model performance need to be tested before the results can be analysed. To test this the McFadden Rho Squared will be performed, which uses the log-likelihood value. In MNL, the choice observations are assumed to be independent of both the decision makers and the choice situations. Therefore, the log-likelihood can be estimated using the following formula (Hensher et al., 2015);

Equation 5 Log-likelihood

$$LL(\beta) = \sum_{q}^{N} \sum_{i} y_{iq} * \ln\,(P_{iq})$$

$LL(\beta) = Log - likelihood\ with\ estimated\ parameters\ (\beta)$

$N = Total\ number\ of\ choices\ made\ in\ the\ model$

$i = Alternative$

$y_{iq} = Choice\ made\ by\ indivual\ q\ for\ an\ alternative\ i\ (chosen = 1, not\ chosen = 0)$

$P_{iq} = Probability\ of\ alternative\ i\ for\ individual\ q$

$\ln = Natural\ logarithm$

In the base model, there are three alternative options (alternative 1, alternative 2, and a 'neither one' option). Therefore, LL(0) can be calculated by multiplying the number of observations by LN(1/3).

Goodness of fit: McFadden Rho Square test

As mentioned before, the model performance can be tested using the McFadden's Rho Square test. The goodness-of-fit is calculated using the log-likelihood value of the estimated model divided by the log-likelihood value of the null model. The result of this calculation is subtracted from 1 to end with the Rho Squared value. (McFadden, 1974) A goodness-of-fit of the model is considered adequate when the Rho Squared Adjusted value falls between 0.2 and 0.4. A value higher than 0.5 is deemed unrealistic for behavioural experiments (Domencich & McFadden, 1973).

Equation 6 McFadden Rho Square

$$\rho^2 = 1 - \frac{LL(\beta)}{LL(0)}$$

$\rho^2 = Rho\ Square$

$LL(\beta) = Log - likelihood\ of\ estimated\ model$

$LL(0) = Log - likelihood\ of\ null\ model$

Intrinsic to the McFadden Rho Square equation (Equation 6) is the increase of the rho squared when variables or attributes are added. However, not every added variable improves the model. Therefore, an adjusted rho squared needs to be calculated to counter the increase in rho squared solely on added variables. This is calculated using Equation 7 (Long & Freese, 2001).

Equation 7 Adjusted Rho Squared

$$\rho^2_{Adjusted} = 1 - \frac{LL(\beta) - K}{LL(0)}$$

$\rho^2_{Adjusted} = Adjusted\ Rho\ Square$

$K = number\ of\ estimated\ parameters\ in\ the\ model$

Mixed Logit model model

A mixed logit model is a random utility model, so that a sample of respondents (individuals) include multiple choices based on a variety of alternatives. The model assumes that the respondents will choose the alternative based on the highest utility. (Hensher & Greene, 2003)

The mixed logit model is seen as a highly flexible model that can approximate any random utility model (McFadden & Train, 2000). The mixed logit model eliminates three limitations of a standard logit model. Namely, (1) allowing for random taste variations, (2) unrestricted substitution patterns, and (3) correlations in unobserved factors over time (Train, 2009).

Mixed logit models are of interest because it takes heterogeneity of the population (respondents) into account by assuming that parameters vary from one individual to the next. In other words, the Mixed Logit model assumes that every individual has its own inter-related systematic and random components for every alternative in their perceptual choice set. As a result, this model is generally seen as more realistic compared to other discrete choice models. (Hensher & Greene, 2003)

Willingness to pay

The willingness to pay (WTP) can be estimated using a SCE. The combination of costs variables and other variables can be used as trade-offs by individuals, making it possible to express the preferences of individuals in monetary values. WTP describes the cost an individual want to pay for goods, services or actions. The amount that the costs needs to change before the utility value is changed is described by the marginal WTP. Therefore, the respondents' WTP can be estimated for different attributes of a green façade using the following formula; (Hensher et al., 2015)

Equation 8 Willingness to pay

$$WTP_n = \frac{\beta_n}{\beta_c}$$

$WTP_n = Willingness\ to\ pay\ for\ attribute\ (n)$

$\beta_n = Marginal\ utility\ for\ attribute\ (n)$

$\beta_c = Marginal\ utility\ for\ the\ attribute\ of\ cost$

3.3. Conclusion

An experimental design is constructed, including a survey and a choice-experiment. The survey consisted out of closed-end questions, several statements regarding the theory of planned behaviour (attitude, social norm, and perceived behavioural control) and statements regarding context variables (e.g. amount of greenery present, governmental support, perceived noise disturbance, and perceived heat stress). Followed by a ranking of the potential benefits of a green façade. The choice experiment is constructed using a non-orthogonal design, after which 16 alternatives are randomly combined into four different versions of the survey.

A total of 238 respondents started the survey, 170 completed it. Removing the irrelevant responses resulted in 140 respondents, which is larger than the minimum threshold of 125.

Furthermore, the section elaborated the background/theories of the analysis that are going to be conducted in chapter 4.

4. Data analysis

In this chapter the analysation of the data survey data and its results will be elaborated. First, the distribution of the respondents in terms of location followed by the socio-demographical data and whether the sample is representative for the Netherlands is discussed. Second, the results of the statements regarding the predictors of the Theory of Planned Behaviour. Third, the context variables are elaborated. Lastly, the ranking of the advantages of green facades is discussed.

4.1. Data distribution

Figure 6 visualizes the distribution of the respondents across the Netherlands. It can be seen that the center of gravity (dark red) is located in both, Eindhoven (Noord-Brabant) and Hengelo (Overijssel). However, the majority of the Dutch inhabitants are located in the west of the country ('Randstad'). The Randstad houses 47.8 percent of the total population. (CBS, 2021b) Therefore, the distribution of the sample does not represent the Dutch population in terms of spatial distribution.

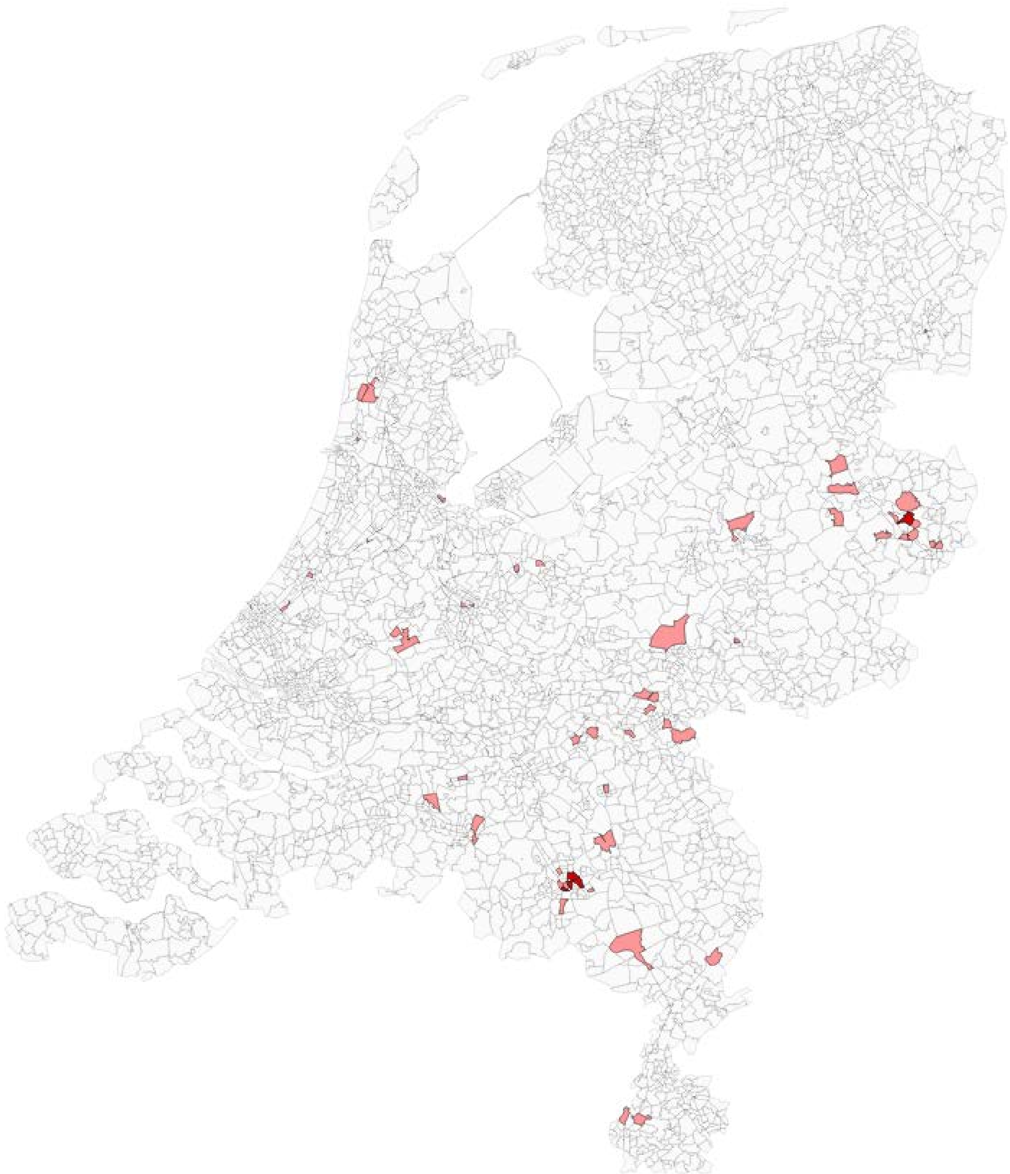


Figure 6 Distribution of respondents (Kadaster, n.d.)

4.2. Socio-demographics sample

A total of 140 respondents filled in the survey. In this section the socio-demographics of the respondents are tested to see if the sample is representative. This is done by comparing the frequencies of the sample to the Dutch average (Table 5). Only home-owners of land-based dwellings are targeted by the survey, which is a specific segment within the Dutch population. However, the socio-demographical data provided by CBS is about the whole Dutch population. Therefore, the WoOn2018 database is used. This dataset includes over 67.000 Dutch households, from which only the households that own their houses were selected for the purpose of this research.

Table 5 Frequencies of socio-demographical data compared to the distribution of the Dutch population

Variable	**Level**	**Frequency**	**Percentage (%)**	**WoON2018**
Gender	Male	77	55.0	49.1
	Female	60	42.9	50.9
	Neither one	1	0.7	-
	No answer	2	1.4	-
Age	18-24 years	2	1.4	1.1
	25-34 years	9	7.9	11.2
	35-44 years	24	17.1	16.3
	45-54 years	41	29.3	21.9
	55-64 years	44	31.4	21.8
	65 years or older	20	14.3	27.6
Education level	MAVO/VMBO/ Lower vocational education	1	0.7	28.9
	Secondary vocational education	15	10.7	22.5
	HAVO/VWO	7	5.0	16.8
	Higher professional education / Bachelor's degree	58	41.4	25.5
	University master's degree	59	42.1	6.2
Income	Lower than €2000 per month	1	0.7	3.1
	€2001-€4200 per month	50	35.7	28.0
	€4201-€6250 per month	38	27.1	31.8
	More than €6250 per month	30	21.4	37.2
	Do not want to say	21	15.0	-
House type	Row house	53	37.9	45.9
	Corner house	25	17.9	22.5
	Semi-detached house	32	22.9	25.4
	Detached house	23	16.4	2.8
	Terraced house	7	5.0	3.4

Comparing the WoON2018 dataset with the sample data retrieved from the survey it can be concluded that the distribution of the genders is slightly different, males (55 percent) are more present in the sample, were the distribution is almost 50/50 within the WoON2018 dataset. Furthermore, the age groups follow a similar distribution in both datasets with the exception of the age groups 55 until 64 years old and 65+ years old. For these two groups a different distribution is present between both datasets. The largest group of home-owners in the sample are between 55 and 64 years old (31.4 percent), whereas the largest group of home-owners within the WoON2018 dataset are 65 years or older (27.6 percent).

Comparing the distributions of both datasets in regards to the education level than it can be concluded that the distributions are different. The largest group of home-owners in the WoON2018 dataset have finished MAVO/VMBO/Lower vocational education (28.9 percent) followed by higher professional education / bachelor’s degree (25.5 percent), whereas the largest group within the sample data has a master degree (42.1 percent) followed by higher professional education / bachelor’s degree (41.4 percent). It can be concluded that the sample dataset consist predominantly out of higher educated people.

The distribution of the household income of the sample differs from the WoOn2018 dataset. The sample has a higher frequency for the income level ‘€2001 - €4200 per month’ compared to the WoON2018 dataset (35.7 percent vs. 28.0 percent), whereas all the other income levels have a lower frequency in the sample compared to the WoON2018 dataset

For the house types the distribution between the two datasets are similar for the house types: row house, corner house, and semi-detached house. These three types follow the same distribution in terms of frequency size. In other words, in both datasets the house type row house is the most common (37.9 percent vs. 45.9 percent), followed by the semi-detached house (22.9 percent vs. 25.4 percent), and corner house (17.9 percent vs. 22.5 percent). However, the detached houses (16.4 percent) are much more frequent in the sample data compared to the WoOn2018 dataset (2.8 percent)

All in all, the sample is not representative for the Dutch population as its distribution of frequencies is not in-line with the distribution within the WoON2018 dataset.

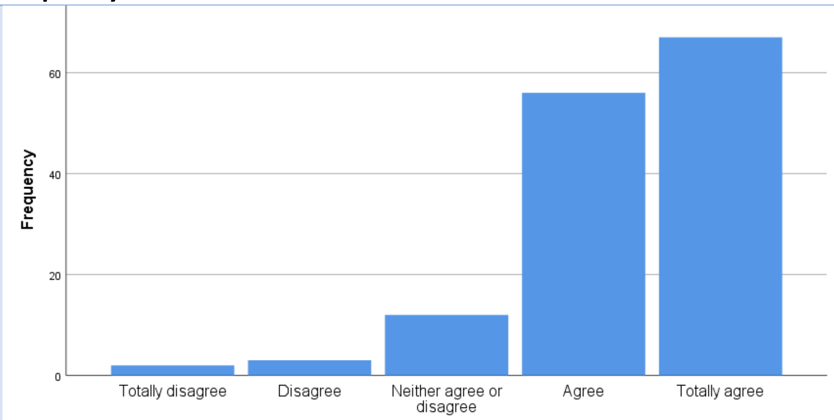
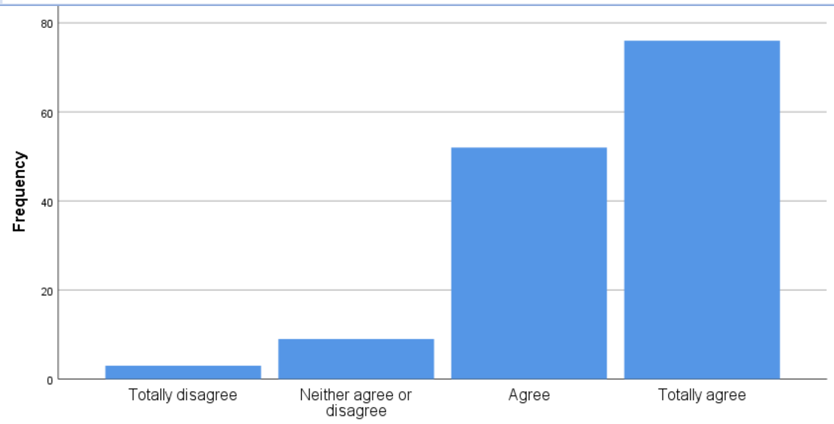
4.3. Statements: attitude, social norm, and perceived behavioural control

This section consist out of three different subjects, based on the theory of planned behaviour. Namely, attitude, social norm, and perceived behavioural control. These three subjects are questioned by means of several statements to which the respondents were asked to reply.

4.3.1. Attitude

The attitude towards climate change in general and more specifically green facades was asked. It can be concluded from Table 6 that the majority of the respondents are worried about climate change (87.9 percent) plus the majority is also concerned about the human processes that are damaging the climate (91.4 percent).

Table 6 Frequency table: attitude towards climate change

<table>
<tr><th></th><th>Level</th><th>Frequency</th></tr>
<tr><td>Attitude</td><td>I’m worried about the climate</td><td>
</td></tr>
<tr><td></td><td>I’m concerned about the human processes that damage the climate</td><td>
</td></tr>
</table>

Identifying the attitude towards climate change in general is done by combining the answers of both previously mentioned statements. Using SPSS the two answers to the statements are summed and then divided by two to reach the overall score for the attitude towards climate change. This resulted in Figure 7. As mentioned before the majority of the respondents indicated their attitude towards climate change as concerned (4.00 and higher).

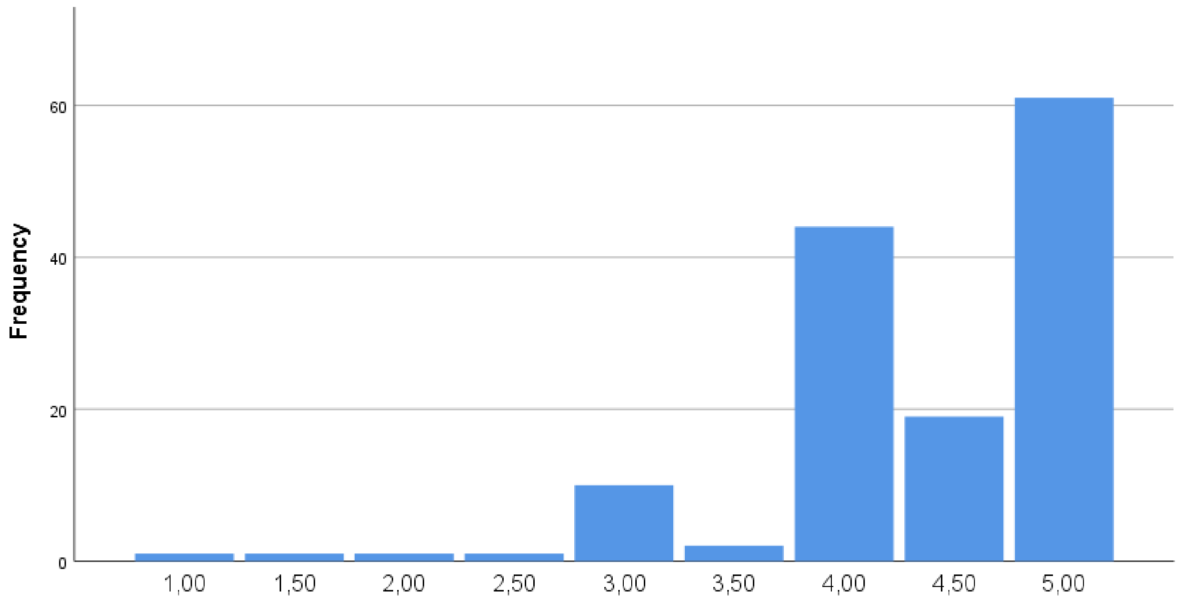
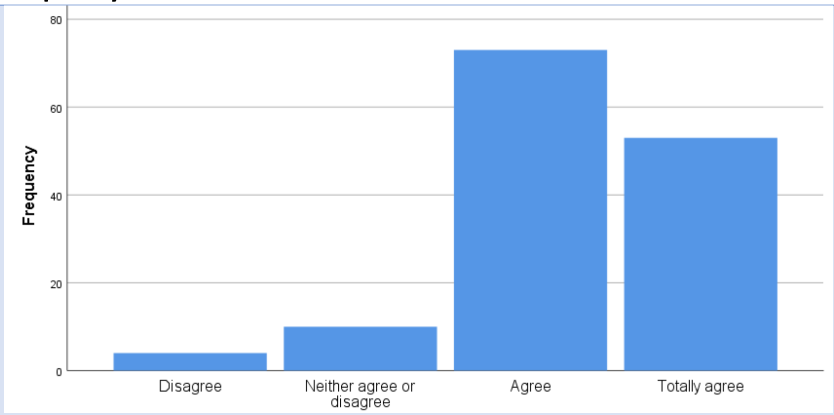
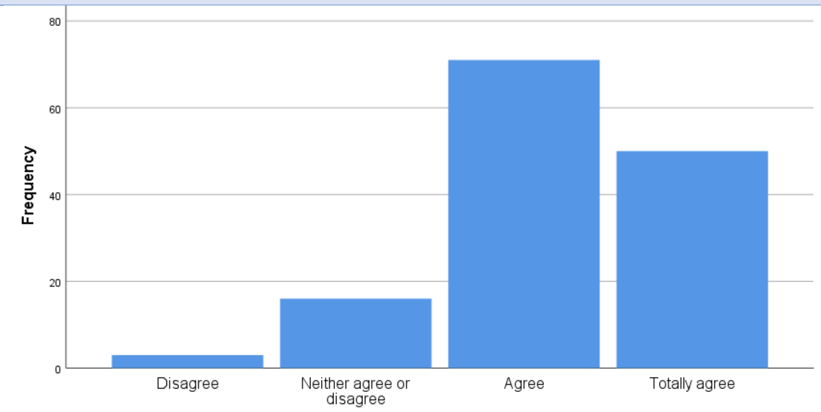
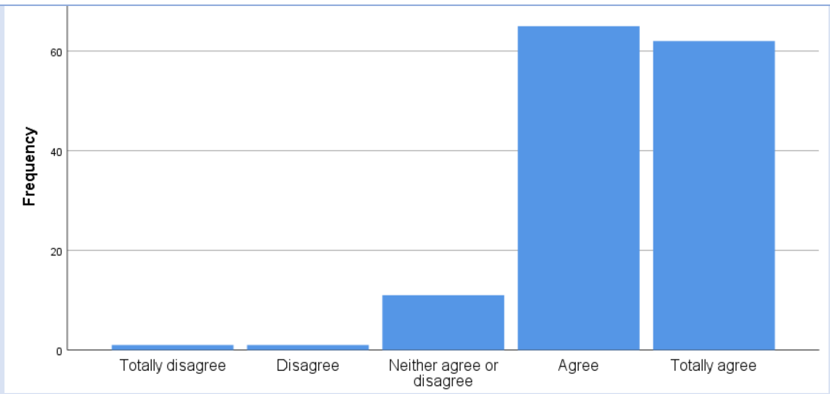
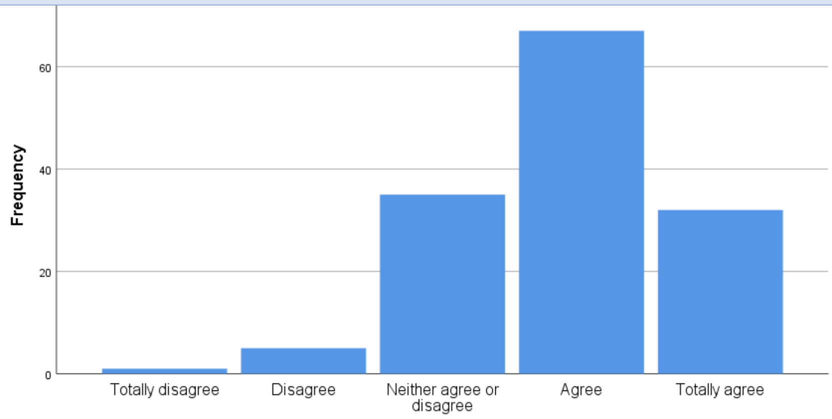


Figure 7 Overall score: attitude climate change

A total of four statements were asked regarding the potential benefits of a green façade (Table 7). These benefits were derived from the literature study and include: increased biodiversity, improved air-quality, reduction in the urban heat island effect, and improved indoor climate. These statements are supplemented by two more general statements about the green façade. Namely, 'are green facades beneficial to the neighbourhood' and 'green facades are aesthetically pleasant' as shown in Table 8.

Table 7 Attitude: benefits green facades

<table>
<tr><th></th><th>Level</th><th>Frequency</th></tr>
<tr><td>Attitude</td><td>Green facades are beneficial to the biodiversity in the neighbourhood</td><td>
</td></tr>
<tr><td></td><td>Green facades are beneficial to the air quality in the neighbourhood</td><td>
</td></tr>
<tr><td></td><td>Green facades are beneficial to the reduction of the urban heat island effect in the neighbourhood</td><td>
</td></tr>
<tr><td></td><td>I think green facades are beneficial to the thermal comfort in the house</td><td>
</td></tr>
</table>

Again an overall score is created but now for the attitude towards the potential benefits of a green façade. Using the same steps as previously mentioned. However, this time combining four statements (summing them) and then divide them by four. The result is shown in Figure 8.

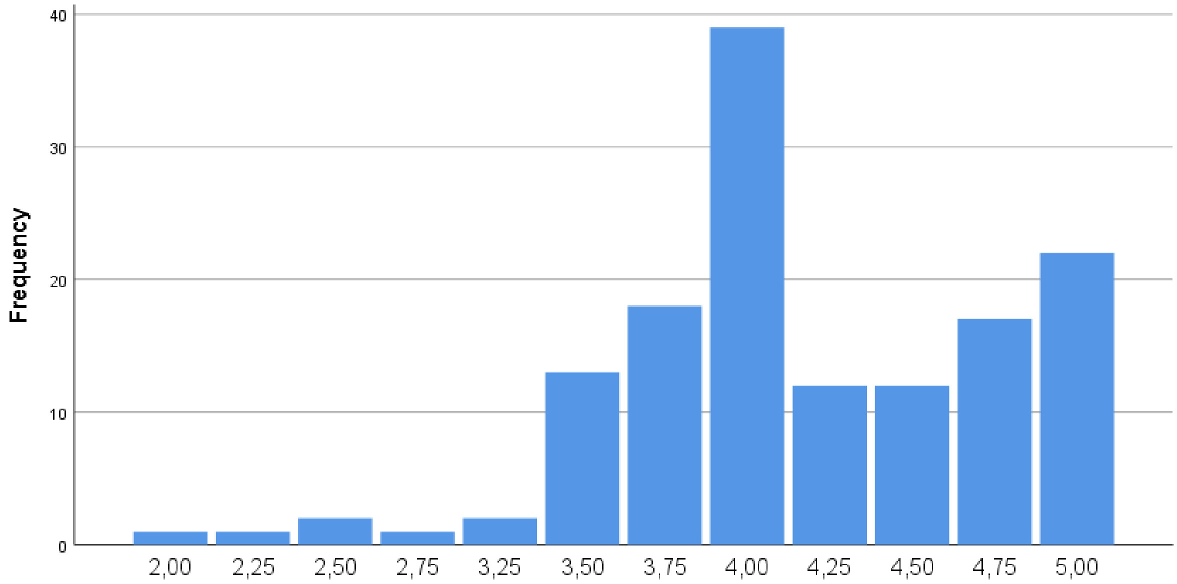
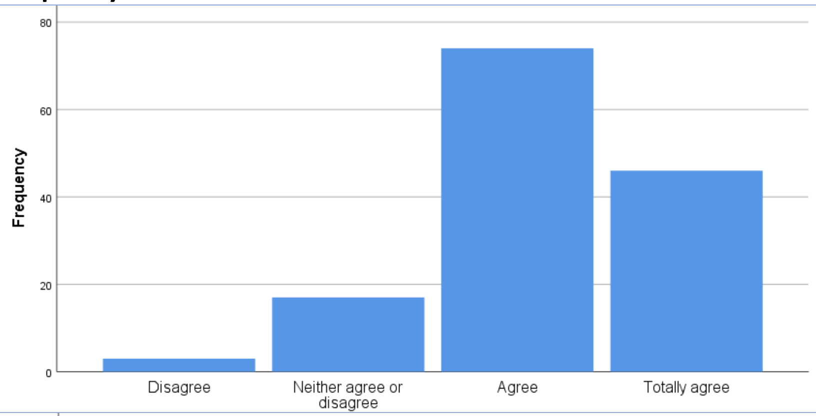
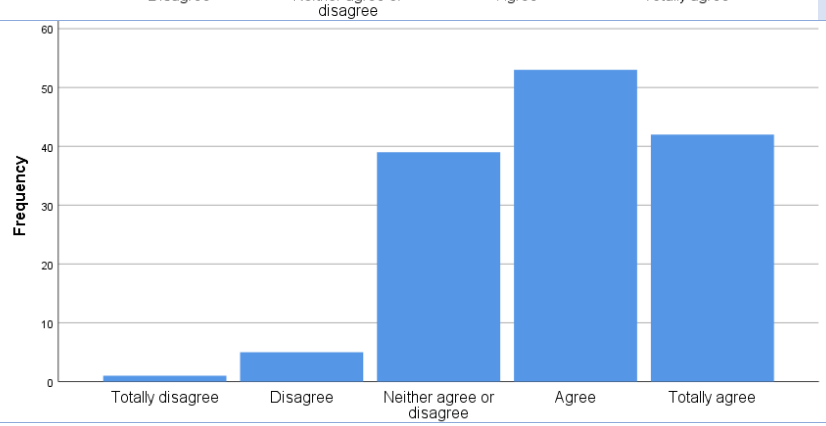


Figure 8 Overall score: attitude potential benefits green facade

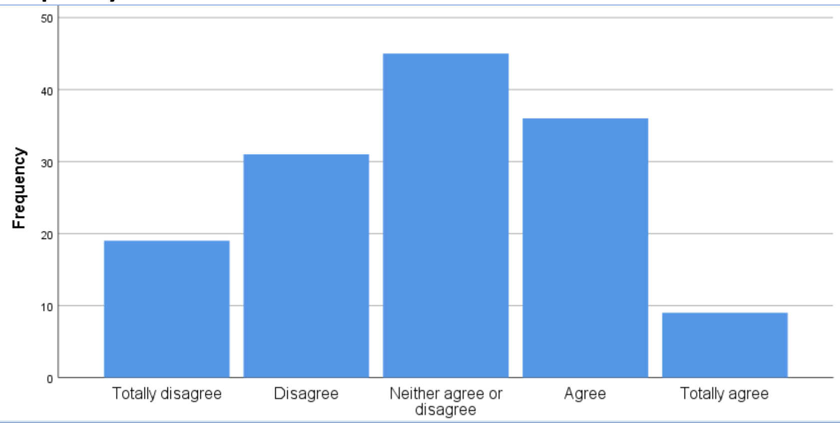
Table 8 Attitude: general statements green facades

	Level	Frequency
Attitude	Green facades are beneficial to the neighbourhood	
	Green facades are aesthetically pleasing	

Overall, the majority of the respondents agreed with the potential benefits of a green façade. The same can be said about the two more general statements. Therefore, the attitude of the respondents towards a green façade is positive.

When asked about the respondents attitude towards the implementation of a green façade the attitude is more modest, as can be seen in Table 9. The majority of the respondents indicated to neither agree or disagree (32.1 percent), while 32.1 percent agreed (combining both totally agree and agree) with the statement and 35.7 percent did not (combining both totally disagree and disagree). Meaning that only one third of the population has a positive attitude towards implementing a green façade, which is a large share compared when taking into account that green facades are not that common.

Table 9 Attitude: implementing a green facade

	Level	**Frequency**
Attitude	I am thinking of implementing a green façade	

Clarifying the difference between attitude towards implementing a green façade and actually considered implementing a green façade by the respondents is shown in Table 10. It can be concluded that the majority of the respondents (62.9 percent) has not considered implementing a green façade at all and a further 27.9 percent of the respondents has considered it but conducted no further action. Only 4.3 percent considered it and made actual plans while 5 percent of the total sample are actually implementing a green façade. Again showing the lack of consideration within the respondents.

Table 10 Attitude: have you thought about implementing a green facade?

Level	**Frequency**	**Percentage (%)**
Not considered it al	88	62.9
Considered it but no further action	39	27.9
Considered it and made plans for it	6	4.3
Considered it and a green façade will be implemented	7	5.0

4.3.2. Social norm

The social norm or the social perception of an individual is influenced by its surroundings. A common good or behaviour in a certain environment is most likely to be adapted by the individual if that action or behaviour is seen as positive. Therefore, four statements about the social environment are shown to the respondents in which they needed to state if they agreed or disagreed with these statements. The results are shown in Table 12.

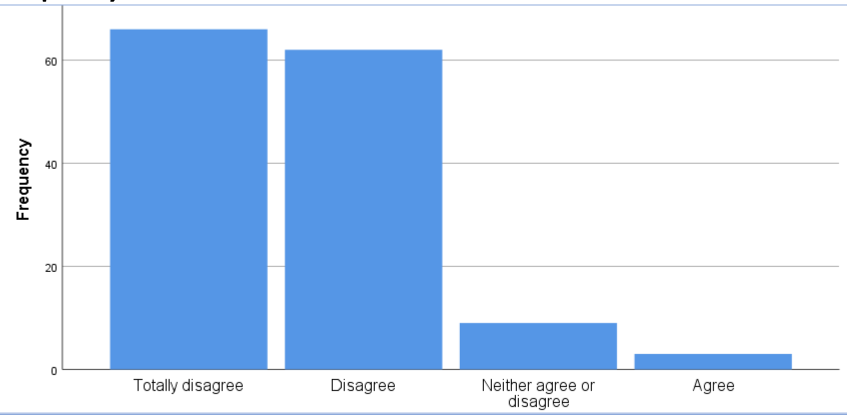
It can be concluded that green facades are not common in both, close company of the respondent (e.g. friends) as well as in their neighbourhood (Table 11). Furthermore, the possibilities of green facades are not mentioned by others to the majority of the respondents (89.4 percent). Finally, the perceived influence of others opinions on a green wall is asked. The overwhelming majority of the respondents indicated that they do not feel influenced or they do not care what others think about a green façade (72.9 percent).

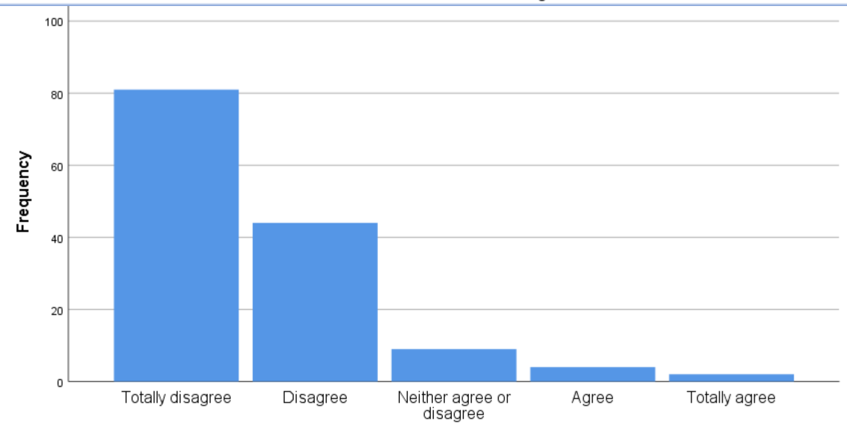
Therefore, the social norm is not positive. Due to the lack of green facades present in the neighbourhoods. Furthermore, the concept of a green façade (including information about a green façade) is not a subject of conversation, which means that having a green façade is not seen as the social norm. Normally, the theory states that people are often conducting actions or behaviours because of the opinion of others on that behaviour. Meaning that a positive opinion about a specific behaviour by others results in a higher probability that the behaviour is conducted by a specific individual. However, the majority of the respondents of this sample indicated that they do not feel influenced (do not care about others opinions) by other opinions, which is contrary to the theory. This could be a consequence of people wanting to base their opinions not on the opinion of others or because they do not feel like they are influenced by others even though they probably are. The latter could mean that the lack of green facades being the social norm is not that big of a problem, since the respondents are not influenced by the social environment that surrounds them.

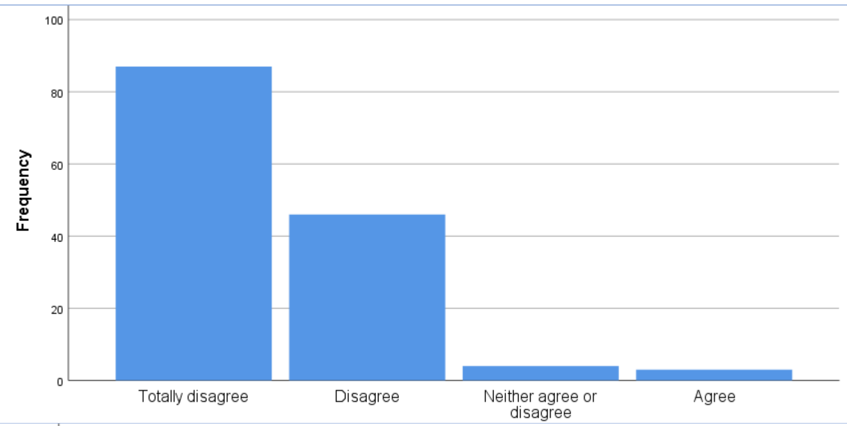
Table 11 Social norm: I know people who have a green facade

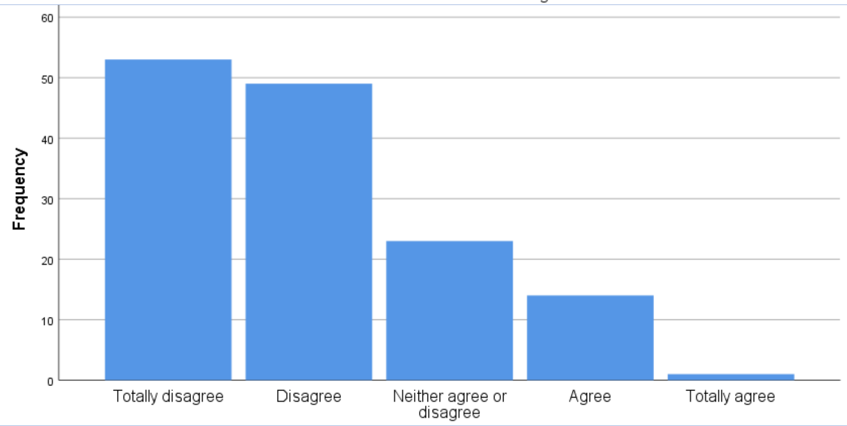
Level	**Frequency**	**Percentage (%)**
Yes	20	14.3
No	120	85.7

Table 12 Statements: social norm

<table>
<tr><th></th><th>Level</th><th>Frequency</th></tr>
<tr><td rowspan="4">Social norm</td><td>Green facades are common in my neighbourhood</td><td>


</td></tr>
<tr><td>Others have alerted me to the possibility of implementing a green façade</td><td>


</td></tr>
<tr><td>I know many friends who have a green façade</td><td>


</td></tr>
<tr><td>I care what others think of green facades</td><td>


</td></tr>
</table>

The overall score for the social norm is again computed using SPSS. The combining of the three statements resulted in Figure 9. All statements are equally important and are interpreted the same way, because of the way the overall score is computed (summing all statement results and divide them by the total amount of statements). In addition, a majority of the respondents in the sample indicated that they did not care (are not influenced by) about the opinion of others regarding green facades. This can be a positive, because of the low social norm (meaning that they are potentially going against the social norm and thereby implementing a green façade).

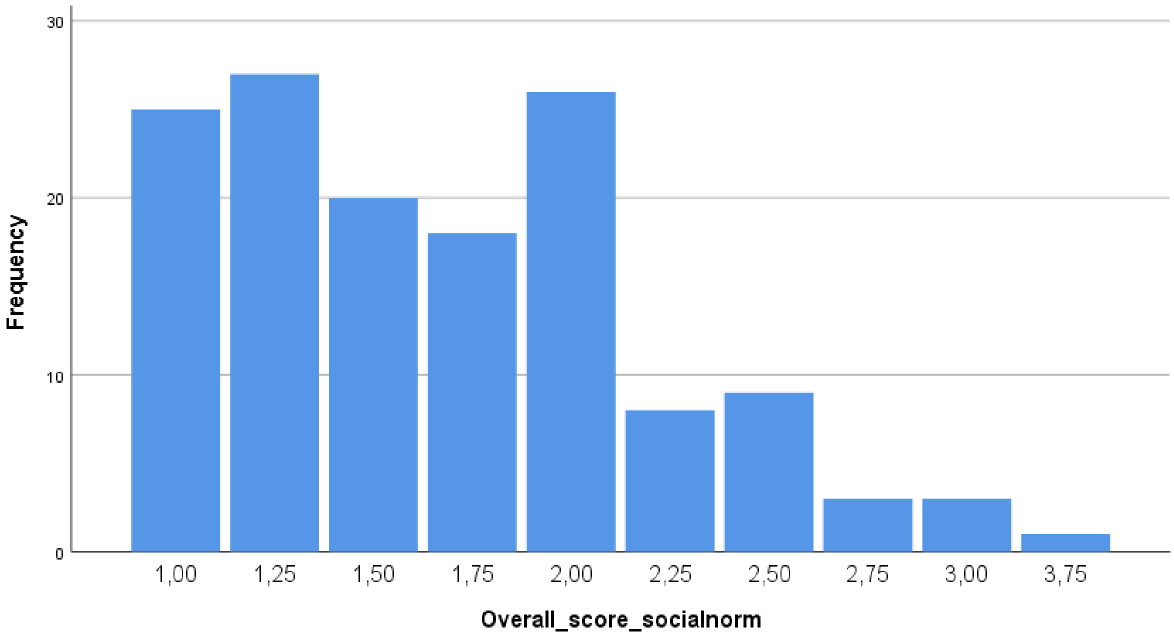


Figure 9 Overall score: social norm

4.3.3. Perceived behavioural control

The last part of the theory of planned behavioural is the perceived behavioural control. This reflects the control the individual has on the behaviour. A positive perception of the perceived behavioural control means that the individual has the means to conduct the behaviour (implementing a green façade) and that the individual thinks that it has a positive effect. Therefore, three statements are shown to the respondents about their knowledge of how to implement a green façade, if they are able to maintain the green façade, and if they can financially afford a green façade.

Table 13 Statements: perceived behavioural control

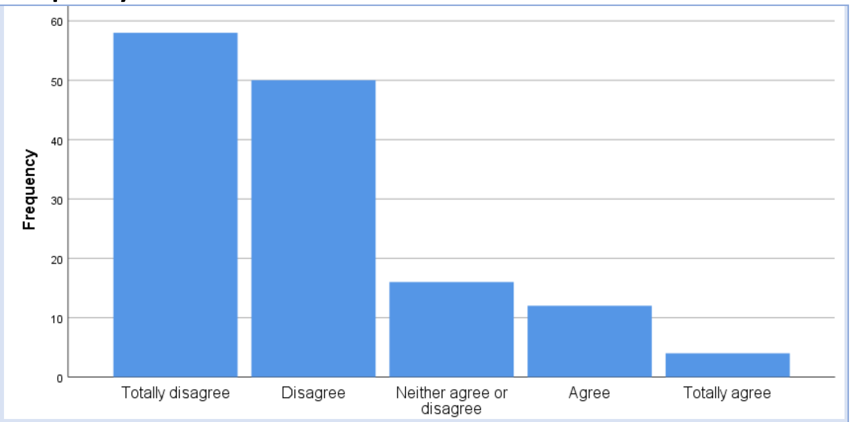
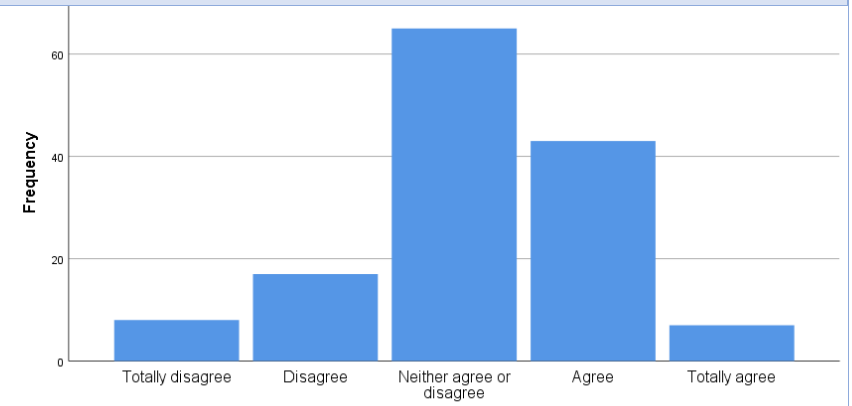
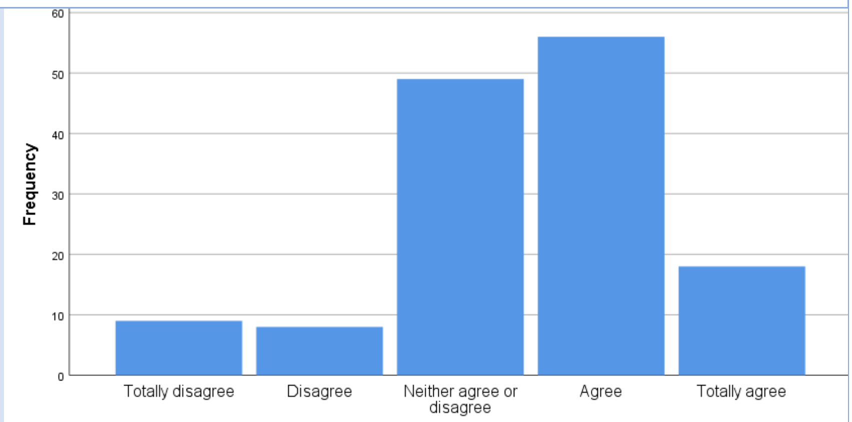
<table>
<tr><th></th><th>Level</th><th>Frequency</th></tr>
<tr><td rowspan="3">Perceived behavioural control</td><td>I have the information to be able to implement a green façade</td><td>
</td></tr>
<tr><td>I can handle the added amount of maintenance of a green façade</td><td>
</td></tr>
<tr><td>I can buy a green façade for my house, if I wanted to</td><td>
</td></tr>
</table>

Table 13 shows the result of these three statements. It can be seen that the majority of the respondents indicated that they do not have the information to implement a green façade (77.1 percent). The results of the other two statements are similar to one another. Namely, the majority indicated that they neither agree or disagree for both the added amount of maintenance and the financial ability to buy a green façade, 46.4 percent and 35 percent respectively. In addition, more respondents indicated that they could handle the added maintenance (35.7 percent) than the ones who cannot handle the added maintenance (17.8 percent). The same is true for the financial ability to buy a green façade, 52.9 percent vs. 12.1 percent respectively.

The overall score for perceived behavioural control is computed and shown in Figure 10.

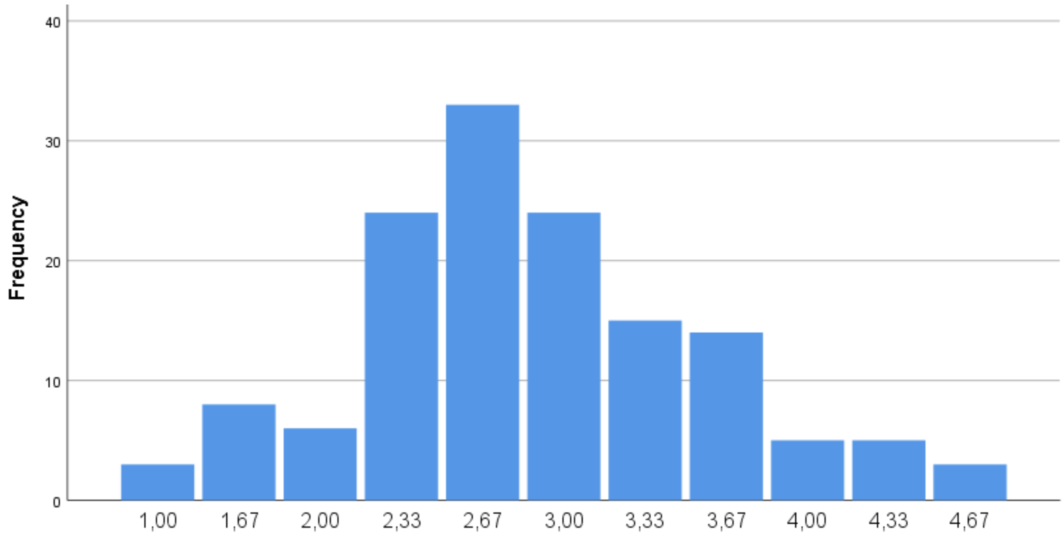
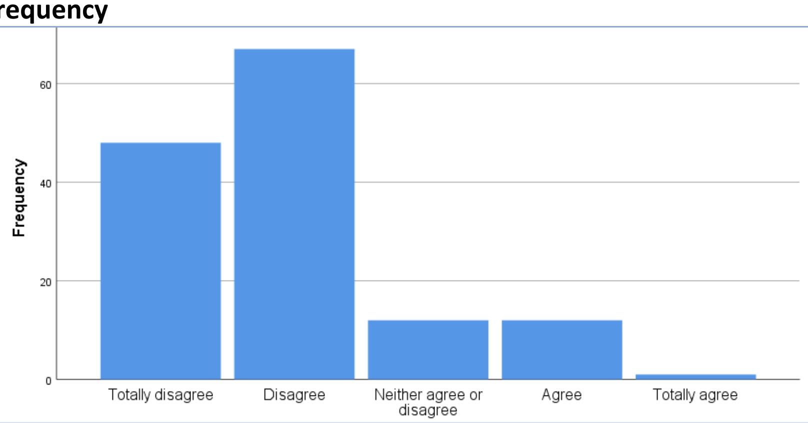


Figure 10 Overall score: perceived behavioural control

In addition to the previously mentioned four statements, an extra statements was shown to the respondents. This statement is about the effect a green façade has and if the respondents perceive that effect to be positive even if no one else would implement a green façade (Table 14). It is clear that the overwhelming majority of the respondents (82.2 percent) indicated that the implementation of a green façade would benefit and is effective even when no other green façade is implemented by other people. Whereas only 9.3 percent indicated that there is no point in realizing a green façade, if no else is realizing one.

Table 14 Perceived behavioural control: perceived effect

	Level	**Frequency**
Perceived behavioural control	There is no point in realizing a green façade, if no one else is realizing one	

4.3.4. Conclusion statements: attitude, social norm, and perceived behavioural control

Attitude to potential benefits of green façade is positive. However, the attitude to actually think about implementing a green façade is not that clear. Here the distribution between the respondents that are thinking about it, neither thinking about it or not thinking about it, and not thinking about it is almost in a ratio of 30 percent of each other. Meaning that only one third of the respondents actually thought about implementing a green façade.

Social norm, green façades are not common within neighbourhoods as well as within close relationships of the respondents (e.g. families). Meaning that the social stimulance is not present. This is strengthened by the fact that the majority of the respondents indicated that they had not received any information about the possible effect of green facades by others. However, the majority did indicate that they do not feel influenced (do not care) by the opinion about green facades by others. The latter could mean that the lack of green facades being the social norm is not that big of a problem, since the respondents indicated that they are not influenced by the social environment that surrounds them.

Perceived behavioural control, the respondents indicated that they do not have the information needed. The majority can handle the added maintenance (or neither) and the majority is financially capable to buy a green façade. The latter might also be the result of the sample which included a lot of high income respondents. Lastly, the majority did indicate that adding a green façade is beneficial even if no one else is implementing one.

All in all, attitude is high except for the actual thinking of implementation. Social norm is low because of the lack of green facades present in the neighbourhood. However, the 'not care about others' is positive for the social norm. The perceived behavioural control is medium as the majority indicates that they can handle the added maintenance, the price and find that the adding of one green façade is already beneficial. The perceived behavioural control would go to high if the information on how to implement a green façade would be available to the respondents.

4.4. Context variables

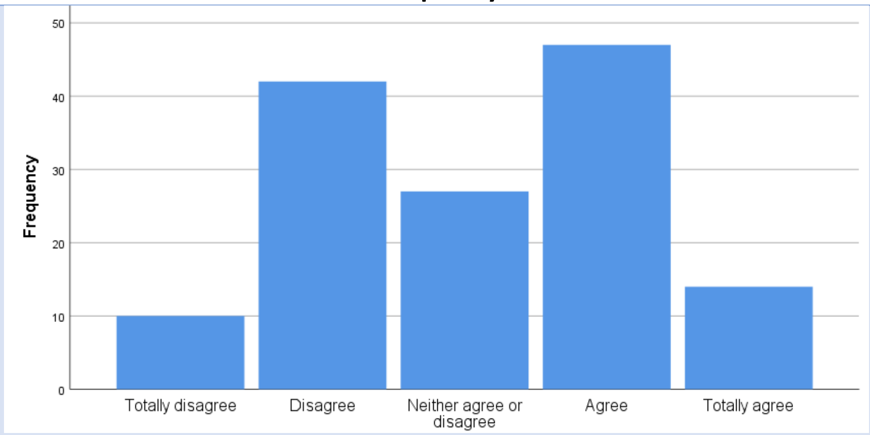
Several context variables where tested by asking the respondents questions in regards of the amount of greenery present, heat waves, noise disturbance, and the availability of governmental support. First, the amount of greenery present in their direct surroundings. Table 15 shows the frequencies that one of the four greenery levels has been chosen by the respondents. It can be concluded that the minority of the respondents do not have greenery within their direct surroundings. Whereas, 96 percent of the respondents indicated that their direct surroundings consisted of at least some green (e.g. trees along the streets).

Table 15 Frequency table: amount of greenery present in the direct surroundings of the respondent

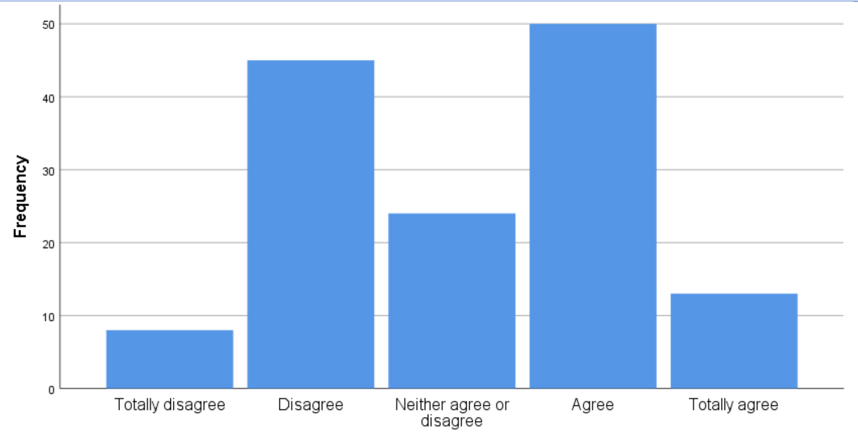
Level	**Frequency**	**Percentage (%)**
No greenery	5	3.6
Some green (e.g. trees along the streets)	50	35.7
Greenery (trees + low rise plants)	39	27.9
A lot of greenery (park living)	46	32.9

Second, the respondents were asked several questions regarding heat waves. These questions are about symptoms that might be caused by heat waves (according to the literature) and these symptoms are than translated into the amount of discomfort the respondents feel during heat waves. Table 16 shows that the distribution of respondents who are sweating at home during a heat wave is almost equally distributed between the ones that do sweat (43.6 percent) and the ones that do not (37.1 percent), with a small majority to the ones that do sweat. The same structure of frequency distribution resulted from the question about sleeping problems (45 percent vs. 37.5 percent). However, the majority of the respondents do not have headaches at home as a result of these heat waves (77.2 percent), whereas the majority does indicate to have problems with being productive during heat waves (49.3 percent).

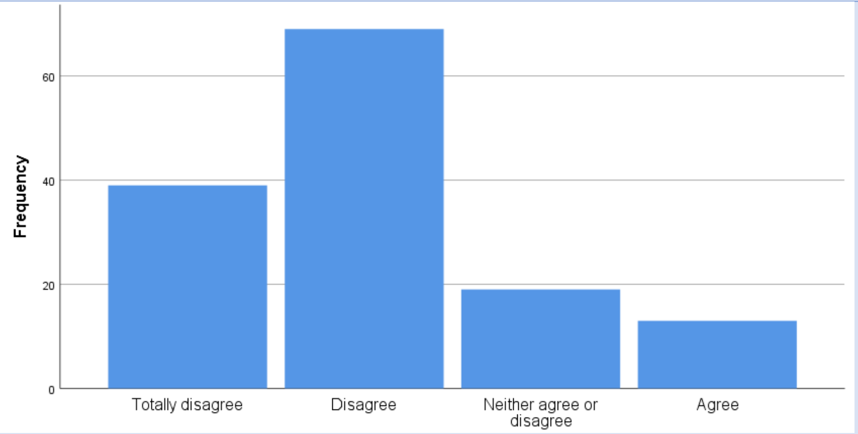
Table 16 Frequency table: statements about heat waves

Level	**Frequency**
During heat waves I sweat a lot at home	

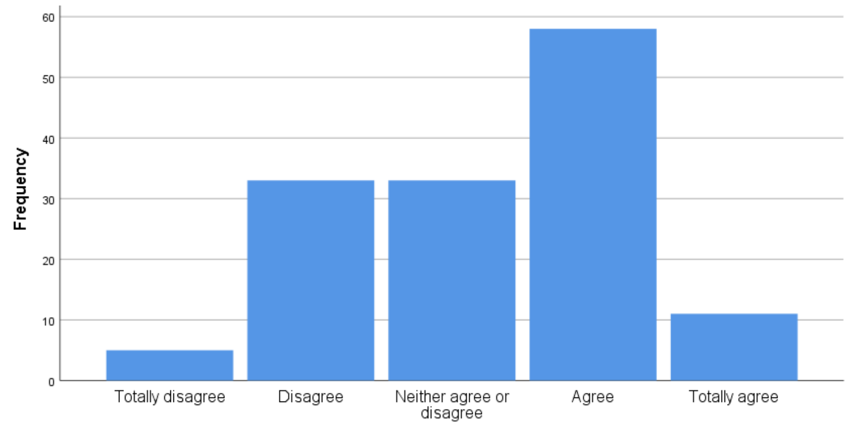
During heat waves I have problems sleeping at night



During heat waves I often have headaches at home



During heat waves I have problems with being productive



An overall score is computed for the context variable '*heat waves*'. This is done by computing a new variable within SPSS that uses the input of the four previously mentioned questions and sums these answers. After which, the total sum is divided by four. Resulting in Figure 11. These scores will later be used to find the relation between these context variables and the willingness to implement a green façade.

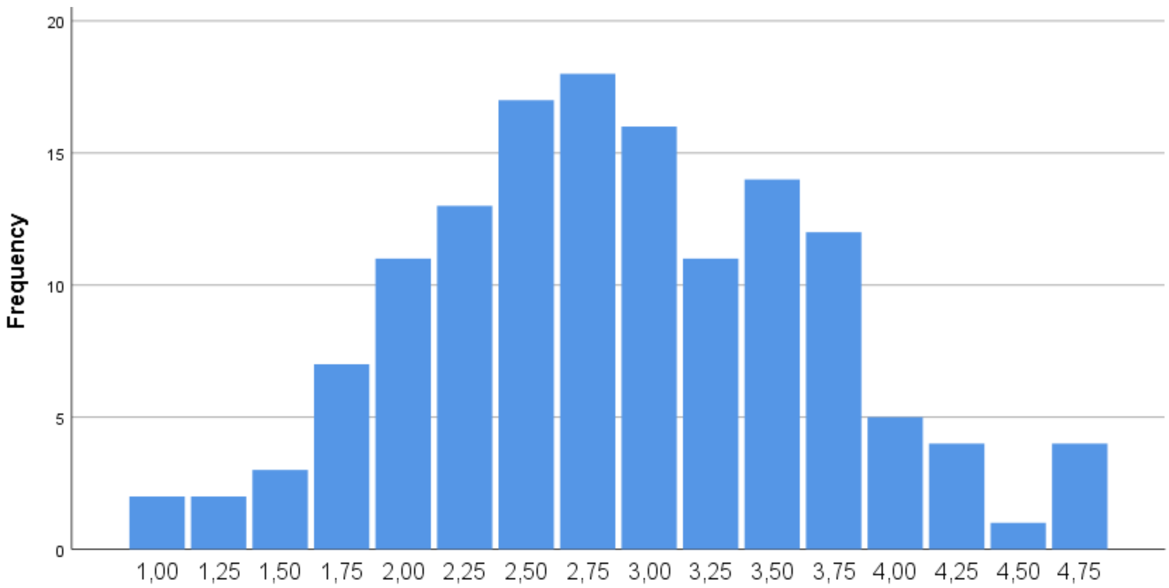
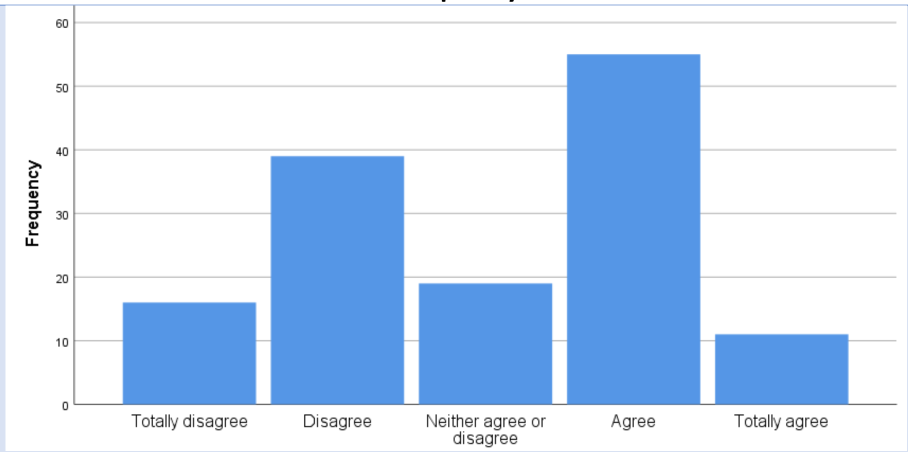


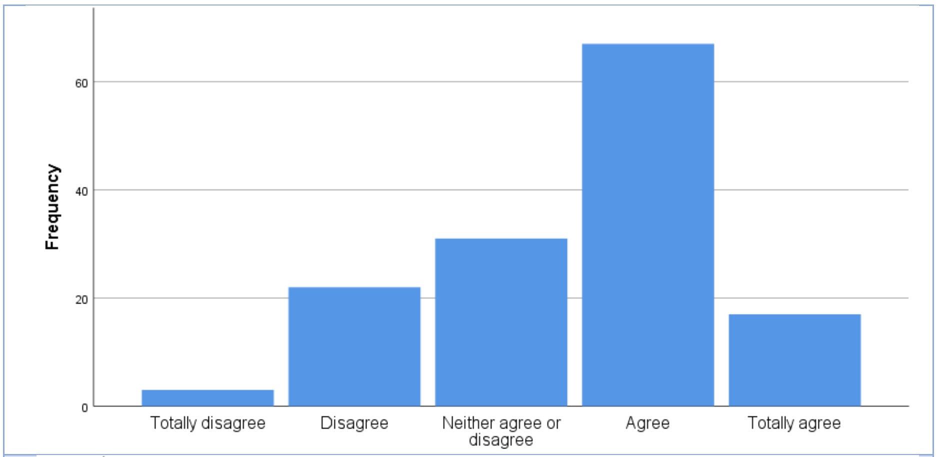
Figure 11 Frequency overall score: heat waves

Third, the respondents had to indicate their weather they agreed or disagreed with some statements regarding symptoms caused by noise disturbance (Table 17). These symptoms are retrieved from the literature study and include; disturbance of sleep, being annoyed, and problems with productivity. The respondents indicated that the effect of noise disturbance on sleep is seen by 47.2 percent as a disturbance and 39.3 percent as not a disturbance. Furthermore, the majority of the respondents indicated that noise disturbance makes them annoyed (60 percent) and that noise disturbance decreases their productivity (54.3 percent).

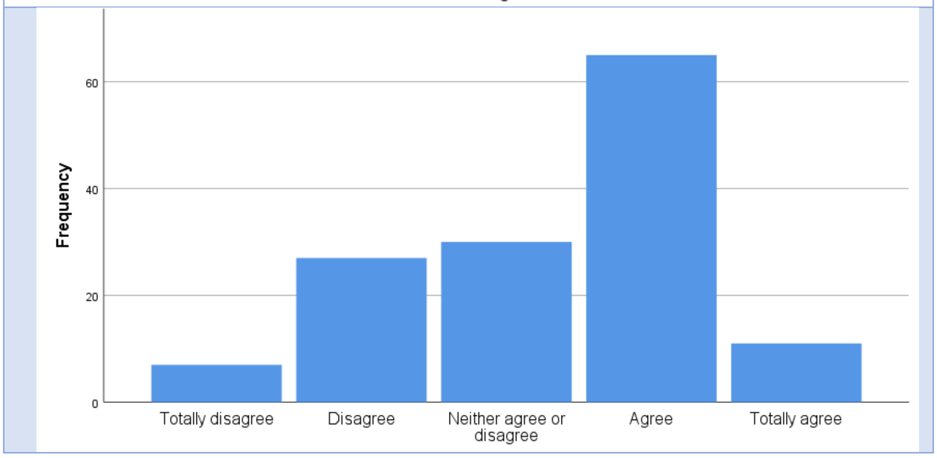
Table 17 Frequency table: statements about noise disturbance

Level	**Frequency**
Noise disturbance disturbs my sleep	

Noise disturbance makes me annoyed



Noise disturbance decreases my productivity



Calculating the overall score for the context variable '*noise disturbance'* is done by summing all three answers and divide them by three, so that the overall score is identified between 1 (no disturbance) and 5 (a lot of disturbance). This results in Figure 12.

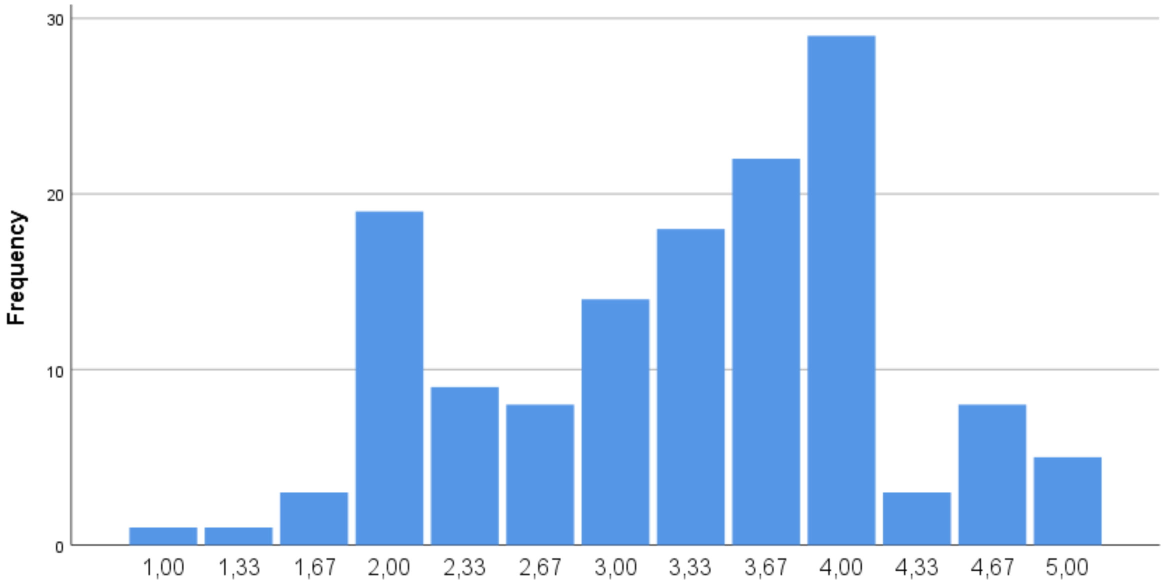
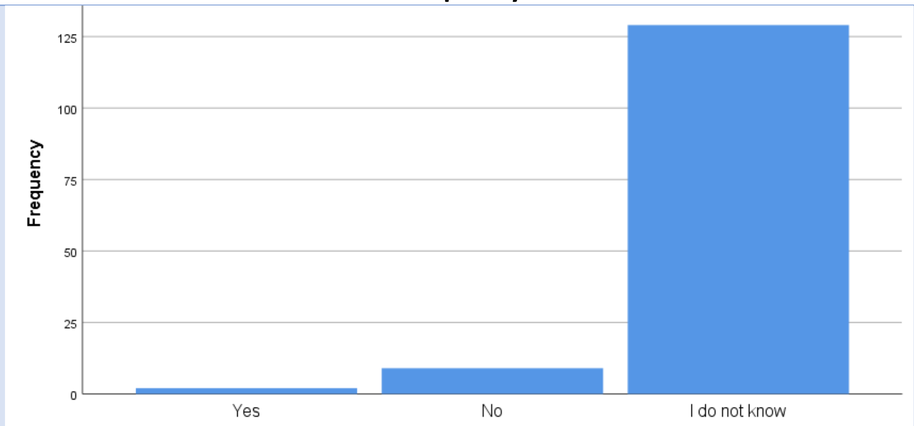
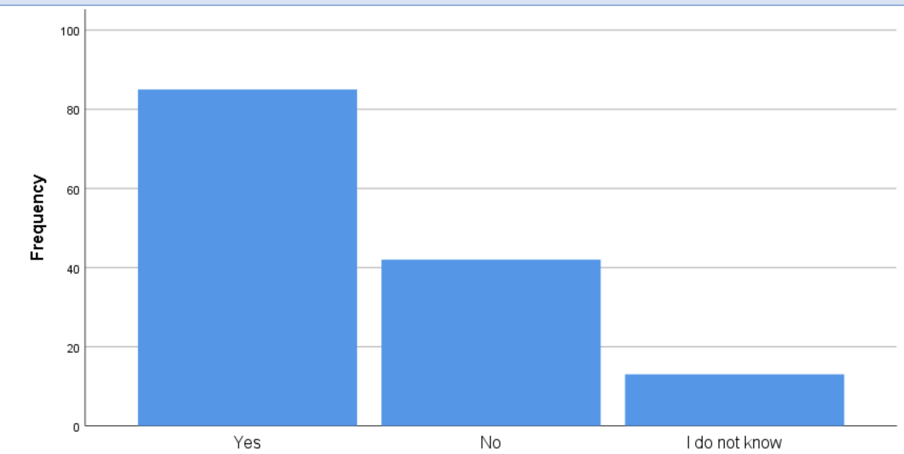
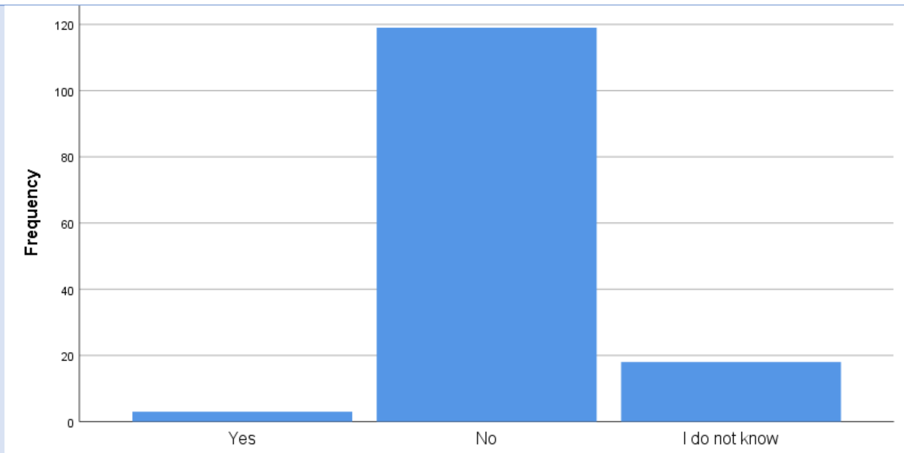


Figure 12 Frequency overall score: noise disturbance

The last context variable is about the availability of and the knowledge of governmental support for green facades. As shown in Table 18, the majority of the respondents indicated that they do not know whether their municipality gives subsidies for green facades (92.1 percent). Furthermore, the majority of the respondents indicated that they had received information about making their house more sustainable (60.7 percent), though 85 percent of the respondents indicated that they did not receive any information about green facades.

Table 18 Frequency table: statements about governmental support

Level	**Frequency**
Does the municipality grand a subsidy for green facades?	
Have you received information for making your house more sustainable?	
Have you received information for making your house more sustainable, including information about green facades?	

Again an overall score for the governmental support variable is computed. Following the same steps as is done previous times, resulting in Figure 13.

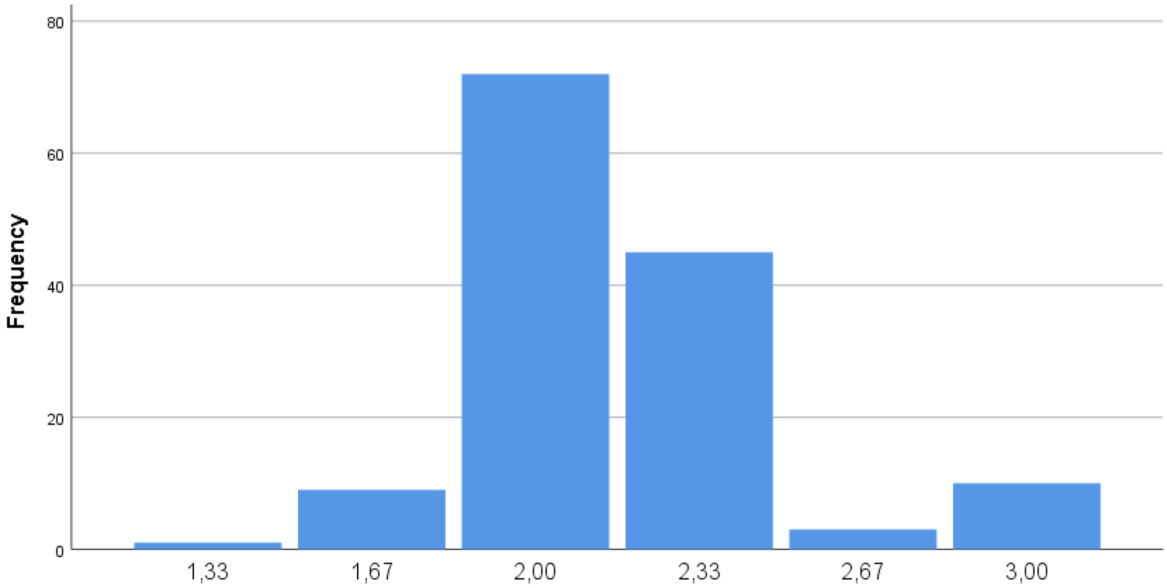


Figure 13 Frequency overall score: governmental support

A total of four context variables have been created: '*amount of greenery present in the direct surroundings of the respondent', 'the perceived amount of heat stress present in the area', 'the perceived amount of noise disturbance present in the area',* and *'the availability of stimulating policies for the implementation of green facades'.*

The majority of the respondents indicated that they have greenery within their direct surroundings. For the 'perceived amount of heat stress present in the area' the majority of the respondents indicated that the symptom headage is not occurring during heat waves. However, heat waves effected the majority of the respondents in terms of a decrease in productivity, and to a lesser extent sleep problems and sweating.

For the 'perceived amount of noise disturbance present in the area' the majority of the respondents indicated that it has an negative effect on their sleep, productivity, and it makes them annoyed. Furthermore, the '*availability of stimulating policies for the implementation of green facades'* has an interesting result. It showed that the majority of the respondents is not aware of potentially available stimulating policies for green facades. They are informed about how to improve their dwelling and make it more sustainable. However, the vast majority did not receive any information about the possible effects of green facades.

It can be concluded that the majority of the respondents does suffer from noise- and heat disturbance. And that the potential of informing the population about the effects of green façades can be massively improved. For example by including information about green facades into the next round of information distribution regarding sustainability measures for houses.

4.5. Ranked advantages of green facades

Respondents were asked to rank the different advantages of a green façade, derived from the scientific literature study, on their importance. The frequencies of the ranked advantages are shown in Figure 14. Rank 1 is the most important advantage, whereas rank 7 is the least important.

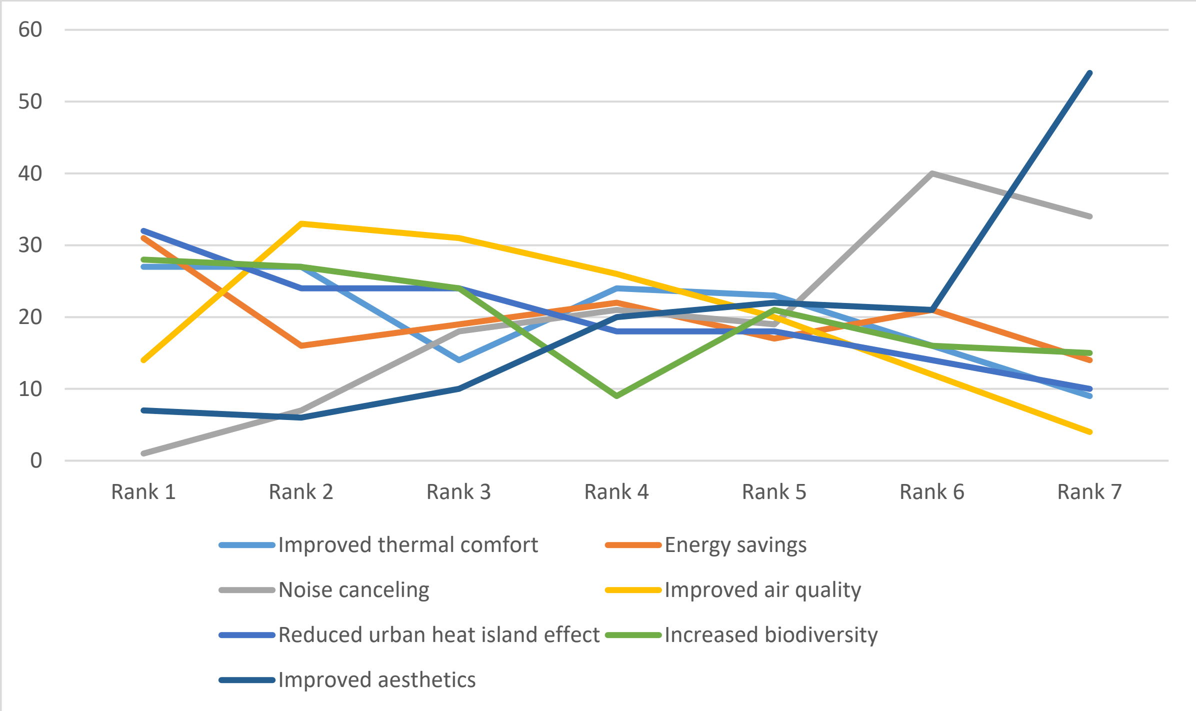


Figure 14 Ranking advantages of green facade

Conclusion ranking advantages of a green façade:

The following can be concluded out of Figure 14: (1) the most frequent and most important advantage (rank 1) is the reduction of the urban island effect, followed by energy savings, increased biodiversity, and improved thermal comfort. Whereas noise canceling abilities of a green wall were the least frequently chosen.

The advantage 'improved air quality' is the most important advantage for the second most important advantage. The least important advantages according to the respondents were the 'improved aesthetics' followed by 'noise canceling (rank 7). Simplifying the graph results in the following conclusion:

1. The most important advantages are 'reduced urban heat island effect', 'energy savings', 'increased biodiversity', and 'improved thermal comfort'. These advantages have a line that follows a declining fashion, meaning that they are ranked mostly on the more important ranks, and lower on the least important ranks.
2. The advantage 'improved air quality' follows a specific line, where it is the most frequently chosen advantage for rank 2, even though it has the fifth most frequency for rank 1. After which, the line follows the same trend as the ones mentioned above.
3. The advantages 'improved aesthetics' and 'noise canceling' follow a different trend compared to the previously mentioned advantages. Here the trend is increasing, meaning that these two advantages are the most frequently chosen for the lower ranks (6 & 7).

4.6. Conclusion

The sample is not representative for the Dutch population as its distribution of frequencies is not in-line with the distribution within the WoON2018 dataset. As individuals aged 55 to 64, highly educated, and higher incomes are overrepresented in the sample.

Regarding the statements that were introduced to understand the three predictors of the Theory of Planned behaviour: attitude, social norm, and perceived behavioural control. The attitude towards a green façade is generally high, except for the actual implementation of a green façade. While the social norm is low as there is a lack of green facades present in the neighbourhoods. The perceived behavioural control is mediocre as the majority indicated that they can handle both, the added maintenance and the price. In addition, the majority also stated that implementing a green façade while no other green facade is implemented is still beneficial. All three lead to a positive perceived behavioural control, except the lack of available information regarding the implementation of a green façade. Resulting in a perceived behavioural control that is mediocre.

In addition to the statements surrounding the Theory of Planned Behaviour also several statements were analysed regarding the context. The majority indicated that their direct surroundings consist of at least some greenery (e.g. trees along the streets). The analysis also showed that the majority indicated to be effected by heat stress, in terms of decreased productivity, sleep problems, and sweating. While sleep problems, productivity loss, and increased annoyance are effects seen by the majority as a result of noise disturbance in the area. Furthermore, the majority indicated that they are not aware of any potentially available stimulating policies regarding green facades. They are informed about sustainability measures that could be taken to improve the sustainability of their dwellings. However, information about green facades is lacking.

Lastly, the most important advantages of a green façade are; its ability to reduce the urban heat island effect, energy savings potential, increased biodiversity, and improved thermal comfort followed by improved air-quality. While the least important advantages of green facades are its aesthetics and noise canceling abilities.

5. Model based analysis & estimation results

Within this chapter the conducted analysis and results are elaborated. First, the input data will be discussed, followed by a data analysis and the MNL model of the raw data. The MNL model is estimated to find the influence of attributes on the preference of the respondent regarding a green façade. The model is estimated using a software program called NLOGIT6 (Econometric Software, 2016). The results from this model are then discussed and a different analysing method called Multiple Correspondence analyses (MCA) is conducted to potentially remove correlations within the data. The results of the MCA are then used as input in both a MNL model and a Mixed Logit model (ML).

5.1. Frequencies versions & correlations

As mentioned in section 4.3.1, four different versions of the survey were created to prevent order bias and enable alternative pairing of choice-sets . These four versions should be randomly distributed by the software ('Limesurvey'). However, the number of respondents per version differs considerably. 76 respondents filled in version 1 of the survey, 84 version 2, and for both version 3 and version 4 only one respondent completed it. Furthermore, 22 respondents answered homogeneously, meaning that these respondents answered all the choice-set questions with the same alternative (e.g. all alternative 1) (which is a chance of 1/3^8) and were therefore removed from the dataset. Resulting in 65 respondents for version 1, 73 respondents for version 2, 1 respondent for version 3 and 1 respondent for version 4.

The unequal distribution of the respondents over the versions can lead to effects, such as: the presence of order bias, and potentially correlations between attributes. To test the latter, a Spearman correlation matrix was created using SPSS (Table 20). It can be concluded that several attributes correlate highly with one another (coefficient > 0.7 (Akoglu, 2018)). These values are surrounded by red circles.

Table 19 Legend: Spearsman's rho correlation matrix (Table 20)

Label	Meaning	Label	Meaning
INV_X1	Investment cost of €1500	MCOST_1	Maintenance cost of €200 per year
INV_X2	Investment cost of €3000	MCOST_2	Maintenance cost of €400 per year
INV_X3	Investment cost of €4500	TYPE	Type of wall: Living wall
FINAL_1	Time it takes to reach the final image: 2 years	SIZE	Size/coverage of the wall: Whole
FINAL_2	Time it takes to reach the final image: 4 years	BIO	Increased biodiversity by a lot
MFREQ_1	Maintenance frequency: 2x per year	ENERGY	30 percent savings
MFREQ_2	Maintenance frequency: 4x per year		

Table 20 Spearman's rho correlation matrix

Correlations

		INV_X1	INV_X2	INV_X3	FINAL_1	FINAL_2	MFREQ_1	MFREQ_2	MCOST_1	MCOST_2	TYPE	SIZE	BIO	ENERGY
INV_X1	Correlation Coefficient	1,000	,500**	,500**	,500**	-,456**	,000	,000	,000	,000	,707**	,707**	,000	,000
	Sig. (2-tailed)	.	,000	,000	,000	,000	1,000	1,000	1,000	1,000	,000	,000	1,000	1,000
	N	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360
INV_X2	Correlation Coefficient	,500**	1,000	,500**	,000	,000	,000	,000	,000	,000	,707**	,000	-,707**	,000
	Sig. (2-tailed)	,000	.	,000	1,000	1,000	1,000	1,000	1,000	1,000	,000	1,000	,000	1,000
	N	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360
INV_X3	Correlation Coefficient	,500**	,500**	1,000	-,500**	-,822**	,000	,000	,000	,000	,000	,707**	-,707**	,000
	Sig. (2-tailed)	,000	,000	.	,000	,000	1,000	1,000	1,000	1,000	1,000	,000	,000	1,000
	N	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360
FINAL_1	Correlation Coefficient	,500**	,000	-,500**	1,000	,365**	,000	,000	,000	,000	,707**	,000	,707**	,000
	Sig. (2-tailed)	,000	1,000	,000	.	,000	1,000	1,000	1,000	1,000	,000	1,000	,000	1,000
	N	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360
FINAL_2	Correlation Coefficient	-,456**	,000	-,822**	,365**	1,000	,000	,050**	,000	,050**	,258**	-,904**	,258**	,000
	Sig. (2-tailed)	,000	1,000	,000	,000	.	1,000	,004	1,000	,004	,000	,000	,000	1,000
	N	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360
MFREQ_1	Correlation Coefficient	,000	,000	,000	,000	,000	1,000	,365**	,000	,000	,000	,000	,000	,707**
	Sig. (2-tailed)	1,000	1,000	1,000	1,000	1,000	.	,000	1,000	1,000	1,000	1,000	1,000	,000
	N	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360
MFREQ_2	Correlation Coefficient	,000	,000	,000	,000	,050**	,365**	1,000	,000	,050**	,000	,000	,000	,258**
	Sig. (2-tailed)	1,000	1,000	1,000	1,000	,004	,000	.	1,000	,004	1,000	1,000	1,000	,000
	N	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360
MCOST_1	Correlation Coefficient	,000	,000	,000	,000	,000	,000	,000	1,000	,365**	,000	,000	,000	,000
	Sig. (2-tailed)	1,000	1,000	1,000	1,000	1,000	1,000	1,000	.	,000	1,000	1,000	1,000	1,000
	N	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360
MCOST_2	Correlation Coefficient	,000	,000	,000	,000	,050**	,000	,050**	,365**	1,000	,000	,000	,000	,000
	Sig. (2-tailed)	1,000	1,000	1,000	1,000	,004	1,000	,004	,000	.	1,000	1,000	1,000	1,000
	N	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360
TYPE	Correlation Coefficient	,707**	,707**	,000	,707**	,258**	,000	,000	,000	,000	1,000	,000	,000	,000
	Sig. (2-tailed)	,000	,000	1,000	,000	,000	1,000	1,000	1,000	1,000	.	1,000	1,000	1,000
	N	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360
SIZE	Correlation Coefficient	,707**	,000	,707**	,000	-,904**	,000	,000	,000	,000	,000	1,000	,000	,000
	Sig. (2-tailed)	,000	1,000	,000	1,000	,000	1,000	1,000	1,000	1,000	1,000	.	1,000	1,000
	N	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360
BIO	Correlation Coefficient	,000	-,707**	-,707**	,707**	,258**	,000	,000	,000	,000	,000	,000	1,000	,000
	Sig. (2-tailed)	1,000	,000	,000	,000	,000	1,000	1,000	1,000	1,000	1,000	1,000	.	1,000
	N	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360
ENERGY	Correlation Coefficient	,000	,000	,000	,000	,000	,707**	,258**	,000	,000	,000	,000	,000	1,000
	Sig. (2-tailed)	1,000	1,000	1,000	1,000	1,000	,000	,000	1,000	1,000	1,000	1,000	1,000	.
	N	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360

**. Correlation is significant at the 0.01 level (2-tailed).

As a result of these correlations the output of the MNL model using NLOGIT (including all attributes) gives 'fixed parameter' and making it not possible to identify the effects of individual attributes to the willingness to implement a green façade (Appendix III).

The highest correlation is between the attributes 'size of the wall' ('SIZE), 'investment cost of €3000' (INV_X3), and 'time it takes to reach the final image of 4 years' (FINAL_2). To reduce the correlation within the date an analytical method called Multiple Correspondence Analysis (MCA) was conducted, this is elaborated in section 5.2.

5.2. Multiple Correspondence Analysis

This section is about the Multiple Correspondence Analysis (MCA). This method is used to transform the gathered non-orthogonal data into so-called dimensions in order to remove the correlation problem previously mentioned. Within this section the theory behind the MCA is described, followed by the calculation of the dimensions. These dimensions are then used in a MNL model and ML model.

5.2.1. Theory behind MCA

Multiple Correspondence Analysis (MCA) is conducted to remove the correlation problem from the MNL model. MCA is used to analyse the patterns of relationships between several categorical dependent variables. The MCA is an extension of the correspondence analysis (CA). MCA is used when observations are described by (a set of) nominal variables. These variables can have multiple levels that are coded as binary variables. (Abdi & Valentin, 2007)

MCA uses a distance measure instead of an orthogonalization technique used in, for example, a Principle Component Analysis (PCA). The relationships between the categories are transformed into coordinates in a multi-dimensional space, by assigning scale-values to the categories and maximizing the variance of those values. This will help find the relationships between these categories. When the results are plotted in a graph, the points that are in the same direction from the origin are highly related, while points close to the origin represent the mean. (Dungey, Tchatoka, & Yanotti, 2018)

MCA makes use of so-called *"bins"*, these are quantitative variables that are recoded into nominal variables. For example, a score ranging from -4 to +4 could be recoded as three levels: (1) less than zero, (2) equal as zero, or (3) more than zero. Therefore, the coding scheme of a MCA implies that the total sum of a row is equal for every row. (Abdi & Valentin, 2007)

In other words, there are *p* attributes Q_k that consist of K levels. $K = 1, \dots, q_k$ $(k = 1, \dots., p)$, respectively. There are *n* *(*rows or respondents) by Q $(Q_1 + Q_2 + \cdots + Q_p$ columns or attribute levels$)$ indicator matrix **Z**, represented as: (Greenacre, 1984; Kaciak & Louviere, 1990)

Equation 9 Indicator matrix

$$Z = [\, Z_1\, Z_2 \dots Z_p],$$

Where

Equation 10 Indicator submatrix

$$Z_k = [\, Z_{1k}\, Z_{2k} \dots Z_{j_k k}],$$

is a submatrix whose attribute levels (columns) correspond to levels K of attribute Q_k. Every row of the submatrix (Z_k) sums up to one, while every row of the indicator matrix (Z) sums up to *p.* (Kaciak & Louviere, 1990) Table 20 shows the recoding into a binary system, where the sum of each attribute row (level (K)) is equal to one.

Table 21 Dummy coding attribute levels

Attributes	ID	Level	A	B	C	D
Type of green façade	0	Green wall	1	0		
	1	Living wall	0	1		
Investment cost	0	€950	1	0	0	0
	1	€1500	0	1	0	0
	2	€3000	0	0	1	0
	3	€4500	0	0	0	1
Maintenance cost	0	€50	1	0	0	
	1	€200	0	1	0	
	2	€400	0	0	1	
Maintenance frequency	0	Monthly	1	0	0	
	1	2 times per year	0	1	0	
	2	4 times per year	0	0	1	
Size	0	Half	1	0		
	1	Whole	0	1		
Improved biodiversity	0	Average	1	0		
	1	A lot	0	1		
Energy savings	0	20 percent	1	0		
	1	30 percent	0	1		
Time it takes to reach the final image	0	Direct or in a couple of months	1	0	0	
	1	2 years	0	1	0	
	2	4 years	0	0	1	

Table 22 shows the indicator matrix (submatrix ($\boldsymbol{Z_k}$)) used:

Table 22 Indicator Matrix

Responden t	INV_X1	INV_X2	INV_X3	INV_X4	FINAL_1	FINAL_2	…	BI O	BIO 2	ENERG Y	ENERGY 2
1	0	0	0	1	0	1	…	1	0	0	1
1	1	0	0	0	1	0	…	1	0	1	0
…	…	…	…	…	…	…	…	…	…	…	…
248	0	0	0	1	0	1	…	1	0	0	1
248	0	0	0	1	0	1	…	1	0	0	1

The indicator matrix is transformed into a so-called Burt matrix (**B**), according to the following structure (Greenacre, 1984);

Equation 11 Burt matrix

$$B = Z^T Z = \begin{bmatrix} Z_1^T Z_1 & Z_1^T Z_2 & \cdots & Z_1^T Z_Q \\ Z_2^T Z_1 & Z_2^T Z_2 & \cdots & \vdots \\ \vdots & \vdots & \ddots & \vdots \\ Z_Q^T Z_1 & \cdots & \cdots & Z_Q^T Z_Q \end{bmatrix}$$

Table 23 Burt matrix showing a sample of the pairwise cross-tables of four variables. (Appendix IV)

	INV_X1	INV_X2	INV_X3	INV_X4	FINAL_1	FINAL_2	…	BIO	BIO2	ENERGY	ENERGY2
INV_X1	259	0	0	0	259	0	…	259	0	130	129
INV_X2		289	0	0	0	289	…	0	289	132	157
INV_X3			236	0	0	0	…	0	236	106	130
INV_X4				170	0	170	…	170	0	59	111
FINAL_1					259	0	…	259	0	130	129
FINAL_2						459	…	170	289	191	268
⋮	…	…	…	…	…	…	…	…	…	…	…
BIO							…	429	0	189	240
BIO2							…		525	238	287
ENERGY							…			427	0
ENERGY2							…				527

Dividing the values from the Burt matrix (**B**) with the total amount of respondents results in the so-called Correspondence matrix (**C**). The following formula is used to conduct this step:

Equation 12 Correspondence matrix

$$C = \{p_{ij}\} = Z_i^T Z_j / n$$

$$n = \sum_i \sum_j c_{ij}$$

$$c_{ij} = Z_i Z_j$$

where $n = 954$, gives:

Table 24 Correspondence matrix showing a sample of the pairwise cross-tables of four variables. (Appendix VII)

	INV_X1	INV_X2	INV_X3	INV_X4	FINAL_1	FINAL_2	…	BIO	BIO2	ENERGY	ENERGY2
INV_X1	0.2715	0	0	0	0.2715	0	…	0.2715	0	0.1363	0.1352
INV_X2		0.3029	0	0	0	0.3029	…	0	0.3029	0.1384	0.1646
INV_X3			0.2474	0	0	0	…	0	0.2472	0.1111	0.1363
INV_X4				0.1782	0	0.1782	…	0.1782	0	0.0618	0.1164
FINAL_1					0.2715	0	…	0.2715	0	0.1363	0.1352
FINAL_2						0.4811	…	0.1782	0.3029	0.2002	0.2809
⋮	…	…	…	…	…	…	…	…	…	…	…
BIO							…	0.4497	0	0.1981	0.2516
BIO2							…		0.5503	0.2495	0.3008
ENERGY							…			0.4476	0
ENERGY2							…				0.5524

Table 24 indicates the percentage chosen for each level per attribute. For example, the attribute levels of investment cost were chosen in the following quantities; 27 percent of the respondents chose for an investment cost of €950 (INV_X1), 30 percent for €1500, 25 percent for €3000, and 18 percent for €4500, respectively. The Correspondence Matrix (**C**) enables to interpret the results from the Burt matrix (**B**) with ease.

Percentages of variances dimensions

Equations 13 - 16 are used to translate the information from the Burt matrix (**B**) into the independent dimensions. The formulas are applied to find out how many dimensions are minimally needed to include most of the information within the data. First, the total inertia or the total variance of the cloud is calculated, using the following formula;

Equation 13 Total inertia

$$\Phi^2 = \frac{K - Q}{Q}$$

Q equals the amount of attributes (Q = 8) and K equals the amount of attribute levels (K = 21). Therefore, the formula results in a total inertia (Φ^2) of 1.625. The total inertia is used to calculate the percentages of variances for each dimension. To calculate the inertia ratio per dimension, the following formula is used;

Equation 14 Inertia ratio

$$\tau_l = \frac{\lambda_l}{\Phi^2}$$

λ_l are the eigenvalues of the dimensions, which represent the relative relevance of each dimensions to the total inertia. Eigenvalues are often called principal inertias as their summation is equal to the total inertia. (Greenacre & Blasius, 2006) Using the total inertia to calculate the percentages of inertia for each of the dimensions results in an optimistic estimation of those percentages. Therefore, Greenacre (1993) proposed an alternative method, which evaluates the percentage of inertia relative to the average inertia of the off-diagonal blocks of the Burt matrix (**B**). This can be denoted as;

Equation 15 Average off-diagonal inertia

$$A_{off-diagonal} = \frac{K}{K-1} * (\sum_l \lambda_l^2 - \frac{J-K}{K^2})$$

After which, the percentage of inertia is obtained by the ratio:

Equation 16 Inertia ratios dimensions using the average off-diagonal

$$\tau_l = \frac{\lambda_l}{A_{off-diagonal}}$$

Inertia of the variables

The inertia of the variables can be calculated using the following formula:

Equation 17 Interia of the variables

$$I = (K_Q - 1)/Q$$

$I = Variable\ inertia$
$K_q =$ Number of attribute levels
$Q =$ Number of attributes

Calculating the inertia of each variable results in Table 25. In the table, the dimension of subspace indicates the spread across a $K_Q - 1$ dimensional space, meaning that a specific variable is strongly linked to a certain number of dimensions. For example, *Type* is only strongly linked with one dimension while *Investment cost* is strongly linked with three dimensions.

Table 25 Inertia of variables

Variable	**Number of categories**	**Inertia (I)**	**Number of dim. of subspace**
Investment cost	4	3/Q	3
Maintenance cost	3	2/Q	2
Maintenance frequency	3	2/Q	2
Time it takes to reach the final result	3	2/Q	2
Type	2	1/Q	1
Size	2	1/Q	1
Improved biodiversity	2	1/Q	1
Energy savings	2	1/Q	1

5.2.2. Dimension calculation

Conducting the MCA using RStudio (Appendix VIII) for all the attributes results in Table 26:

Table 26 Eigenvalues dimensions

	Dimension 1	Dimension 2	Dimension 3	Dimension 4	Dimension 5	Dimension 6	Dimension 7	Dimension 8
λ	0.389	0.384	0.243	0.211	0.126	0.116	0.113	0.042

Using Equation 14 and Equation 15 results in the following inertia ratios for each dimension.

Table 27 Inertia ratios dimensions

	Dimension 1	Dimension 2	Dimension 3	Dimension 4	Dimension 5	Dimension 6	Dimension 7	Dimension 8
τ	0.240	0.236	0.150	0.130	0.078	0.071	0.070	0.026

The results of Table 27 are shown Figure 15. It can be concluded from the percentages of explained variance that the first two dimensions are the most explanatory compared to the others. The first two dimension combined explain 47.6 percent. However, 75.6 percent is explained when taking the first four dimensions into account and 97.5 percent is explained when taking the first seven dimensions into account.

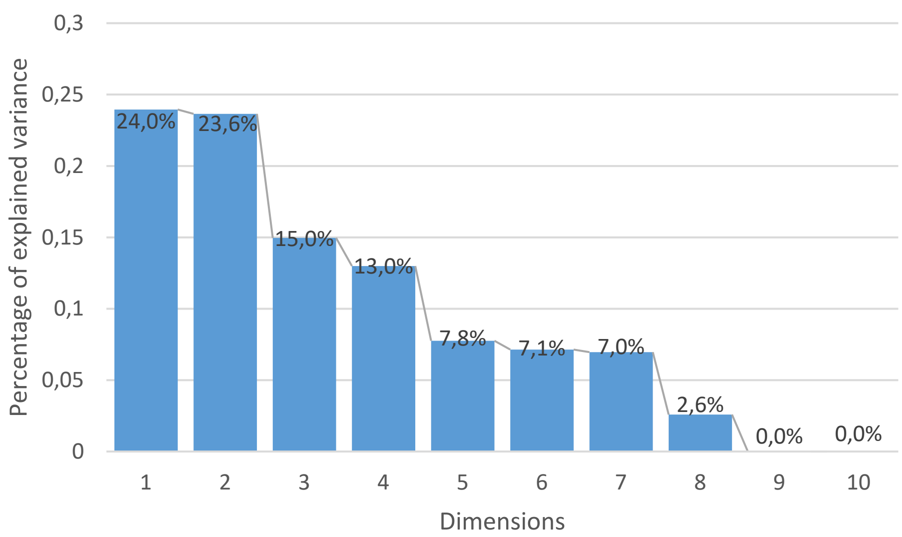


Figure 15 Scree-plot MCA

However, dividing the eigenvalue by the summation of all the eigenvalues results in an optimistic estimation. Therefore, the alternative method by Greenacre (1993) (Equation 15 & Equation 16) is conducted as well. This resulted in Table 28 and Figure 16.

Table 28 Inertia dimensions using the average off-diagonal method

	Dimension 1	Dimension 2	Dimension 3	Dimension 4	Dimension 5	Dimension 6	Dimension 7	Dimension 8
τ	0.224	0.221	0.140	0.122	0.073	0.067	0.065	0.024

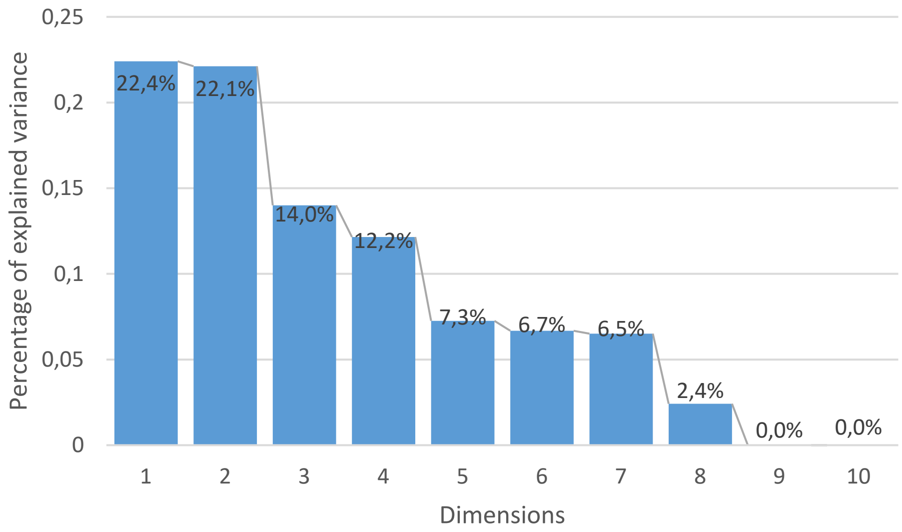


Figure 16 Scree-plot MCA using the average off-diagonal method

The alternative method results in smaller percentages of explained variances. This is expected, since this method reduces the optimistic results from the more traditional system. It can be concluded that 44.5 percent of the variance in the data is explained by the first two dimensions, that 70.7 percent is explained by the first four dimensions and that 91.1 percent is explained by the first seven dimensions. Including all eight dimensions results in an explained variance of 93.5 percent.

However, it is common practice to include only the dimensions that have a eigenvalue that is higher than 0.05, according to Rodriquez-Sabate et al. (2017). Furthermore, a combined inertia higher than 90 percent is generally enough to detect and interpret the main interactions of a system (Rodriguez-sabate et al., 2017). Therefore, dimension eight is removed from future analysis as its eigenvalue is only 0.042 and the remaining seven dimensions have an accumulated inertia higher than 90 percent (91.1 percent).

Creating the functions for each dimension

The categorical variables (categorical attributes) are shown in Table 29. Only the variables having a correlation ratio significantly different to zero are taken into account.

Table 29 Categorical variables (eta2)

	Dim.1	Dim.2	Dim.3	Dim.4	Dim.5	Dim.6	Dim.7
INV	0.994	0.993	0.975	-	-	0.008	0.019
FINAL	0.985	0.983	0.017	-	-	-	-
SIZE	0.632	0.343	0.017	-	-	0.005	-
BIO	0.381	0.180	0.429	-	-	-	-
TYPE	0.079	0.504	0.401	-	-	-	0.012
ENERGY	0.015	-	0.006	0.800	-	-	0.008
MFREQ	0.016	0.057	0.008	0.759	0.738	0.246	0.061
MCOST	0.015	0.057	0.092	0.117	0.255	0.660	0.800

The results of Table 29 can be used as input to create the functions of the different dimensions. Next to the general coefficient used in the functions (e.g. 0.994 for the investment cost (dimension 1)), the influence of the different attribute levels need to be taken into account. This is done by calculating for each attribute level its coefficient using the dimdesc function in R-studio (Appendix IX). Equation 18 describes the generic formula used to compute the seven dimensions, all seven dimension functions can be found in Appendix X.

Equation 18 Generic function dimensions

$$D_i = \sum \beta_{Qi} * \alpha_{Qki} * X_{Qk}$$

$D_i = Dimension\ i\ (i = 1, \dots, i)$

$\beta_{Qi} = Correlation\ ratio\ (eta2)\ for\ attribute\ Q\ for\ dimension\ i$

$\alpha_{Qki} = Coefficient\ of\ level\ k\ from\ attribute\ Q\ for\ dimension\ i$

$X_{Qk} = dummy\ coded\ attribute\ level, chosen = 1\ and\ not\ chosen = 0$

What are the dimensions?

The *variability of the dataset* is mostly explained by dimension 1 and 2, so most of the variability is explained by *'investment costs', 'time it takes to reach the final image', 'size of the wall', 'type of the wall', 'increased biodiversity'), 'energy savings potential', 'maintenance frequency',* and *'maintenance cost'* (in that order of importance). In Table 30, the most important variable categories per dimension are shown. Where a plus sign ('+') indicates a positive relation to that dimension and a negative sign ('-') indicating that the relation to that dimension is negative. After which, a dimension name is linked to each dimension. Incorporating the most important aspects of that dimension.

Table 30 Dimension, variable categories & names

Dimensions	**Variable categories**	**Dimension name**
Dimension 1	+INV lvl1, – INV lvl4, – INV lvl2 +FINAL direct, – FINAL 2years +SIZE half, – SIZE whole	Green façade, least expensive & fastest to reach the final image
Dimension 2	+INV lvl3, – INV lvl4, – INV lvl1, – INV lvl2, +FINAL 4years, – FINAL, direct, – FINAL 2 years, +TYPE LW, – TYPE GW	Green façade, medium to high investment cost & longest to reach the final image (4 years)
Dimension 3	+INV lvl4, – INV lvl3, – INV lvl2 (BIO: 0,429)	Green façade, most expensive & most environmental
Dimension 4	+ENERGY 20, – ENERGY 30 +MFREQ monthly, – MFREQ 4x	Green façade with (20%) energy savings & a high maintenance frequency
Dimension 5	+MFREQ monthly, + MFREQ 4x, – MFREQ 2x	Green façade with medium to high maintenance frequency
Dimension 6	+MCOST lvl3, + MCOST lvl1, – MCOST lvl2	Green façade with an average maintenance cost
Dimension 7	+MCOST lvl3, – MCOST lvl1	Green façade with a high maintenance cost

5.2.3. MNL model with dimensions

The previously constructed dimension functions are implemented into the gathered data for the survey, resulting in specific values. These values are then used within a MNL model to test which utility is given to which dimension or in-other-words to which 'package' of attributes. The result of the estimated MNL model is shown in Table 31 and Figure 17 (Appendix XI).

Table 31 Results MNL model with dimensions

Dimension	Coefficient MNL	Significance	Standard error
Constant	-1.021	***	0.093
Dimension 1	0.025		0.028
Dimension 2	-0.035		0.030
Dimension 3	-0.510	***	0.071
Dimension 4	-0.246	***	0.067
Dimension 5	-0.586	***	0.169
Dimension 6	0.607		0.439
Dimension 7	-0.989	***	0.193

***, **, * --> Significance at 1%, 5%, 10% level

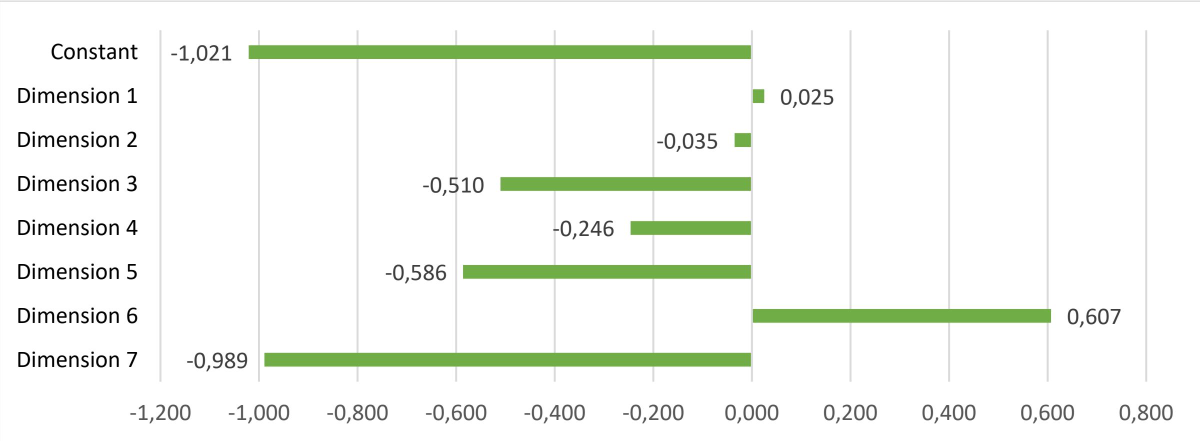


Figure 17 Results MNL model (dimensions)

Table 31 indicates that only the constant, dimension 3, dimension 4, dimension 5, and dimension 7 have a statistically significant coefficient at the 1 percent level. Meaning that the coefficients are statistically different to zero. While dimension 1, dimension 2, and dimension 6 are not statistically different to zero.

The negative coefficient of the constant indicates that a lower utility is given to the constant (no green wall). In other words, indicating that people are giving a higher utility to a green façade than to not having a green façade.

Negative coefficients indicate that the people assign a negative utility to those specific dimensions (Figure 17). Indicating that these dimensions (e.g. attributes of a green façade) negatively impact the willingness to implement a green façade. This is the cause for:

- *A green wall with a high maintenance cost (-0.989, dimension 7)*
- *A green wall with a medium to high maintenance frequency (-0.586, dimension 5)*
- *A green wall, most expensive & most environmental (-0.510, dimension 3)*
- *A green wall with (20 percent) energy savings & a high maintenance frequency (-0.246, dimension 4)*

For some of the dimensions a negative utility makes sense. For example, '*a green wall with a high maintenance cost'* or *'a green wall with a medium to high maintenance frequency'*, these dimensions indicate that people desire a green wall that is not as expensive in regards to maintenance cost and is not as maintenance intensive.

However, for others the negative sign might be surprising. For example the negative utility of '*a green wall with (20 percent) energy savings & a high maintenance frequency'*. This could be caused by people being more concerned with the amount of maintenance compared to the energy savings potential, giving rise to the negative utility.

'A green wall that is most expensive and most environmental' could have received a negative utility because of the high investment cost, even though the environmental aspect of the wall might be desired. Potentially indicating that finances are more important for the utility than the potential benefits regarding the environment.

The sample population used in this research is not representative for the Dutch population, as mentioned in section 5.2.1**.** This could have an effect on the utility given by the respondents. The majority of the respondents are highly educated, aged between 55 and 64, and have an income higher than €4201 per month. Therefore, it could be possible that money is less of a problem. This could indicate why the investment cost has hardly any influence on the utility, except for the most expensive option (investment cost of €4500), which negatively influences the utility. This is in line with the answers given by the majority of the respondents regarding their ability to afford a green façade (perceived behavioural control (PBC)) section 5.3.4. Additionally, the majority of the respondents indicated that they could handle the added maintenance. However, the utility of both the '*maintenance cost'* and the '*maintenance frequency'* are so negative indicating that even though the respondents could handle the extra maintenance, they still find a high maintenance frequency and high maintenance cost undesirable.

Goodness-of-fit: MNL model dimensions

The goodness-of-fit of the MNL model with dimensions is calculated using the formula stated in section 4.3.4. Computing the null-model into the McFadden's rho-squared formula followed by the adjusted McFadden's rho-squared formula (Equation 6 & Equation 7) results in:

Rho-squared of 0.129 and a Rho-squared adjusted of 0.136. The McFadden's ρ^2 value indicates the performance of the model. Domencich and McFadden (1973) argued that a satisfactory fit of a model should have a rho-squared value between 0.2 and 0.4. For this model, the model fit is bad as the rho-squared is 0.136. This could indicate that there is heterogeneity within the data, which is tested using the mixed logit model.

5.2.4. Mixed Logit Model with dimensions

Several mixed logit (ML) models were estimated to possibly improve the fit of the model and to get more interesting results. The following code was used within Nlogit:

```
NLogit
; lhs=CHOICE
; choices=0,1,2
; rhs= 'insert variables'
; Pds=8
; RPL= 'insert variables'
; fcn= 'insert variables' (N)
; halton
; pts=1000
; robust$
```

To get the final ML model a step-wise method was used. This included starting with only the constant as a random parameter. Adding subsequently the other dimensions as random parameters, removing the ones that have a non-significant coefficient for the random parameter estimate as random parameters. While keeping the ones that have a significant coefficient for the random parameter estimate as random parameters. This resulted in Table 32 (Appendix XII).

Table 32 ML results (dimensions)

	Coefficient ML	Significance	Stan. Dev. Of random parameter	Significance
Constant	-2.639	***	2.864	***
Dimension 1	0.057		0.537	***
Dimension 2	-0.031		0.470	***
Dimension 3	-0.848	***	1.237	***
Dimension 4	-0.402	***		
Dimension 5	-0.901	***		
Dimension 6	1.369	**		
Dimension 7	-1.427	***		

The coefficients mentioned in Table 32 determine whether the mean of the sample population random parameters obtained from the 1000 draws (pts=1000) is statistically different to zero (Hensher et al., 2015). It can be concluded that the mean of the sample population is for almost all the included dimensions statistically different to zero, except for dimension 1 and dimension 2.

The standard deviation of random parameter indicate whether there is heterogeneity within the sampled population with regard to individual levels per dimension. If the result is statically insignificant (P-value < 0.05) then there is no heterogeneity over the sampled population regarding that dimension (Hensher et al., 2015). This means that for that particular dimension a single parameter estimate is sufficient to represent all sampled individuals. This holds for dimensions 4, dimension 5, dimension 6, and dimension 7.

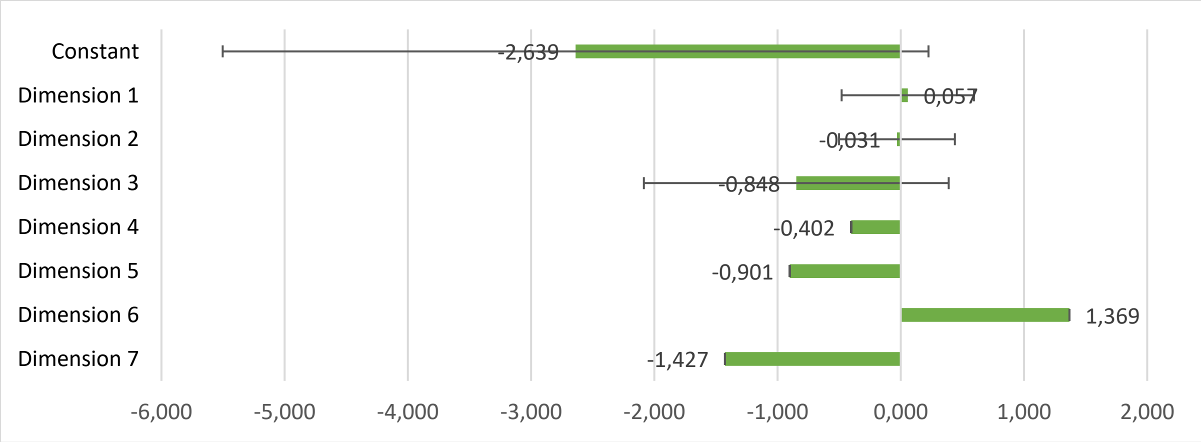


Figure 18 Results MNL model dimensions (incl. standard deviation)

In other words, there is heterogeneity in the sampled population for 'the constant (e.g. the no green wall alternative)', 'a green wall that is the least expensive & fastest to reach the final image (dimension 1)', '*Green wall, medium to high investment cost & longest to reach the final image (4 years)(*dimension 2*)',* and '*a green wall that is the most expensive & most environmental* (dimension 3)'(Figure 18). A total of four ML models were estimated, to see what influences these heterogeneities within these specific dimensions (e.g. the constant, dimension 1, dimension 2, and dimension 3). Three ML models included the socio-demographics (Appendix XIII), the context variables (Appendix XIV), and the statements based on the Theory of Planned Behaviour (Appendix XV) separately. While a fourth model was estimated including only the statistically significant attribute levels of the previous three models (Appendix XVI). This model outperformed the other models, except for the model including only the socio-demographics (0.354 > 0.335) (Table 33). However, the fourth model is chosen to be elaborated and interpreted because it enables to relate the information more broadly to the reality (society) and is elaborated in Table 34 and Figure 19.

Table 33 Rho² & Rho² adjusted for the estimated models

	MNL	**ML**				
	Dimensions	Dimensions	Socio-demographics	Context variables	Statements	Combination
Rho²	0.129	0.260	0.298	0.275	0.274	0.293
Rho² adj.	0.136	0.270	0.354	0.314	0.310	0.329

Table 34 ML results including socio-demographics, context variables and statements

	Coefficient ML	Sign.	Stan. Dev. Of random parameter	Sign.
Constant	1.550		2.291	***
Dimension 1	-0.357		0.467	***
Dimension 2	-0.259		0.404	***
Dimension 3	-0.037		1.145	***
Dimension 4	-0.405	***		
Dimension 5	-0.894	***		
Dimension 6	1.348	**		
Dimension 7	-1.426	***		
Interaction variables				
Constant				
35-44 years old	-2.725	***		
Master's degree	-2.193	***		
No perceived heat stress	-1.290	**		
Dimension 1				
35-44 years old	-0.430	***		
65+ years old	-0.574	**		
Positive attitude towards a green facade	-0.290	**		
Dimension 2				
65+ years old	0.494	***		
Dimension 3				
Trees along the streets	-1.810	***		
Trees and low rise vegetation along the streets	-1.767	***		
Parklike living	-1.336	***		

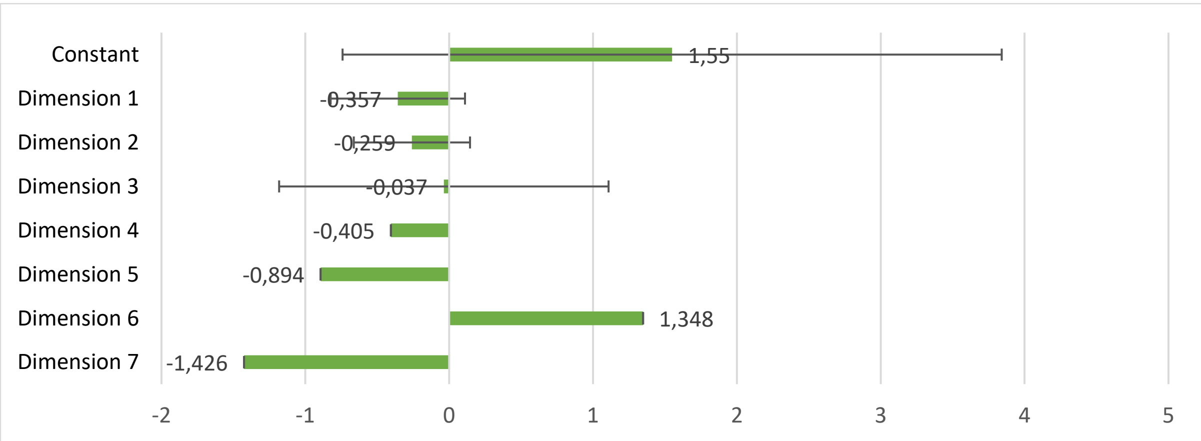


Figure 19 Results ML model (including interaction variables)

It can be concluded that in general the heterogeneity within the constant is caused by socio-demographics. While the heterogeneity within dimension 1 is caused by different age groups and the general attitude towards a green façade. The heterogeneity within the second dimension is also caused by age. While the heterogeneity within dimension 3 is caused by the existing amount of greenery in the neighbourhood.

Individuals who are aged between 35 – 44 years old assign a smaller utility for the constant compared to the base group (individuals aged between 18 – 34 years old), the same is true for: individuals having a university masters' degree compared to the individuals having completed the secondary vocational education (base group). Indicating that they are more likely to choose for a green façade, compared to the base groups.

Individuals aged between 35 – 44 years old or individuals that are older than 65 years old assign a smaller utility to '*a green wall that is the least expensive and the fastest to reach its final image* (dimension 1)' compared to individuals aged 18 to 34 years old (base group). These individuals are therefore less likely to choose '*a green wall that is the least expensive and the fastest to reach its final image* (dimension 1)'. The same is true for individuals that have a really positive attitude towards a green façade, they assign a smaller utility to dimension 1 compared to the individuals that have a neutral attitude. Potentially because these individuals see other aspects of a green façade as more beneficial or more important than it being the least expensive and fastest to reach its final image.

Older individuals (older than 65 years old) assign a larger utility towards '*a green wall, medium to high investment cost & longest to reach the final image (4 years)*(dimension 2)' compared to individuals aged between 18 – 34 years old. Indicating that these individuals are more likely to choose for a green wall that has a medium investment cost and that takes the longest to reach the final image.

The heterogeneity within dimension 3 (*'a green wall that is the most expensive and the most environmental'*) is caused by the context variable, '*amount of greenery present in the direct surroundings of the respondents*'. Individuals having in their direct surroundings streets with only trees assign a smaller utility to the dimension than individuals who have no greenery at all. The same is true for individuals who have trees and small vegetation along the streets and for individuals who live in park like environments (e.g. lots of greenery). Indicating that individuals who do not have any greenery within their close surroundings are more likely to choose for '*a green wall that is the most expensive and the most environmental'* compared to individuals who do have greenery within their close surroundings.

Theory behind the conclusions

Interaction variables constant:

Age

Individuals aged between 35 and 44 years old are less likely to choose for a green façade compared to individuals aged between 18 and 34. This might indicate that the younger generation is more environmentally continuous than the people aged between 35 and 44 years old. Even though the literature states otherwise (CBS, 2018). Or that other aspects in their lives are of greater importance at the moment such as, getting kids etc.

Education level

Higher educated people are less likely to choose for a green façade compared to individuals who have completed secondary vocational education. Even though, the literature stated that higher educated individuals are more environmentally continuous than individuals that are less educated (CBS, 2018).

Interaction variables dimension 1:

Age
Individuals aged between 35 – 44 years old and individuals that are older than 65 years old are less likely to choose '*a green wall that is the least expensive and the fastest to reach the final image'* compared to individuals aged between 18 and 34 years old. Indicating that individuals aged between 18 and 34 years old are more concerned with the investment cost and are less patient than the other two mentioned age groups. Potentially caused by the fact that these individuals (18-34 years old) generally have a lower income than the other two age groups (CBS, 2022).

Attitude towards a green façade
Individuals that have a really positive attitude towards a green façade, assign a smaller utility to dimension 1 compared to the individuals that have a neutral attitude. Potentially because these individuals see other aspects of a green façade as more beneficial or more important than it being the least expensive and fastest to reach its final image.

Interaction variable dimension 2:

Age
Individuals older than 65 years old are more likely to choose a green wall that has a medium investment cost and that takes the longest to reach the final results (e.g. 4 years) compared to individuals aged between 18 and 34 years old. This could be because of the difference in income between these age groups (CBS, 2022), indicating that the younger generation is less likely to spend that amount of money on a green facade. In addition, it also shows that elderly individuals are more patient than the younger generation. This can be explained by the fact that richer individuals (generally the older individuals) have more patience than poorer individuals (Burro, McDonald, Read, & Taj, 2022).

Interaction variables dimension 3:

Amount of greenery present in the surrounding neighbourhood
Individuals that are living in areas that have no greenery are more likely to choose a green façade that is most expensive and most environmental compared to individuals who have greenery. Potentially because these individuals have the greatest benefit of implementing a green façade, as it substantially adds to the amount of greenery present. While individuals that are already living in greener environments do not see that big of a difference when a green façade is added.

Goodness-of-fit: Mixed Logit model

The goodness-of-fit of the ML model (including the socio-demographics, context variables and statements) is calculated in the same manner as the goodness-of-fit of the MNL model (Equation 6 & Equation 7). The results of both calculations (MNL & ML goodness-of-fit) is shown in Table 35.

Table 35 Goodness-of-fit: MNL & ML models

MNL model		**ML model**	
Observations	1120	*Observations*	1120
LL(B)	-1071,40649	*LL(B)*	-886,60949
LL(0)	-1230.45	*LL(0)*	-1230.45
Rho² adjusted	0.136	*Rho² adjusted*	0.329

The Mixed Logit model outperforms the Multinomial Logit model as the McFadden rho² adjusted value for the ML is larger than that of the MNL model. In addition, the threshold for a satisfactory fitting model set by Domencich and McFadden (1973) is met. Therefore, the model fit is satisfactory.

5.3. Conclusion

Conclusions that can be drawn from the conducted analyses are mentioned in this section. First, the frequency analysis indicated that not all versions of the data were equally distributed. The versions should have been equally distributed as the software 'Limesurvey' should have distributed the versions randomly. However, versions 3 and 4 were both only filled in once. Therefore, the MNL analysis on the raw data resulted in an output that could not be used to identify the effects of individual attributes to the willingness to implement a green façade. It resulted in two sub-MNL models were the outputs were 'packages' of correlating attributes that influenced the utility, making it impossible to see the effect of individual attributes to the willingness to implement a green façade.

The fact that the gathered data did not result in an output that could be used to identify the effects of individual attributes to the willingness to implement a green façade was caused by the use of a non-orthogonal design.

A multiple correspondence analysis was conducted to translate the highly correlated data into dimensions. A total of seven dimensions were included in this research. These dimensions were translated into dimension functions, which were based on the general coefficient of the attributes combined with the coefficients of relevant attribute levels. Next, these functions were used to compute a value for each dimension for each observation in the data, essentially transforming the data from a binary system into a continuous data structure. The latter was then used within a MNL model and ML model.

The MNL model including the dimensions indicated that the constant, *'a green façade that is the most expensive & most environmental* (dimension 3)*', 'a green façade with (20%) energy savings & a high maintenance frequency* (dimension 4)*', 'a green façade with a medium to high maintenance frequency* (dimension 5)*'*, and '*a green façade with a high maintenance cost* (dimension 7)' were statistically significant at the 1 percent level. It can be concluded that all the dimensions that have a statistically significant coefficient have a negative coefficient. Indicating that a green façade is chosen over a non-green façade (negative constant).

However, the goodness-of-fit for the estimated MNL model is poor as the McFadden's' rho² adjusted is 0.136. This could indicate that there is heterogeneity within the data. Therefore, a second analysis is conducted using a ML model as this model allows for random taste variation. The results indicated that there is no heterogeneity over the sampled population regarding '*a green façade with (20%) energy savings & a high maintenance frequency* (dimension 4)*', 'a green façade with a medium to high maintenance frequency* (dimension 5)', *'a green façade with an average maintenance cost* (dimension 6)', and '*a green façade with a high maintenance cost* (dimension 7)'.

However, the '*non-green façade* (constant)', '*a green façade that is the least expensive & fastest to reach the final image* (dimension 1)', *'a green façade that has a medium to high investment cost & takes the longest to reach the final image* (dimension 2)', and *'a green façade that is the most expensive & most environmental* (dimension 3)*'* have heterogeneity over the sampled population. This means that the respondents have a different opinion about the size of the utility for those specific dimensions.

Whether the heterogeneity within these dimensions is influenced by socio-demographics, context variables, the general attitude, social norm, or perceived behavioural control is tested by estimating additional ML models. In general the heterogeneity within the constant is caused by socio-demographics. While the heterogeneity within '*a green façade that is the least expensive & fastest to reach the final image* (dimension 1)' is caused by different age groups and the general attitude towards a green façade. The heterogeneity within *'a green façade that has a medium to high investment cost & takes the longest to reach the final image* (dimension 2)' is also caused by age. While the heterogeneity within *'a green façade that is the most expensive & most environmental* (dimension 3)' is caused by the existing amount of greenery in the neighbourhood.

The ML model outperformed the MNL model, 0.329 compared to 0.136. In addition, the goodness-of-fit measured by adjusted McFadden rho^2 is satisfactory**.**

6. Conclusion, limitations and recommendations

Green facades can mitigate the negative effect of climate change and urbanisation. These facades can improve the air-quality, reduce the (city)noise, increase biodiversity, and positively influence the urban heat island effect. In addition to the larger scale influences of a green façade, the indoor climate can be improved. Green facades can stabilise the internal temperature of a house, which positively influences the energy consumption and the thermal comfort. The more green facades are implemented, the greater the potential benefits.

The implementation of green facades has been minimal. Therefore, the objective of this research was to get insight in the preferences of Dutch home-owners of land-bound houses in regards to the type of green façade, the pricing of the green façade, and the effectiveness of governmental policies. This resulted in the following main research question:

What is the willingness of Dutch home-owners of land-bound dwellings to implement a green façade?

To be able to answer this question a literature study was conducted and a survey including a stated choice experiment was developed. Potential benefits of a green façade, according to the literature were used as attributes within the stated choice experiment.

The literature study resulted in a list of important aspects for making a decision on implementing a green façade. These aspects are; investment cost, maintenance cost, energy savings potential, biodiversity improvement, and the time it takes to reach the final image. Furthermore, various personal characteristics and context variables could influence the preferences for a green façade. First, the socio-demographics are; gender, age, education level, income level, and house type. Second, the context variables are; the amount of greenery present in the direct environment, perceived amount of heat stress present in the area, the perceived amount of noise disturbance present in the area, and the availability of stimulating policies for the implementation of a green façade.

In this research the Theory of Planned Behaviour (TPB) was used as a theoretical framework to understand choice behaviour. The theory is based around the individual's intention to conduct a given act or behaviour and is based around the general rule that the higher the individuals intention the more likely the act or behaviour is performed. Intention is influenced by three predictors: attitude towards the behaviour or act, the subjective norm, and the perceived behavioural control. These three predictors for intention are questioned within the survey by means of several statements.

The vast majority of the people are worried about the climate and see human processes as a cause of climate change. Furthermore, the majority of the people are positive towards green facades regarding both the potential benefits of these facades and the aesthetics of it. However, the attitude towards actually implementing a green façade is not that clear. Almost a one third of the people has a positive attitude towards implementing a green façade, which is impressive as green facades are uncommon. Nevertheless, the vast majority of the people has not considered implementing a green façade.

Green facades are not common and are not the subject of conversation, meaning that the social stimulus is not present. Furthermore, information regarding green facades is not known by the majority of the people. In addition, the majority of the people are financially able to buy a green façade and can handle the added maintenance. The latter might be caused by the overrepresentation of high income respondents in the sample influencing the perceived behavioural control. Lastly, the perceived effect of implementing a green façade even if no one else is implementing one is seen as positive. Meaning that the people have perceived control over the desired effect of implementing a green façade even if no other green facades are constructed. Therefore, the perceived behavioural control is rather positive, and could be stimulated if the information needed is available for the respondents.

Regarding the context variables, heat stress leads to a decreased productivity, and to a lesser extent sleep problems and sweating. However, for the vast majority of the people a headache does not occur. Noise disturbance in the area has a negative effect on their sleep, productivity, and increases annoyance. Furthermore, the majority of the people are not aware of available stimulating policies regarding green facades. In addition, the majority did receive information about improving the sustainability of their dwelling. However, for the vast majority this information was not broadened towards the possible effects of a green façade.

The reduction of the urban heat island effect is seen as the most important advantage of a green façade, followed by the energy savings potential, while the noise canceling abilities of a green façade are seen as the least important advantage.

Eight stated choice questions were added to the survey to answer the second sub-question: "To what extent is the willingness of implementation of a green façade influenced by the type of green façade, the maintenance cost, the investment cost, sound insulation, heat insulation, energy savings potential, and increased biodiversity?". Two aspects mentioned in this question were no longer included in the survey. Namely, 'sound insulation' and 'heat insulation'. Both because of the difficulty to interpret the aspect and its effect by the respondents. The aspect 'sound insulation' was also removed because of its minimal effect. The effect of the 'heat insulation' was removed because of the influence of the large amount of aspects related to the existing wall on the effect of heat insulation, going far beyond the aim of this research.

The stated choice experiment was constructed using a non-orthogonal design. Therefore, a Multiple Correspondence Analysis (MCA) was conducted to convert the data into seven dimensions. These dimensions were then used as input for both, a MNL model and ML models.

The MNL model including the dimensions indicated that people are more likely to choose for a green façade than for a non-green façade. Heterogeneity within the sample was tested using the ML model. People have the same opinion regarding ''*a green façade with (20%) energy savings & a high maintenance frequency', 'a green façade with a medium to high maintenance frequency*', '*a green façade with an average maintenance cost*', and '*a green façade with a high maintenance cost*' (e.g. no heterogeneity). While the opinions differ for the '*a non-green façade'*, '*a green façade that is the least expensive & fastest to reach the final image*', *'a green façade that has a medium to high investment cost & takes the longest to reach the final image*', and *'a green façade that is the most expensive & most environmental'*.

In general the heterogeneity within '*a non-green façade'* is caused by socio-demographics (e.g. age and education). While the heterogeneity within '*a green façade that is the least expensive & fastest to reach the final image*' is caused by different age groups and the general attitude towards a green façade. The heterogeneity within *'a green façade that has a medium to high investment cost & takes the longest to reach the final image*' is also caused by age and the heterogeneity within *'a green façade that is the most expensive & most environmental*' is caused by the existing amount of greenery in the neighbourhood.

All in all, the research (partially) answered the previously stated research questions. Dutch home-owners of land-bound dwellings are more likely to choose a green facade than a non-green facade, prompting potential for the actual implementation of a green façade. The most important advantage has been found. Namely, the '*reduction of the urban heat island effect'*. Socio-demographics, age and education level, do influence the willingness to implement a green façade. From the four context variables only the perceived amount of greenery influences the willingness to implement for a green façade that is the most expensive and the most environmental.

Limitations

Sample

The sample is not representative for the Dutch population as its distribution of frequencies is not in-line with the distribution within the WoON2018 dataset. Individuals of 55-64 years old, highly educated, and high incomes are overrepresented in the sample. Furthermore, the geospatial distribution of the sample is not in-line with the geospatial distribution of the Netherlands. Increasing the amount of respondents and distributing the survey around the Randstad could improve the representativeness of the sample.

Non-orthogonal design

The use of the non-orthogonal design resulted in highly correlated variables, which in turn made identifying the individual effects of variables (and attribute levels) on the willingness to implement a green façade impossible. The results were better interpretable after converting the data into dimensions (MCA). Still the individual effects of variables (and attribute levels) on the willingness to implement a green façade was lost. Resulting in the sub-research question: '*To what extent is the willingness of implementation of a green façade influenced by the type of green faced, the maintenance price, the price, sound insulation, heat insulation, energy savings potential, and biodiversity level?*' not being answered in this research. Conducting the research again, but with an orthogonal design could further increase the knowledge of the willingness to implement a green façade and potentially answer the stated sub-research question.

Multiple Correspondence Analysis (MCA)

The Multiple Correspondence Analysis (MCA) made it possible to convert the non-orthogonal data into orthogonal dimensions. This improved the interpretability of the data. Therefore, it can be concluded that this method can be used in situations where a non-orthogonal data is used. However, it needs to be stated that using orthogonal data from the start enables for a more in depth interpretation.

Willingness to pay (WTP)

The willingness to pay (WTP) is not conducted in this research, due to the lack interpretable effects of individual attributes and attribute levels. Not including the WTP in this research means that the quantification of the willingness of Dutch-homeowners of land-bound dwellings is missing.

Recommendations

Green facades are beneficial in terms of improved air-quality, reduced (city)noise, increased biodiversity, positively influencing the urban heat island effect, stabilizing the indoor climate, and saving energy. Therefore, policymakers and homeowners should aim to implement more green facades to mitigate the negative effects of climate change (especially within urban areas).

Making urban areas more adaptable regarding climate change is an ongoing process, where governmental institutions and municipalities try to convert the public spaces into areas that can mitigate the negative effects of climate change. However, space in the horizontal plane is more and more under stress, as several types of space uses battle for the same public space. Therefore, the only space left is in the vertical plane (e.g. facades). However, these facades are often privately owned making it only possible for municipalities to stimulate the implementation by means of information distribution and subsidies. This information, however, is not known by the vast majority of the people, regarding both; the potential benefits of green facades as the availability of subsidies. Therefore, it should be recommended for municipalities to invest into informing its inhabitants better on the potential benefits of a green façade as well as making the subsidies easier to access.

Municipalities could focus their information sharing, regarding both; the potential benefits of a green façade and the availability of subsidies, in areas where there is hardly any to no greenery present. As these individuals are more likely to choose a green façade as these individuals have the greatest benefit of implementing a green façade, as it substantially adds to the amount of greenery present.

Recommendations for future research:

Conduct the survey with a better representative sample for the Netherlands. This can be done by focusing on homeowners of land-bound dwellings with a lower income, lower education level, who are older than 64 years old, and are the owners of both rowhouses and corner houses. In addition, distributing the survey according to the population density in the Netherlands is recommended. In other words, getting the geospatial distribution of the sample more in line with the population distribution of the Netherlands (including more people from the Randstad).

Conducting the research with a stated choice experiment based on an orthogonal design and change the description of the 'neither one' option is highly recommended. This to get better insight into the effect of individual variables (and attribute levels) on the willingness to implement a green façade. Making it possible to better answer the stated research questions as well as conducting both, a Latent Class Model (LCM) and the Willingness To Pay (WTP). A Latent Class model (LCM) to group individuals into different classes, to potentially find interesting groups. These groups could be targeted differently, to increase the changes of them implementing a green façade. Lastly, a Willingness to pay (WTP) could be estimated. Adding a monetary value to the research would increase the knowledge gained for this research and potentially find bottlenecks/solutions for the implementation of a green façade.

The conducted research indicated that the majority of the people did receive information about improving the sustainability of their dwelling. Future research could potentially find a relation between the knowledge (information about improving the sustainability of their dwelling) and the choices regarding a green façade. To be able to potentially increase the effectiveness of these governmental tools in regards to implement a green façade.

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Appendices

Appendix I: Survey

Survey on the willingness to implement a green facade

What is the willingness of Dutch homeowners of land-based homes to realize a green facade?

This survey was made at Eindhoven University of Technology (TUe) and is part of a study into the willingness of Dutch home-owners to implement a green facade. The aim of this stuy is to gain a better understanding of the willingness of Dutch home-owners of land-based homes to implement a green facade. As the owner of a land-based home, it is greatly appreciated if you take 5 minutes of your time to complete this survey.

You must give your consent to participate in this study. You can read more about the research and data collection in the statement below. Please read this information carefully and accept the statement before continuin with the survey.

There are 51 questions in this survey.

Personal information

What is your gender? *

❶ Choose one of the following answers
Please choose **only one** of the following:

- ◯ Male
- ◯ Female
- ◯ Non-binary
- ◯ No answer

What is your age? *

❶ Choose one of the following answers
Please choose **only one** of the following:

- ◯ 18 - 24 years old
- ◯ 25 - 34 years old
- ◯ 35 - 44 years old
- ◯ 45 - 54 years old
- ◯ 54 - 64 years old
- ◯ 65 years or older

Which degree have you completed? *

❶ Choose one of the following answers
Please choose **only one** of the following:

- ◯ Primary school or less
- ◯ MAVO / VMBO / Lower vocational education
- ◯ Secondary vocational education
- ◯ HAVO / VWO
- ◯ Higher professional education / Bachelor's degree
- ◯ University master's degree

What is your households' monthly netto income? *

❶ Choose one of the following answers
Please choose **only one** of the following:

- ◯ Less than €2000 a month
- ◯ €2001 - €4200 a month
- ◯ €4201 - €6250 a month
- ◯ More than €6250 a month
- ◯ I do not know
- ◯ I do not want to say

The monthly netto income is the amount of money that is transferred to your bank account on a monthly basis. This includes your salary, social benefits, and pension income. If your household has more than one income, you must add these togheter.

What type of house do you live in? *

❶ Choose one of the following answers
Please choose only one of the following:

◯


Row house

◯


Corner house

◯


Semi-detached house

◯


Detached house

Terraced house

Apartment

Other

Do you live in an owner-occupied or rented dwelling? *

Choose one of the following answers

Please choose **only one** of the following:

Owner-occupied

Rented

What is your postal code including letters (no space)?

Please write your answer here:

Please fill in 4 numbers and 2 letters.

Statements green facades

Indicate to what extent you agree or disagree with the following statements about the realization of a green facade.

A **Green facade** is a wall overgrown with plants (see images)


Indicate how much you agree or disagree with the following statements about the implementation of green facades.

*

Please choose the appropriate response for each item:

	Totally disagree	Disagree	Neither agree or disagree	Agree	Totally agree
I'm worried about the climate	○	○	○	○	○
I'm concerned about the human processes that damage the climate	○	○	○	○	○
Green facades are beneficial to the neighbourhood	○	○	○	○	○
Green facades are beneficial to the biodiversity in the neighbourhood	○	○	○	○	○
Green facades are beneficial to the air quality in the neighbourhood	○	○	○	○	○
Green facades are beneficial to the reduction of the urban heat island effect in the neighbourhood*	○	○	○	○	○
Green facades are aesthetically pleasing	○	○	○	○	○
I think green facades are beneficial to the thermal comfort in the house	○	○	○	○	○
I am thinking of implementing a green facade	○	○	○	○	○
Green facades are common in my neighbourhood	○	○	○	○	○

	Totally disagree	Disagree	Neither agree or disagree	Agree	Totally agree
Others have alerted me to the possibility of implementing a green façade	○	○	○	○	○
I know many friends who have a green façade	○	○	○	○	○
I care what others think of green facades	○	○	○	○	○
I have the information to be able to implement a green façade	○	○	○	○	○
I can handle the added amount of maintenance of a green façade	○	○	○	○	○
I can buy a green façade for my house, if I wanted to	○	○	○	○	○
There is no point in realizing a green façade, if no one else is realizing one	○	○	○	○	○

*Urban heat island effect is a place where it is warmer than in the close vicinity (e.g. an urban area) (Van Dale, 2019). Urban areas are warmer than rural areas due to the use of hard materials (e.g. concrete, bricks and asphalt) which retain the heat. This heat is released at night, making these areas warmer.

Indicate how much you agree or disagree with the following statement about the implementation of green facades. *

Please choose the appropriate response for each item:

	Not considered at all	Considered it but no further action	Considered it and made plans for it	Considered it and a green facade will be implemented
Have you thought about implementing a green facade?	○	○	○	○

I know people who have a green facade *

Choose one of the following answers

Please choose **only one** of the following:

- ◯ yes
- ◯ No

Your living environment

How would you describe the amount of greenery within the area you live in?

*

❶ Choose one of the following answers

Please choose **only one** of the following:

◯


No green

◯


Some green (e.g. trees allong the streets)

◯


Greenery (trees + low rise plants)

◯


A lot of greenery (park living)

Chose the picture that is closest to the real life situation.

Indicate how much you agree or disagree with the following statements about heat waves.

*

Please choose the appropriate response for each item:

	Totally disagree	Disagree	Neither agree or disagree	Agree	Totally agree
During heat waves I sweat a lot at home	○	○	○	○	○
During heat waves I often have headaches at home	○	○	○	○	○
During heat waves I have problems sleeping at night	○	○	○	○	○
During heat waves I have problems with being productive	○	○	○	○	○

Indicate how much you agree or disagree with the following statements about noise disturbance.

*

Please choose the appropriate response for each item:

	Totally disagree	Disagree	Neither agree or disagree	Agree	Totally agree
Noise disturbance disturbs my sleep	○	○	○	○	○
Noise disturbance makes me annoyed	○	○	○	○	○
Noise disturbance decreases my productivity	○	○	○	○	○

Noise disturbance is unwanted or harmful outdoor noise caused by human activities, including noise generated by means of transport, road traffic, railway traffic, air traffic and locations of industrial activities. (Het Europees Parlement en de Raad van de Europese Unie, 2002)

Is there governmental support in your municipality? *

Please choose the appropriate response for each item:

	Yes	No	I do not know
Does the municipality grand a subsidy for green facades?	○	○	○
Have you received information for making you home more sustainable?	○	○	○
Have you received information for making your home more sustainable, including information about green facades?	○	○	○

Advantages green facades

Rank the following advantages of a green façade, in the right order from most important to least important.

*

❶ All your answers must be different and you must rank in order.
❶ Please select at most 7 answers
Please number each box in order of preference from 1 to 7

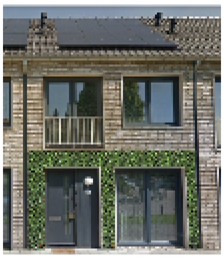
- [ ] Improved thermal comfort
- [ ] Energy savings
- [ ] Noise canceling
- [ ] Improved air quality
- [ ] Reduced urban heat island effect*
- [ ] Increased biodiversity
- [ ] Improved aesthetics

*Urban heat island effect is a place where it is warmer than in the close vicinity (e.g. an urban area) (Van Dale, 2019). Urban areas are warmer than rural areas due to the use of hard materials (e.g. concrete, bricks and asphalt) which retain the heat. This heat is released at night, making these areas warmer.

Information Stated Choice Experiment

In the next 8 questions, two green facades are shown to you. Your preference will be asked each time. If neither of the two green facades appeals to you, you can choose the option 'neither one'. The image shows an example of a possible choice set.

Choice 3/8

Characteristics	Alternative 1	Alternative 2
Type	 Green wall	 Living wall
Size	 Half	 Heel
Investment cost	€950,-	€4.500,-
Maintenance frequency	4 times per year	Monthly
Maintenance cost	€200,-	€200,-
Time it takes to reach the final image	4 years	2 years
Improved biodiversity	Average	Average
Energy savings	30%	20%

Which alternative would you prefer?

Choose one of the following answers

Alternative 1 | Alternative 2 | Neither one

The choices vary in properties of the walls. This concerns the following properties:

- **Type**: green facade (ivy) or living wall (modular system)
- **Size:** covering the entire or half of the facade
- **Investment costs**: the purchase price per green wall
- **Maintenance frequency**: 'how often must maintenance be performed per year'.
- **Maintenance costs**: the maintenance cost per year
- **Time it takes to get the final image:** time it takes to completely cover the wall.
- **Improved Biodiversity:** how much does the wall add to the biodiversity. There are two options here:
    - 1. **Average**: this stands for the addition of nest space for birds.
    - 2. **A lot**: this tands for the addition of nest space for birds & food for insects and birds via flowers.
- **Energy savings**: the energy savings per year, as a result of the stabilized indoor temperature.

Appendix II: Python code transforming data to long-format

```
pip install pandas
import pandas as pd
import numpy as np
```

```
path_to_file = 'C:/XXX.csv'
data = pd.read_csv(path_to_file, sep=';')
```

```
##removal of columns
data = data.drop(["submitdate", "startlanguage", "seed", "lastpage", "Tekstinfo", "Tekstinfo2"], axis=1)
data.head()

##removal of renters
data = data.loc[data["A6"] != "Huurwoning"]
pd.set_option('display.max_columns', None)
data.head()
data.shape

#removal of non land-based dwellings (e.g. apartments)
data = data.loc[data["A5"] != "Appartement"]

data.to_csv('C:/XXX.csv', index=False)
```

```
data.loc[data['PIN'] == '1']
data['E1'] = data['E1'].replace(['Alternatief 1'],['1'])
data['E1'] = data['E1'].replace(['Alternatief 2'],['3'])
data['E1'] = data['E1'].replace(['Geen van beide'],['17'])

data['E2'] = data['E2'].replace(['Alternatief 1'],['2'])
data['E2'] = data['E2'].replace(['Alternatief 2'],['5'])
data['E2'] = data['E2'].replace(['Geen van beide'],['17'])

data['E3'] = data['E3'].replace(['Alternatief 1'],['4'])
data['E3'] = data['E3'].replace(['Alternatief 2'],['7'])
data['E3'] = data['E3'].replace(['Geen van beide'],['17'])

data['E4'] = data['E4'].replace(['Alternatief 1'],['6'])
data['E4'] = data['E4'].replace(['Alternatief 2'],['9'])
data['E4'] = data['E4'].replace(['Geen van beide'],['17'])

data['E5'] = data['E5'].replace(['Alternatief 1'],['8'])
data['E5'] = data['E5'].replace(['Alternatief 2'],['11'])
data['E5'] = data['E5'].replace(['Geen van beide'],['17'])

data['E6'] = data['E6'].replace(['Alternatief 1'],['10'])
data['E6'] = data['E6'].replace(['Alternatief 2'],['13'])
data['E6'] = data['E6'].replace(['Geen van beide'],['17'])

data['E7'] = data['E7'].replace(['Alternatief 1'],['12'])
data['E7'] = data['E7'].replace(['Alternatief 2'],['15'])
data['E7'] = data['E7'].replace(['Geen van beide'],['17'])

data['E8'] = data['E8'].replace(['Alternatief 1'],['14'])
data['E8'] = data['E8'].replace(['Alternatief 2'],['16'])
data['E8'] = data['E8'].replace(['Geen van beide'],['17'])

data.loc[data['PIN'] == '2']
data['E9'] = data['E9'].replace(['Alternatief 1'],['1'])
data['E9'] = data['E9'].replace(['Alternatief 2'],['16'])
data['E9'] = data['E9'].replace(['Geen van beide'],['17'])
```

```
data['E10'] = data['E10'].replace(['Alternatief 1'],['2'])
data['E10'] = data['E10'].replace(['Alternatief 2'],['7'])
data['E10'] = data['E10'].replace(['Geen van beide'],['17'])

data['E11'] = data['E11'].replace(['Alternatief 1'],['4'])
data['E11'] = data['E11'].replace(['Alternatief 2'],['13'])
data['E11'] = data['E11'].replace(['Geen van beide'],['17'])

data['E12'] = data['E12'].replace(['Alternatief 1'],['6'])
data['E12'] = data['E12'].replace(['Alternatief 2'],['11'])
data['E12'] = data['E12'].replace(['Geen van beide'],['17'])
```

```
data['E13'] = data['E13'].replace(['Alternatief 1'],['8'])
data['E13'] = data['E13'].replace(['Alternatief 2'],['9'])
data['E13'] = data['E13'].replace(['Geen van beide'],['17'])

data['E14'] = data['E14'].replace(['Alternatief 1'],['10'])
data['E14'] = data['E14'].replace(['Alternatief 2'],['15'])
data['E14'] = data['E14'].replace(['Geen van beide'],['17'])

data['E15'] = data['E15'].replace(['Alternatief 1'],['12'])
data['E15'] = data['E15'].replace(['Alternatief 2'],['5'])
data['E15'] = data['E15'].replace(['Geen van beide'],['17'])

data['E16'] = data['E16'].replace(['Alternatief 1'],['14'])
data['E16'] = data['E16'].replace(['Alternatief 2'],['3'])
data['E16'] = data['E16'].replace(['Geen van beide'],['17'])

data.loc[data['PIN'] == '3']
data['E17'] = data['E17'].replace(['Alternatief 1'],['1'])
data['E17'] = data['E17'].replace(['Alternatief 2'],['8'])
data['E17'] = data['E17'].replace(['Geen van beide'],['17'])

data['E18'] = data['E18'].replace(['Alternatief 1'],['3'])
data['E18'] = data['E18'].replace(['Alternatief 2'],['5'])
data['E18'] = data['E18'].replace(['Geen van beide'],['17'])

data['E19'] = data['E19'].replace(['Alternatief 1'],['6'])
data['E19'] = data['E19'].replace(['Alternatief 2'],['13'])
data['E19'] = data['E19'].replace(['Geen van beide'],['17'])

data['E20'] = data['E20'].replace(['Alternatief 1'],['9'])
data['E20'] = data['E20'].replace(['Alternatief 2'],['10'])
data['E20'] = data['E20'].replace(['Geen van beide'],['17'])

data['E21'] = data['E21'].replace(['Alternatief 1'],['11'])
data['E21'] = data['E21'].replace(['Alternatief 2'],['4'])
data['E21'] = data['E21'].replace(['Geen van beide'],['17'])

data['E22'] = data['E22'].replace(['Alternatief 1'],['14'])
data['E22'] = data['E22'].replace(['Alternatief 2'],['7'])
data['E22'] = data['E22'].replace(['Geen van beide'],['17'])

data['E23'] = data['E23'].replace(['Alternatief 1'],['15'])
data['E23'] = data['E23'].replace(['Alternatief 2'],['12'])
data['E23'] = data['E23'].replace(['Geen van beide'],['17'])

data['E24'] = data['E24'].replace(['Alternatief 1'],['2'])
data['E24'] = data['E24'].replace(['Alternatief 2'],['16'])
data['E24'] = data['E24'].replace(['Geen van beide'],['17'])

data.loc[data['PIN'] == '4']
data['E25'] = data['E25'].replace(['Alternatief 1'],['11'])
data['E25'] = data['E25'].replace(['Alternatief 2'],['10'])
data['E25'] = data['E25'].replace(['Geen van beide'],['17'])

data['E26'] = data['E26'].replace(['Alternatief 1'],['3'])
data['E26'] = data['E26'].replace(['Alternatief 2'],['14'])
data['E26'] = data['E26'].replace(['Geen van beide'],['17'])
```

```
data['E27'] = data['E27'].replace(['Alternatief 1'],['4'])
data['E27'] = data['E27'].replace(['Alternatief 2'],['5'])
data['E27'] = data['E27'].replace(['Geen van beide'],['17'])

data['E28'] = data['E28'].replace(['Alternatief 1'],['7'])
data['E28'] = data['E28'].replace(['Alternatief 2'],['8'])
data['E28'] = data['E28'].replace(['Geen van beide'],['17'])

data['E29'] = data['E29'].replace(['Alternatief 1'],['13'])
data['E29'] = data['E29'].replace(['Alternatief 2'],['12'])
data['E29'] = data['E29'].replace(['Geen van beide'],['17'])

data['E30'] = data['E30'].replace(['Alternatief 1'],['15'])
data['E30'] = data['E30'].replace(['Alternatief 2'],['6'])
data['E30'] = data['E30'].replace(['Geen van beide'],['17'])

data['E31'] = data['E31'].replace(['Alternatief 1'],['2'])
data['E31'] = data['E31'].replace(['Alternatief 2'],['9'])
data['E31'] = data['E31'].replace(['Geen van beide'],['17'])

data['E32'] = data['E32'].replace(['Alternatief 1'],['1'])
data['E32'] = data['E32'].replace(['Alternatief 2'],['16'])
data['E32'] = data['E32'].replace(['Geen van beide'],['17'])
```

```
##Saving the data set for MNL
data_set = data[['id','PIN', 'E1','E2','E3','E4','E5','E6',
                 'E7','E8','E9','E10','E11','E12','E13','E14',
                 'E15','E16','E17','E18','E19','E20','E21','E22',
                 'E23','E24','E25','E26','E27','E28','E29','E30',
                 'E31','E32']]
data_set2 = data.iloc[ : , 1:46]
data_set.to_csv('C:/XXX.csv', index=False)
data_set2.to_csv('C:/XXX.csv', index=False)
```

```
## Wide format to long format
path_to_file = 'C:/XXX.csv'
data2 = pd.read_csv(path_to_file, sep=',', dtype=str)

##Removal of PIN
data3 = data2.drop(["PIN"], axis=1)

#wide_format -> long_format
data4 = data2.set_index(['id']).stack()

data4.to_csv('C:/XXX.csv')
```

```
#making the data neater
path_to_file = 'C:/XXX.csv'
data5 = pd.read_csv(path_to_file, sep=',')

#adding names to columns
data5.columns = ["id", "Task", "Alternative"]

data5.to_csv('C:/XXX.csv', index=False)
```

```
#PIN Removal
path_to_file = 'C:/XXX.csv'
data6 = pd.read_csv(path_to_file, sep=',')

data6 = data6.loc[data6["Task"] != "PIN"]

#Adding csv_file with all the possible choices
path_to_file = 'C:/XXX.csv'
data7 = pd.read_csv(path_to_file, sep=';')
```

```
#Merging dataframes
data9 = pd.merge(data6, data7, left_on='Task', right_on='task')

#Adding choice
data9['Choice'] = np.where(data9['Alternative']==data9['Alternatieven'], '1', '0')

#Selecting columns
data10 = data9[['id', 'Task', 'Alternatieven', 'Choice']]

data10.to_csv('C:/XXX.csv', index=False)
```

```
#Transforming the data
path_to_file = 'C:/XXX.csv'
data11 = pd.read_csv(path_to_file, sep=',')

#Transforming Task to choice-set per respondent
data11['Task'] = data11['Task'].replace(['E1'],['1'])
data11['Task'] = data11['Task'].replace(['E2'],['2'])
data11['Task'] = data11['Task'].replace(['E3'],['3'])
data11['Task'] = data11['Task'].replace(['E4'],['4'])
data11['Task'] = data11['Task'].replace(['E5'],['5'])
data11['Task'] = data11['Task'].replace(['E6'],['6'])
data11['Task'] = data11['Task'].replace(['E7'],['7'])
data11['Task'] = data11['Task'].replace(['E8'],['8'])
data11['Task'] = data11['Task'].replace(['E9'],['1'])
data11['Task'] = data11['Task'].replace(['E10'],['2'])
data11['Task'] = data11['Task'].replace(['E11'],['3'])
data11['Task'] = data11['Task'].replace(['E12'],['4'])
data11['Task'] = data11['Task'].replace(['E13'],['5'])
data11['Task'] = data11['Task'].replace(['E14'],['6'])
data11['Task'] = data11['Task'].replace(['E15'],['7'])
data11['Task'] = data11['Task'].replace(['E16'],['8'])
data11['Task'] = data11['Task'].replace(['E17'],['1'])
data11['Task'] = data11['Task'].replace(['E18'],['2'])
data11['Task'] = data11['Task'].replace(['E19'],['3'])
data11['Task'] = data11['Task'].replace(['E20'],['4'])
data11['Task'] = data11['Task'].replace(['E21'],['5'])
data11['Task'] = data11['Task'].replace(['E22'],['6'])
data11['Task'] = data11['Task'].replace(['E23'],['7'])
data11['Task'] = data11['Task'].replace(['E24'],['8'])
data11['Task'] = data11['Task'].replace(['E25'],['1'])
data11['Task'] = data11['Task'].replace(['E26'],['2'])
data11['Task'] = data11['Task'].replace(['E27'],['3'])
data11['Task'] = data11['Task'].replace(['E28'],['4'])
data11['Task'] = data11['Task'].replace(['E29'],['5'])
data11['Task'] = data11['Task'].replace(['E30'],['6'])
data11['Task'] = data11['Task'].replace(['E31'],['7'])
data11['Task'] = data11['Task'].replace(['E32'],['8'])

#Sorting the data on id & Task
sorted_id = data11.sort_values(['id','Task'])

#Changing column sequence
sorted_id = sorted_id[['id', 'Task', 'Choice', 'Alternatieven']]

#Changing alternatieve to alternatives
sorted_id.rename(columns={'Alternatieven': 'Alternatives'}, inplace=True)

#Saving the final dataset
sorted_id.to_csv('C:/XXX.csv', index=False)
```

```
#Combining data_sorted_for_MNL with effect-coding
#Input data dummycoding file & data sorted file
path_to_file = 'C:/XXX.csv'
data12 = pd.read_csv(path_to_file, sep=',')
path_to_file = 'C:/XXX.csv'
data13 = pd.read_csv(path_to_file, sep=';')
data14 = pd.merge(data12, data13, left_on='Alternatives', right_on='Alternatives')
data14 = data14.sort_values(['id','Task'])
data14 = data14[['id','Task', 'Choice', 'Constant', 'Alternatives', 'INV_X1', 'INV_X2',
                 'INV_X3', 'INV_X4', 'FINAL_1', 'FINAL_2', 'FINAL_3', 'MFREQ_1', 'MFREQ_2',
                 'MFREQ_3', 'MCOST_1', 'MCOST_2', 'MCOST_3', 'TYPE', 'TYPE2', 'SIZE', 'SIZE2',
                 'BIO', 'BIO2', 'ENERGY', 'ENERGY2']]
data14.to_csv('C:/XXX.csv', index=False)
```

```
#Merging categorical input alternatives & Personal information
path_to_file = 'C:/XXX.csv'
data14 = pd.read_csv(path_to_file, sep=';')
path_to_file = 'C:/XXX.csv'
data15 = pd.read_csv(path_to_file, sep=',')

data16 = pd.merge(data14, data15, left_on='id', right_on='id')
data16 = data16[data16['Choice'] == 1]

#Rename columns
data16.rename(columns={'A1': 'Gender', 'A2':'Age', 'A3':'Degree', 'A4': 'Income', 'A5':'Type of dwelling'}, inplace=True)

data16.to_csv('C:/XXX.csv', index=False)
```

```
#frequency calculations
Frequency_alternatives = data14['Alternatives'].value_counts().rename_axis('Alternatives').reset_index(name='Max Frequency')
Frequency_alternatives.to_csv('C:/XXX.csv', index=False)

path_to_file = 'C:/XXX.csv'
data17 = pd.read_csv(path_to_file, sep=',')

#Frequency chosen alternatives
data18= data14[['Choice', 'Alternatives']]
data18 = data18.loc[data18['Choice'] == 1]
data18 = data18['Alternatives'].value_counts().rename_axis('Alternatives').reset_index(name='Chosen frequency')
data18 = data18.sort_values(['Alternatives'])

#Merging frequency tables
path_to_file = 'C:/XXX.csv'
data17 = pd.read_csv(path_to_file, sep=',')

data19 = pd.merge(data17, data18, left_on='Alternatives', right_on='Alternatives')

#Calculating percentage
data19['Relative %'] = (data19['Chosen frequency'] / data19['Max Frequency'])*100

#ranking
data19['Rank'] = data19['Relative %'].rank(ascending=False)

#arraging
data19 = data19.sort_values(['Alternatives'])

data19.to_csv('C:/XXX.csv', index=False)
```

```
#input csv_file Dimensions & Personal data
path_to_file = 'C:/XXX.csv'
data1 = pd.read_csv(path_to_file, sep=';')

path_to_file = 'C:/XXX.csv'
data2 = pd.read_csv(path_to_file, sep=';')

#Merging dataframes
data3 = pd.merge(data1, data2, left_on='id', right_on='id')

#Saving dataframe
data3.to_csv('C:/XXX.csv', index=False)
```

Appendix III: Output MNL raw data

```
|-> Nlogit
    ; lhs=CHOICE
    ; choices=0,1,2
    ; rhs=CONSTANT, INV_X1, INV_X2, INV_X3, FINAL_1, FINAL_2, MFREQ_1, MFREQ_2, MCOST_1,
MCOST_2, TYPE, SIZE, BIO, ENERGY$
Hessian is not positive definite at start values.
Error    803: Hessian is not positive definite at start values.
B0 is too far from solution for Newton method.
Switching to BFGS as a better solution method.
Iterative procedure has converged
Normal exit:  14 iterations. Status=0, F=    .1070385D+04

-----------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable               Choice
Log likelihood function     -1070.38461
Estimation based on N =    1120, K =  14
Inf.Cr.AIC  =    2168.8 AIC/N =    1.936
---------------------------------------
            Log likelihood R-sqrd R2Adj
Constants only  -1181.0605  .0937 .0880
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
---------------------------------------
Response data are given as ind. choices
Number of obs.=  1120, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
CONSTANT|      .95278***       .22081      4.31  .0000       .52000    1.38556
  INV_X1|      .10023     .....(Fixed Parameter).....
  INV_X2|      .13077     .....(Fixed Parameter).....
  INV_X3|      .11497     .....(Fixed Parameter).....
 FINAL_1|     -.01474     .....(Fixed Parameter).....
 FINAL_2|      .16751     .....(Fixed Parameter).....
 MFREQ_1|     -.12009          .64664      -.19  .8527     -1.38748    1.14729
 MFREQ_2|      .21087     .....(Fixed Parameter).....
 MCOST_1|      .36444     .....(Fixed Parameter).....
 MCOST_2|     -.09782     .....(Fixed Parameter).....
    TYPE|      .11603     .....(Fixed Parameter).....
    SIZE|      .08442     .....(Fixed Parameter).....
     BIO|     -.14551     .....(Fixed Parameter).....
  ENERGY|     -.16485     .....(Fixed Parameter).....
--------+--------------------------------------------------------------------
***, **, * ==>  Significance at 1%, 5%, 10% level.
Fixed parameter ... is constrained to equal the value or
had a nonpositive st.error because of an earlier problem.
Model was estimated on May 10, 2022 at 10:41:22 AM
-----------------------------------------------------------------------------
```

Appendix IV: Output MNL model 1

```
|-> Nlogit
     ; lhs=CHOICE
     ; choices=0,1,2
     ; rhs=CONSTANT, INV_X1, INV_X2, INV_X3, MFREQ_1, MFREQ_2, MCOST_1, MCOST_2, ENERGY$
Iterative procedure has converged
Normal exit:   5 iterations. Status=0, F=    .1070385D+04

-----------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable               Choice
Log likelihood function     -1070.38461
Estimation based on N =   1120, K =   9
Inf.Cr.AIC  =   2158.8 AIC/N =    1.927
---------------------------------------
            Log likelihood R-sqrd R2Adj
Constants only  -1181.0605  .0937 .0901
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
---------------------------------------
Response data are given as ind. choices
Number of obs.=   1120, skipped    0 obs
--------+--------------------------------------------------------------------
        |                Standard            Prob.      95% Confidence
  CHOICE|  Coefficient     Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
CONSTANT|      .99466***    .09219    10.79  .0000      .81397   1.17535
  INV_X1|      .09855       .07760     1.27  .2041    -.05354     .25064
  INV_X2|      .43353***    .07144     6.07  .0000     .29351     .57355
  INV_X3|      .03421       .07414      .46  .6444    -.11109     .17952
 MFREQ_1|    -.12009        .09636    -1.25  .2127    -.30897     .06878
 MFREQ_2|      .21087***    .04838     4.36  .0000     .11604     .30570
 MCOST_1|      .36444***    .08523     4.28  .0000     .19738     .53150
 MCOST_2|    -.09782        .11143     -.88  .3801    -.31622     .12059
  ENERGY|    -.16485***     .06056    -2.72  .0065    -.28355    -.04616
--------+--------------------------------------------------------------------
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on May 23, 2022 at 11:27:15 AM
-----------------------------------------------------------------------------
```

Appendix V: Output MNL model 2

```
|-> Nlogit
    ; lhs=CHOICE
    ; choices=0,1,2
    ; rhs=CONSTANT, MFREQ_1, MFREQ_2, MCOST_1, MCOST_2, TYPE, SIZE, BIO, ENERGY$
Iterative procedure has converged
Normal exit:   5 iterations. Status=0, F=    .1070385D+04

-----------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable               Choice
Log likelihood function     -1070.38461
Estimation based on N =    1120, K =   9
Inf.Cr.AIC  =   2158.8 AIC/N =    1.927
---------------------------------------
            Log likelihood R-sqrd R2Adj
Constants only  -1181.0605  .0937 .0901
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
---------------------------------------
Response data are given as ind. choices
Number of obs.=  1120, skipped    0 obs
--------+--------------------------------------------------------------------
        |                Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
CONSTANT|      .99466***      .09219    10.79  .0000      .81397   1.17535
 MFREQ_1|     -.12009         .09636    -1.25  .2127    -.30897    .06878
 MFREQ_2|      .21087***      .04838     4.36  .0000      .11604    .30570
 MCOST_1|      .36444***      .08523     4.28  .0000      .19738    .53150
 MCOST_2|     -.09782         .11143     -.88  .3801    -.31622    .12059
    TYPE|      .26604***      .04549     5.85  .0000      .17689    .35519
    SIZE|      .06638*        .03688     1.80  .0719    -.00590    .13866
     BIO|     -.23387***      .04974    -4.70  .0000    -.33137   -.13638
  ENERGY|     -.16485***      .06056    -2.72  .0065    -.28355   -.04616
--------+--------------------------------------------------------------------
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on May 30, 2022 at 00:13:09 PM
-----------------------------------------------------------------------------
```

Appendix VI: Burt matrix

	INV_X1	INV_X2	INV_X3	INV_X4	FINAL_1	FINAL_2	FINAL_3	MFREQ_1	MFREQ_2	MFREQ_3	MCOST_1	MCOST_2	MCOST_3	TYPE	TYPE2	SIZE	SIZE2	BIO	BIO2	ENERGY	ENERGY2
INV_X1	259	0	0	0	259	0	0	62	134	63	62	134	63	259	0	259	0	259	0	130	129
INV_X2		289	0	0	0	289	0	51	164	74	81	125	83	289	0	0	289	0	289	132	157
INV_X3			236	0	0	0	236	31	149	56	56	149	31	0	236	236	0	0	236	106	130
INV_X4				170	0	170	0	32	106	32	79	64	27	0	170	0	170	170	0	59	111
FINAL_1					259	0	0	62	134	63	62	134	63	259	0	259	0	259	0	130	129
FINAL_2						459	0	83	270	106	160	189	110	289	170	0	459	170	289	191	268
FINAL_3							236	31	149	56	56	149	31	0	236	236	0	0	236	106	130
MFREQ_1								176	0	0	0	83	31	113	63	93	83	94	82	176	0
MFREQ_2									553	0	0	283	110	298	255	283	270	240	313	251	302
MFREQ_3										225	0	106	63	137	88	119	106	95	130	0	225
MCOST_1											278	0	0	143	135	118	160	141	137	143	135
MCOST_2												472	0	259	213	283	189	198	274	226	246
MCOST_3													204	146	58	94	110	90	114	58	146
TYPE														548	0	259	289	259	289	262	286
TYPE2															406	236	170	170	236	165	241
SIZE																495	0	259	236	236	259
SIZE2																	459	170	289	191	268
BIO																		429	0	189	240
BIO2																			525	238	287
ENERGY																				427	0
ENERGY2																					527

Appendix VII: Correspondence matrix

	INV_X1	INV_X2	INV_X3	INV_X4	FINAL_1	FINAL_2	FINAL_3	MFREQ_1	MFREQ_2	MFREQ_3	MCOST_1	MCOST_2	MCOST_3	TYPE	TYPE2	SIZE	SIZE2	BIO	BIO2	ENERGY	ENERGY2
INV_X1	0,2715	0,0000	0,0000	0,0000	0,2715	0,0000	0,0000	0,0650	0,1405	0,0660	0,0650	0,1405	0,0660	0,2715	0,0000	0,2715	0,0000	0,2715	0,0000	0,1363	0,1352
INV_X2		0,3029	0,0000	0,0000	0,0000	0,3029	0,0000	0,0535	0,1719	0,0776	0,0849	0,1310	0,0870	0,3029	0,0000	0,0000	0,3029	0,0000	0,3029	0,1384	0,1646
INV_X3			0,2474	0,0000	0,0000	0,0000	0,2474	0,0325	0,1562	0,0587	0,0587	0,1562	0,0325	0,0000	0,2474	0,2474	0,0000	0,0000	0,2474	0,1111	0,1363
INV_X4				0,1782	0,0000	0,1782	0,0000	0,0335	0,1111	0,0335	0,0828	0,0671	0,0283	0,0000	0,1782	0,0000	0,1782	0,1782	0,0000	0,0618	0,1164
FINAL_1					0,2715	0,0000	0,0000	0,0650	0,1405	0,0660	0,0650	0,1405	0,0660	0,2715	0,0000	0,2715	0,0000	0,2715	0,0000	0,1363	0,1352
FINAL_2						0,4811	0,0000	0,0870	0,2830	0,1111	0,1677	0,1981	0,1153	0,3029	0,1782	0,0000	0,4811	0,1782	0,3029	0,2002	0,2809
FINAL_3							0,2474	0,0325	0,1562	0,0587	0,0587	0,1562	0,0325	0,0000	0,2474	0,2474	0,0000	0,0000	0,2474	0,1111	0,1363
MFREQ_1								0,1845	0,0000	0,0000	0,0000	0,0870	0,0325	0,1184	0,0660	0,0975	0,0870	0,0985	0,0860	0,1845	0,0000
MFREQ_2									0,5797	0,0000	0,0000	0,2966	0,1153	0,3124	0,2673	0,2966	0,2830	0,2516	0,3281	0,2631	0,3166
MFREQ_3										0,2358	0,0000	0,1111	0,0660	0,1436	0,0922	0,1247	0,1111	0,0996	0,1363	0,0000	0,2358
MCOST_1											0,2914	0,0000	0,0000	0,1499	0,1415	0,1237	0,1677	0,1478	0,1436	0,1499	0,1415
MCOST_2												0,4948	0,0000	0,2715	0,2233	0,2966	0,1981	0,2075	0,2872	0,2369	0,2579
MCOST_3													0,2138	0,1530	0,0608	0,0985	0,1153	0,0943	0,1195	0,0608	0,1530
TYPE														0,5744	0,0000	0,2715	0,3029	0,2715	0,3029	0,2746	0,2998
TYPE2															0,4256	0,2474	0,1782	0,1782	0,2474	0,1730	0,2526
SIZE																0,5189	0,0000	0,2715	0,2474	0,2474	0,2715
SIZE2																	0,4811	0,1782	0,3029	0,2002	0,2809
BIO																		0,4497	0,0000	0,1981	0,2516
BIO2																			0,5503	0,2495	0,3008
ENERGY																				0,4476	0,0000
ENERGY2																					0,5524

Appendix VIII: R-script

```
#installing packages
install.packages("FactoMineR", "factoextra")
install.packages("tidyverse")

#load packages
library("FactoMineR")
library("factoextra")
library("ggplot2")

#Loading dataset
dataset1 <- read.csv(file = "C:/Users/s168889/OneDrive - TU Eindhoven/Documents/Master/Afstuderen/Green facades/survey/Analysis/Results Python/MCA analysis/MCA_ZonderGeenvanBeide.csv" , sep=';')
head(dataset1)

#select columns
#dataset2 <- dataset1[, c("Constant", "INV", "FINAL", "MFREQ", "MCOST", "TYPE", "SIZE", "BIO", "ENERGY")]
#head(dataset2)
#length(dataset)

#number of categories per variable
dataset2 = apply(dataset1, 2, function(x) nlevels(as.factor(x)))
dataset2

#summary attributes
#plot(dataset1, main=colnames(dataset1), col="steelblue", las=3)

#MCA
MCA <- MCA(dataset1, ncp = 6, axes=5:6) # exci = NULL, graph = TRUE, level.ventil = 0, axes = c(1,2), row.w = NULL,method="Indicator", na.method="NA", tab.disj = NULL)
summary(MCA, nbelements=Inf)

MCA2 <- MCA(dataset1, ncp =7)
summary(MCA2, nbelemts=Inf )

##dimdesc is designed to point out the variables and the categories that are the most characteristic according to each dimension obtained by factor analysis.
dimdesc(MCA2, axes = 1:7, proba= 0.05) #axes are the dimensions taken into account, proba = significance threshold considered.

#Quality of representation of variables categories
head(var$cos2, 21)
cos2 = var$cos2
write.csv(cos2, "Cos2 output.csv")

fviz_mca_var(res.mca, col.var = "cos2",
         axes = 1:2,
         gradient.cols = c("#bdd7e7", "#6baed6", "#2171b5"),
         repel = TRUE,
         ggtheme = theme_minimal())
fviz_mca_var(res.mca, col.var = "cos2",
         axes = 2:3,
         gradient.cols = c("#bdd7e7", "#6baed6", "#2171b5"),
         repel = TRUE,
         ggtheme = theme_minimal())
fviz_mca_var(res.mca, col.var = "cos2",
```

```
        axes = 3:4,
        gradient.cols = c("#bdd7e7", "#6baed6", "#2171b5"),
        repel = TRUE,
        ggtheme = theme_minimal())
fviz_mca_var(res.mca, col.var = "cos2",
        axes = 4:5,
        gradient.cols = c("#bdd7e7", "#6baed6", "#2171b5"),
        repel = TRUE,
        ggtheme = theme_minimal())

##visualizing the cos2 of row categories on all dimensions:
library("corrplot")
corrplot(var$cos2, is.corr=FALSE)

##visualizing the cos2 of variables on a bar plot:
fviz_cos2(res.mca, choice = "var", axes=1:2)
fviz_cos2(res.mca, choice = "var", axes=2:3)
fviz_cos2(res.mca, choice = "var", axes=3:4)
fviz_cos2(res.mca, choice = "var", axes=4:5)

#Contribution of variables categories to the dimensions
head(round(var$contrib,2), 21)
contrib=var$contrib
path_out = "C:\\Users\\s168889\\OneDrive - TU Eindhoven\\Documents\\Master\\afstuderen\\Green
facades\\survey\\Analysis\\Results Python\\MCA analysis\\2e ronde\\"
write.csv(contrib,paste(path_out,'Contrib output.csv', sep= ''))

##contribution of rows to the dimensions
fviz_contrib(res.mca, choice="var", axes = 1, top = 21)
fviz_contrib(res.mca, choice="var", axes = 2, top = 21)
fviz_contrib(res.mca, choice="var", axes = 3, top = 21)
fviz_contrib(res.mca, choice="var", axes = 4, top = 21)
fviz_contrib(res.mca, choice="var", axes = 5, top = 21)

fviz_mca_var(res.mca, col.var="contrib",
        gradient.cols = c("#bdd7e7", "#6baed6", "#2171b5"),
        repel = TRUE,
        ggtheme = theme_minimal())
fviz_mca_var(res.mca, col.var="contrib", axes=2:3,
        gradient.cols = c("#bdd7e7", "#6baed6", "#2171b5"),
        repel = TRUE,
        ggtheme = theme_minimal())
fviz_mca_var(res.mca, col.var="contrib", axes=3:4,
        gradient.cols = c("#bdd7e7", "#6baed6", "#2171b5"),
        repel = TRUE,
        ggtheme = theme_minimal())
fviz_mca_var(res.mca, col.var="contrib", axes=4:5,
        gradient.cols = c("#bdd7e7", "#6baed6", "#2171b5"),
        repel = TRUE,
        ggtheme = theme_minimal())

eig.val <- get_eigenvalue(res.mca)
head(eig.val)

var <- get_mca_var(res.mca)
var
head(var$contrib)
```

Appendix IX: Output Dimdesc

```
> dimdesc(MCA2, axes = 1:8, proba= 0.05) #axes are the dimensions taken into account, proba = significance thr
eshold considered.
$`Dim 1`
$quali
              R2       p.value
INV    0.99411008  0.000000e+00
FINAL  0.98474915  0.000000e+00
SIZE   0.63171361 1.038394e-208
BIO    0.38055053 4.133961e-101
TYPE   0.07915501  8.145386e-19
ENERGY 0.01455485  1.876656e-04
MFREQ  0.01625723  4.122667e-04
MCOST  0.01476070  8.493600e-04

$category
                          Estimate       p.value
FINAL=Direct            0.83827683  0.000000e+00
INV=INV_Level 1         0.98806166  0.000000e+00
SIZE=Half               0.49637844 1.038394e-208
BIO=Average             0.38695423 4.133961e-101
TYPE=Green wall         0.17756103  8.145386e-19
MFREQ=Monthly           0.13245530  8.858578e-05
ENERGY=Small            0.07570879  1.876656e-04
MCOST=MCOST_Level 2     0.08683238  6.664775e-04
MFREQ=2 times per year -0.07798768  9.881634e-03
MCOST=MCOST_Level 1    -0.08927438  6.897931e-04
ENERGY=High            -0.07570879  1.876656e-04
TYPE=Living wall       -0.17756103  8.145386e-19
INV=INV_Level 4        -0.38258991  3.030515e-21
INV=INV_Level 2        -0.56285429 3.450694e-100
BIO=A lot              -0.38695423 4.133961e-101
SIZE=Whole             -0.49637844 1.038394e-208
FINAL=2 years          -0.64587454 1.038394e-208

attr(,"class")
[1] "condes" "list"

$`Dim 2`
$quali
              R2       p.value
INV   0.99256011  0.000000e+00
FINAL 0.98333129  0.000000e+00
TYPE  0.50434749 2.918067e-147
SIZE  0.34341481  4.723747e-89
BIO   0.17967318  6.933945e-43
MCOST 0.05725963  6.659566e-13
MFREQ 0.01377258  1.368038e-03

$category
                          Estimate       p.value
FINAL=4 years           0.94223956  0.000000e+00
INV=INV_Level 3         1.05723557  0.000000e+00
TYPE=Living wall        0.44521792 2.918067e-147
SIZE=Half               0.36354784  4.723747e-89
BIO=A lot               0.26411577  6.933945e-43
MCOST=MCOST_Level 2     0.19518200  9.605780e-13
MFREQ=2 times per year  0.08372628  3.911687e-03
MCOST=MCOST_Level 1    -0.03426389  5.715987e-03
MFREQ=Monthly          -0.11040809  5.837141e-04
MCOST=MCOST_Level 3    -0.16091811  2.474492e-08
INV=INV_Level 4        -0.27913751  5.301508e-10
FINAL=Direct           -0.43616015  1.167874e-21
INV=INV_Level 1        -0.32116414  1.167874e-21
BIO=Average            -0.26411577  6.933945e-43
INV=INV_Level 2        -0.45693392  6.820232e-54
SIZE=Whole             -0.36354784  4.723747e-89
FINAL=2 years          -0.50607941  4.723747e-89
TYPE=Green wall        -0.44521792 2.918067e-147

attr(,"class")
[1] "condes" "list"
```

```
$`Dim 3`
$quali
              R2       p.value
INV    0.975288956  0.000000e+00
BIO    0.429289659 4.460898e-118
TYPE   0.400709986 5.829695e-108
MCOST  0.091751758  1.337430e-20
SIZE   0.016786936  5.981906e-05
FINAL  0.017279137  2.515062e-04
ENERGY 0.006342473  1.387416e-02
MFREQ  0.008222427  1.972385e-02

$category
                          Estimate       p.value
INV=INV_Level 4         0.87822675  0.000000e+00
BIO=Average             0.32476935 4.460898e-118
TYPE=Living wall        0.31569661 5.829695e-108
MCOST=MCOST_Level 1     0.22463669  5.414706e-20
SIZE=Whole              0.06394181  5.981906e-05
FINAL=2 years           0.08572676  5.981906e-05
ENERGY=High             0.03949282  1.387416e-02
MFREQ=2 times per year  0.04647169  2.119797e-02
ENERGY=Small           -0.03949282  1.387416e-02
MFREQ=4 times per year -0.06273991  6.696910e-03
FINAL=4 years          -0.05806892  5.391300e-03
INV=INV_Level 3        -0.17290260  5.391300e-03
MCOST=MCOST_Level 2    -0.05732413  2.699408e-04
SIZE=Half              -0.06394181  5.981906e-05
MCOST=MCOST_Level 3    -0.16731256  2.930628e-08
INV=INV_Level 2        -0.56283262 2.112511e-104
TYPE=Green wall        -0.31569661 5.829695e-108
BIO=A lot              -0.32476935 4.460898e-118

attr(,"class")
[1] "condes" "list"

$`Dim 4`
$quali
              R2       p.value
ENERGY 0.7998324  0.000000e+00
MFREQ  0.7593172 7.536325e-295
MCOST  0.1170437  1.968323e-26

$category
                         Estimate       p.value
ENERGY=Small            0.4131754  0.000000e+00
MFREQ=Monthly           0.6307454 1.267926e-137
MCOST=MCOST_Level 1     0.1837557  6.261541e-11
MCOST=MCOST_Level 2     0.0688872  1.890317e-02
MCOST=MCOST_Level 3    -0.2526429  6.770046e-25
MFREQ=4 times per year -0.6115188 4.917291e-137
ENERGY=High            -0.4131754  0.000000e+00

attr(,"class")
[1] "condes" "list"

$`Dim 5`
$quali
             R2       p.value
MFREQ 0.7382959 1.475356e-277
MCOST 0.2548739  1.758919e-61

$category
                          Estimate       p.value
MFREQ=Monthly           0.24732079  4.780524e-73
MFREQ=4 times per year  0.16623460  2.916575e-62
MCOST=MCOST_Level 1     0.11651844  1.617419e-23
MCOST=MCOST_Level 3     0.12263264  7.007378e-17
FINAL=4 years           0.03690053  3.985090e-02
INV=INV_Level 3         0.04042408  3.985090e-02
MCOST=MCOST_Level 2    -0.23915108  7.935522e-63
MFREQ=2 times per year -0.41355539 3.840696e-275

attr(,"class")
[1] "condes" "list"
```

```
$`Dim 6`
$quali
              R2       p.value
MCOST 0.660136822 1.364916e-223
MFREQ 0.245569613  6.425641e-59
SIZE  0.004838144  3.169963e-02
INV   0.008354763  4.654047e-02

$category
                          Estimate       p.value
MFREQ=2 times per year   0.22447847  1.330606e-59
MCOST=MCOST_Level 1      0.16393165  2.085939e-56
MCOST=MCOST_Level 3      0.20630377  3.307286e-50
SIZE=Half                0.02368243  3.169963e-02
SIZE=Whole              -0.02368243  3.169963e-02
FINAL=2 years           -0.03181546  3.169963e-02
INV=INV_Level 4         -0.05657107  9.838960e-03
MFREQ=Monthly           -0.08628522  2.092637e-13
MFREQ=4 times per year  -0.13819324  2.221395e-30
MCOST=MCOST_Level 2     -0.37023542 3.665186e-224

attr(,"class")
[1] "condes" "list"

$`Dim 7`
$quali
                R2      p.value
MCOST  0.799989014 0.000000e+00
MFREQ  0.060846288 1.087154e-13
INV    0.019399289 3.275586e-04
TYPE   0.012323139 5.928417e-04
ENERGY 0.008369757 4.684604e-03

$category
                          Estimate       p.value
MCOST=MCOST_Level 3      0.43921714 4.236193e-166
MFREQ=Monthly            0.13249960  4.481361e-10
INV=INV_Level 4          0.08406569  6.310923e-05
TYPE=Living wall         0.03780439  5.928417e-04
ENERGY=Small             0.03097933  4.684604e-03
INV=INV_Level 2         -0.04909969  1.619535e-02
ENERGY=High             -0.03097933  4.684604e-03
TYPE=Green wall         -0.03780439  5.928417e-04
MFREQ=4 times per year  -0.12555561  2.270927e-09
MCOST=MCOST_Level 1     -0.41718591 7.464046e-154

attr(,"class")
[1] "condes" "list"

$`Dim 8`
$quali
              R2      p.value
ENERGY 0.1702745 1.612604e-40
MFREQ  0.1577188 3.588036e-36

$category
                          Estimate      p.value
ENERGY=Small             0.08487536 1.612604e-40
MFREQ=4 times per year   0.12234631 2.941966e-22
MCOST=MCOST_Level 3      0.02167541 4.697613e-02
MFREQ=Monthly           -0.13007780 8.821511e-25
ENERGY=High             -0.08487536 1.612604e-40

attr(,"class")
[1] "condes" "list"
```

Appendix X: Functions dimensions

Dimension 1

$$Dim_1 = 0.994 * (0.988 * INV_{level1} + -0.563 * INV_{level2} + -0.382 * INV_{level4}) + 0.985 * \left(0.838 * FINAL_{direct} + -0.646 * FINAL_{2years}\right) + 0.632 * \left(0.496 * SIZE_{Half} + -0.496 * SIZE_{Whole}\right) + 0.381 * \left(0.387 * BIO_{Average} + -0.387 * BIO_{Alot}\right) + 0.079 * \left(0.178 * TYPE_{Greenwall} + -0.178 * TYPE_{Livingwall}\right) + 0.016 * \left(0.132 * MFREQ_{Monthly} + -0.078 * MFREQ_{2timesperyear}\right) + 0.015 * (-0.089 * MCOST_{level1} + 0.087 * MCOST_{level2}) + 0.015 * (0.076 * ENERGY_{20percent} + -0.076 * ENERGY_{30percent})$$

Dimension 2

$$Dim_2 = 0.993 * (1.057 * INV_{level3} + -0.279 * INV_{level4} + -0.321 * INV_{level1} + -0.457 * INV_{level2}) + 0.983 * (0{,}942 * FINAL_{4years} + -0.436 * FINAL_{direct} + -0.506 * FINAL_{2years}) + 0.504 * (0.445 * TYPE_{Livingwall} + -0.445 * TYPE_{Greenwall}) + 0.343 * (0.364 * SIZE_{Half} + -0.364 * SIZE_{Whole}) + 0.18 * (0.264 * BIO_{Alot} + -0.264 * BIO_{Average}) + 0.057 * (0.195 * MCOST_{level2} + -0.034 * MCOST_{level1} + -0.161 * MCOST_{Level3}) + 0.014 * (0.084 * MFREQ_{2timesperyear} + -0.110 * MFREQ_{Monthly})$$

Dimension 3

$$Dim_3 = 0.975 * (-0.563 * INV_{Level2} + -0.173 * INV_{Level3} + 0.878 * INV_{Level4}) + 0.429 * (0.325 * BIO_{Average} + -0.325 * BIO_{Alot}) + 0.401 * (-0.316 * TYPE_{Greenwall} + 0.316 * TYPE_{Livingwall}) + 0.092 * (0.225 * MCOST_{Level1} + -0.057 * MCOST_{Level2} + -0.167 * MCOST_{Level3}) + 0.017 * (0.086 * FINAL_{2years} + -0.058 * FINAL_{4years}) + 0.017 * (-0.064 * SIZE_{Half} + 0.064 * SIZE_{Whole}) + 0.008 * (0.046 * MFREQ_{2timesperyear} + -0.063 * MFREQ_{4timesperyear}) + 0.006 * (-0.039 * ENERGY_{20percent} + 0.039 * ENERGY_{30percent})$$

Dimension 4

$$Dim_4 = 0.8 * (0{,}413 * ENERGY_{20percent} + -0{,}413 * ENERGY_{30percent}) + 0.759 * (0{,}631 * MFREQ_{Monthly} + -0{,}612 * MFREQ_{4timesperyear}) + 0.117 * (0{,}184 * MCOST_{level1} + 0{,}069 * MCOST_{level2} + -0{,}253 * MCOST_{level3})$$

Dimension 5

$$Dim_5 = 0.738 * (0{,}247 * MFREQ_{Monthly} + 0{,}166 * MFREQ_{4timesperyear} + -0{,}414 * MFREQ_{2timesperyear}) + 0.255 * (0{,}117 * MCOST_{level1} + -0.239 * MCOST_{level2} + 0.123 * MCOST_{level3})$$

Dimension 6

$$Dim_6 = 0.660 * (0.164 * MCOST_{Level1} + 0.206 * MCOST_{Level3} + -0.370 * MCOST_{Level2}) + 0.246 * \left(0.224 * MFREQ_{2timesperyear} + -0.138 * MFREQ_{4timesperyear} + -0.086 * MFREQ_{Monthly}\right) + 0.008 * (-0.057 * INV_{€4500}) + 0.005 * (0.024 * SIZE_{half} + -0.024 * SIZE_{whole})$$

Dimension 7

$$Dim_7 = 0.800 * (0.440 * MCOST_{Level3} + -0.417 * MCOST_{Level1}) + 0.061 * \left(0.132 * MFREQ_{Monthly} + -0.126 \ * MFREQ_{4timesperyear}\right) + 0.019 * (0.084 * INV_{€4500} + -0.049 * INV_{€1500}) + 0.012 * \left(0.0378 * TYPE_{Livingwall} + -0.0378 * TYPE_{Greenwall}\right) + 0.008 * \left(0.031 * ENERGY_{20percent} + -0.031 * ENERGT_{30percent}\right)$$

Appendix XI: Output MNL dimensions

```
|-> Nlogit
    ; lhs = CHOICE
    ; choices = 0,1,2
    ; rhs = CONSTANT, DIM1, DIM2, DIM3, DIM4, DIM5, DIM6, DIM7
    ; pds = 8$
Iterative procedure has converged
Normal exit:   5 iterations. Status=0, F=    .1071406D+04

-----------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable                 Choice
Log likelihood function     -1071.40649
Estimation based on N =    1120, K =   8
Inf.Cr.AIC  =   2158.8 AIC/N =    1.928
---------------------------------------
            Log likelihood R-sqrd R2Adj
Constants only  -1181.0605  .0928 .0896
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
---------------------------------------
Response data are given as ind. choices
Number of obs.=  1120, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z     |z|>Z*        Interval
--------+--------------------------------------------------------------------
CONSTANT|   -1.02085***      .09253   -11.03  .0000    -1.20221   -.83948
    DIM1|     .02461         .02752      .89  .3712     -.02932    .07854
    DIM2|    -.03455         .02974    -1.16  .2453     -.09284    .02374
    DIM3|    -.51008***      .07064    -7.22  .0000     -.64854   -.37162
    DIM4|    -.24611***      .06661    -3.69  .0002     -.37666   -.11556
    DIM5|    -.58575***      .16914    -3.46  .0005     -.91727   -.25424
    DIM6|     .60689         .43918     1.38  .1670     -.25389   1.46767
    DIM7|    -.98901***      .19301    -5.12  .0000    -1.36730   -.61072
--------+--------------------------------------------------------------------
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Nov 12, 2022 at 11:41:03 AM
-----------------------------------------------------------------------------
Rho² = 0.129            Rho²adj.= 0.136
```

Appendix XII: Output ML model dimensions

```
|-> Nlogit
    ; Lhs = CHOICE
    ; choices=0,1,2
    ; RHS = CONSTANT, DIM1, DIM2, DIM3, DIM4, DIM5, DIM6, DIM7,
    ; RPL
    ; Fcn = CONSTANT (n), DIM1 (n), DIM2 (n), DIM3 (n)
    ; halton
    ; pts=1000
    ; pds=8
    ; robust$
Iterative procedure has converged
Normal exit:   5 iterations. Status=0, F=    .1071406D+04

-----------------------------------------------------------------------------
Start values obtained using MNL model
Dependent variable                Choice
Log likelihood function      -1071.40649
Estimation based on N =   1120, K =   8
Inf.Cr.AIC  =   2158.8 AIC/N =    1.928
---------------------------------------
            Log likelihood R-sqrd R2Adj
Constants only  -1181.0605  .0928 .0880
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
---------------------------------------
Using robust VC matrix, V = <H>*GtG<<G>
Response data are given as ind. choices
Number of obs.=  1120, skipped    0 obs
--------+--------------------------------------------------------------------
        |                Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*        Interval
--------+--------------------------------------------------------------------
CONSTANT|   -1.02085***      .09370   -10.90  .0000    -1.20449    -.83720
    DIM1|     .02461         .02830      .87  .3846     -.03086     .08007
    DIM2|    -.03455         .02997    -1.15  .2490     -.09330     .02420
    DIM3|    -.51008***      .07144    -7.14  .0000     -.65010    -.37006
    DIM4|    -.24611***      .06672    -3.69  .0002     -.37689    -.11534
    DIM5|    -.58575***      .17377    -3.37  .0007     -.92633    -.24518
    DIM6|     .60689         .44149     1.37  .1692     -.25841    1.47219
    DIM7|    -.98901***      .19466    -5.08  .0000    -1.37054    -.60748
--------+--------------------------------------------------------------------
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Nov 20, 2022 at 06:43:34 PM
-----------------------------------------------------------------------------

Iterative procedure has converged
Normal exit:  28 iterations. Status=0, F=    .9104837D+03

-----------------------------------------------------------------------------
Random Parameters Multinom. Logit Model
Dependent variable                CHOICE
Log likelihood function       -910.48373
Restricted log likelihood    -1230.44576
Chi squared [ 12](P= .000)     639.92407
Significance level                .00000
McFadden Pseudo R-squared       .2600375
Estimation based on N =   1120, K =  12
Inf.Cr.AIC  =   1845.0 AIC/N =    1.647
---------------------------------------
            Log likelihood R-sqrd R2Adj
No coefficients -1230.4458  .2600 .2561
Constants only  -1181.0605  .2291 .2249
At start values -1071.4065  .1502 .1456
Note: R-sqrd = 1 - logL/Logl(constants)
```

Warning: Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.

Response data are given as ind. choices
Replications for simulated probs. =1000
Used Halton sequences in simulations.
RPL model with panel has 140 groups
Fixed number of obsrvs./group= 8
Robust Covariance Matrix, VC = <H>G<H>.
Number of obs.= 1120, skipped 0 obs

CHOICE	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval	
	Random parameters in utility functions.............................					
CONSTANT	-2.63850***	.40431	-6.53	.0000	-3.43092	-1.84607
DIM1	.05718	.06261	.91	.3611	-.06553	.17988
DIM2	-.03060	.05970	-.51	.6083	-.14761	.08642
DIM3	-.84831***	.15405	-5.51	.0000	-1.15025	-.54638
	Nonrandom parameters in utility functions..........................					
DIM4	-.40228***	.08701	-4.62	.0000	-.57281	-.23174
DIM5	-.90089***	.27345	-3.29	.0010	-1.43685	-.36493
DIM6	1.36906**	.63125	2.17	.0301	.13182	2.60629
DIM7	-1.42663***	.24512	-5.82	.0000	-1.90706	-.94619
	Distns. of RPs. Std.Devs or limits of triangular...................					
NsCONSTA	2.86406***	.31409	9.12	.0000	2.24845	3.47967
NsDIM1	.53748***	.08117	6.62	.0000	.37839	.69657
NsDIM2	.46983***	.08910	5.27	.0000	.29519	.64447
NsDIM3	1.23732***	.17476	7.08	.0000	.89480	1.57985

***, **, * ==> Significance at 1%, 5%, 10% level.
Model was estimated on Nov 20, 2022 at 07:00:50 PM

Rho^2 = 0.260 Rho^2 adj. = 0.270

Appendix XIII – ML model including socio-demographics

```
|-> Nlogit
    ; Lhs = CHOICE
    ; choices=0,1,2
    ; RHS = CONSTANT, DIM1, DIM2, DIM3, DIM4, DIM5, DIM6, DIM7,
    ; RPL =  GF,
    X3,X4,X5,X6,
    E3,E4,E5,
    I3,I4,
    T2,T3,T4,T5
    ; Fcn = CONSTANT (n), DIM1 (n), DIM2 (n), DIM3 (n)
    ; halton
    ; pts=1000
    ; pds=8
    ; robust$
Iterative procedure has converged
Normal exit:   5 iterations. Status=0, F=    .1071406D+04

-----------------------------------------------------------------------------
Start values obtained using MNL model
Dependent variable                 Choice
Log likelihood function      -1071.40649
Estimation based on N =   1120, K =   8
Inf.Cr.AIC  =   2158.8 AIC/N =    1.928
---------------------------------------
            Log likelihood R-sqrd R2Adj
Constants only  -1181.0605  .0928 .0644
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
---------------------------------------
Using robust VC matrix, V = <H>*GtG<<G>
Response data are given as ind. choices
Number of obs.=  1120, skipped    0 obs
--------+--------------------------------------------------------------------
        |                Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
CONSTANT|   -1.02085***      .09370   -10.90  .0000    -1.20449    -.83720
    DIM1|     .02461         .02830      .87  .3846     -.03086     .08007
    DIM2|    -.03455         .02997    -1.15  .2490     -.09330     .02420
    DIM3|    -.51008***      .07144    -7.14  .0000     -.65010    -.37006
    DIM4|    -.24611***      .06672    -3.69  .0002     -.37689    -.11534
    DIM5|    -.58575***      .17377    -3.37  .0007     -.92633    -.24518
    DIM6|     .60689         .44149     1.37  .1692     -.25841    1.47219
    DIM7|    -.98901***      .19466    -5.08  .0000    -1.37054    -.60748
--------+--------------------------------------------------------------------
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Nov 20, 2022 at 07:13:09 PM
-----------------------------------------------------------------------------

Iterative procedure has converged
Normal exit:  82 iterations. Status=0, F=    .8633680D+03

-----------------------------------------------------------------------------
Random Parameters Multinom. Logit Model
Dependent variable                 CHOICE
Log likelihood function       -863.36801
Restricted log likelihood    -1230.44576
Chi squared [ 68](P= .000)     734.15551
Significance level                .00000
McFadden Pseudo R-squared       .2983291
Estimation based on N =   1120, K =  68
Inf.Cr.AIC  =   1862.7 AIC/N =    1.663
---------------------------------------
            Log likelihood R-sqrd R2Adj
```

```
No coefficients -1230.4458  .2983 .2764
Constants only  -1181.0605  .2690 .2461
At start values -1071.4065  .1942 .1689
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
---------------------------------------
Response data are given as ind. choices
Replications for simulated probs. =1000
Used Halton sequences in simulations.
RPL model with panel has     140 groups
Fixed number of obsrvs./group=        8
Robust Covariance Matrix,  VC = <H>G<H>.
Number of obs.=  1120, skipped    0 obs
```

CHOICE	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval	
	Random parameters in utility functions					
CONSTANT	.76149	.93075	.82	.4133	-1.06274	2.58573
DIM1	.26156	.22451	1.17	.2440	-.17847	.70158
DIM2	-.54227**	.25613	-2.12	.0342	-1.04428	-.04026
DIM3	-1.97262***	.68842	-2.87	.0042	-3.32190	-.62334
	Nonrandom parameters in utility functions					
DIM4	-.39794***	.08633	-4.61	.0000	-.56714	-.22874
DIM5	-.92883***	.27418	-3.39	.0007	-1.46622	-.39144
DIM6	1.34910**	.65204	2.07	.0385	.07113	2.62707
DIM7	-1.42370***	.24664	-5.77	.0000	-1.90712	-.94029
	Heterogeneity in mean, Parameter:Variable					
CONS:GF	.79970	.56244	1.42	.1551	-.30267	1.90207
CONS:X3	-4.04649***	1.13978	-3.55	.0004	-6.28042	-1.81257
CONS:X4	-1.52363	1.00519	-1.52	.1296	-3.49376	.44650
CONS:X5	-1.58480	1.04494	-1.52	.1294	-3.63284	.46325
CONS:X6	-.35949	1.00842	-.36	.7215	-2.33595	1.61697
CONS:E3	-.90106	1.69167	-.53	.5943	-4.21667	2.41455
CONS:E4	-1.96495**	.80526	-2.44	.0147	-3.54322	-.38667
CONS:E5	-2.91736***	.82980	-3.52	.0004	-4.54373	-1.29099
CONS:I3	-.19347	.73851	-.26	.7933	-1.64091	1.25398
CONS:I4	.93134	.80322	1.16	.2462	-.64294	2.50561
CONS:T2	-1.20247	.87892	-1.37	.1713	-2.92512	.52018
CONS:T3	.42346	.69645	.61	.5432	-.94156	1.78848
CONS:T4	1.26194*	.72902	1.73	.0835	-.16691	2.69078
CONS:T5	-3.00378*	1.80520	-1.66	.0961	-6.54191	.53435
DIM1:GF	-.13228	.13322	-.99	.3207	-.39338	.12882
DIM1:X3	-.38879*	.20858	-1.86	.0623	-.79759	.02002
DIM1:X4	-.02489	.19996	-.12	.9009	-.41681	.36702
DIM1:X5	.05418	.21087	.26	.7972	-.35911	.46747
DIM1:X6	-.46275*	.26965	-1.72	.0861	-.99126	.06576
DIM1:E3	.11161	.37585	.30	.7665	-.62504	.84827
DIM1:E4	-.02241	.20595	-.11	.9133	-.42607	.38124
DIM1:E5	.04817	.20471	.24	.8140	-.35305	.44939
DIM1:I3	-.10249	.14653	-.70	.4843	-.38969	.18470
DIM1:I4	-.12710	.17920	-.71	.4782	-.47833	.22413
DIM1:T2	-.06098	.19020	-.32	.7485	-.43377	.31181
DIM1:T3	-.16838	.16440	-1.02	.3057	-.49059	.15383
DIM1:T4	.26069	.21912	1.19	.2342	-.16877	.69015
DIM1:T5	.14820	.28614	.52	.6045	-.41261	.70902
DIM2:GF	.12621	.11680	1.08	.2799	-.10270	.35513
DIM2:X3	.57306**	.22388	2.56	.0105	.13426	1.01187
DIM2:X4	.37550*	.20518	1.83	.0672	-.02664	.77763
DIM2:X5	.34526	.21935	1.57	.1155	-.08465	.77517
DIM2:X6	.83519***	.25662	3.25	.0011	.33223	1.33815
DIM2:E3	-.57733	.44875	-1.29	.1983	-1.45686	.30220
DIM2:E4	.00691	.21624	.03	.9745	-.41692	.43073
DIM2:E5	-.14129	.21506	-.66	.5112	-.56280	.28022
DIM2:I3	.20035	.12487	1.60	.1086	-.04438	.44509
DIM2:I4	.23209*	.13272	1.75	.0803	-.02804	.49222

```
 DIM2:T2|     .21182         .18687     1.13  .2570     -.15444    .57808
 DIM2:T3|    -.10807         .14843     -.73  .4666     -.39898    .18284
 DIM2:T4|    -.13097         .15362     -.85  .3939     -.43206    .17012
 DIM2:T5|     .31361         .25563     1.23  .2199     -.18741    .81464
 DIM3:GF|     .29606         .29454     1.01  .3148     -.28121    .87334
 DIM3:X3|     .85954         .63128     1.36  .1733     -.37775   2.09683
 DIM3:X4|     .62527         .59655     1.05  .2946     -.54395   1.79450
 DIM3:X5|     .49091         .59271      .83  .4075     -.67077   1.65259
 DIM3:X6|    1.06581         .77799     1.37  .1707     -.45902   2.59063
 DIM3:E3|    -.40858         .88302     -.46  .6436    -2.13927   1.32212
 DIM3:E4|     .80097         .56084     1.43  .1532     -.29826   1.90020
 DIM3:E5|     .49889         .58823      .85  .3964     -.65401   1.65180
 DIM3:I3|    -.06520         .33976     -.19  .8478     -.73112    .60071
 DIM3:I4|     .04675         .41196      .11  .9096     -.76068    .85419
 DIM3:T2|     .00236         .48419      .00  .9961     -.94664    .95136
 DIM3:T3|    -.31893         .45392     -.70  .4823    -1.20860    .57075
 DIM3:T4|    -.05414         .43363     -.12  .9006     -.90404    .79576
 DIM3:T5|    -.67198         .63138    -1.06  .2872    -1.90946    .56550
        |Distns. of RPs. Std.Devs or limits of triangular....................
NsCONSTA|    2.33216***      .30304     7.70  .0000     1.73820   2.92612
  NsDIM1|     .47352***      .07600     6.23  .0000      .32457    .62247
  NsDIM2|     .35379***      .08426     4.20  .0000      .18865    .51893
  NsDIM3|    1.17831***      .18043     6.53  .0000      .82468   1.53195
--------+--------------------------------------------------------------------
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Nov 20, 2022 at 08:17:17 PM
-----------------------------------------------------------------------------
Rho² = 0.298             Rho² adj. = 0.354
```

Appendix XIV – ML model including context variables

```
|-> Nlogit
    ; Lhs = CHOICE
    ; choices=0,1,2
    ; RHS = CONSTANT, DIM1, DIM2, DIM3, DIM4, DIM5, DIM6, DIM7,
    ; RPL = GR2,GR3,GR4,
    H30,H40,
    N30,N40,
    G20,G30
    ; Fcn = CONSTANT (n), DIM1 (n), DIM2 (n), DIM3 (n)
    ; halton
    ; pts=1000
    ; pds=8
    ; robust$
Iterative procedure has converged
Normal exit:   5 iterations. Status=0, F=    .1071406D+04

-----------------------------------------------------------------------------
Start values obtained using MNL model
Dependent variable               Choice
Log likelihood function     -1071.40649
Estimation based on N =    1120, K =   8
Inf.Cr.AIC  =   2158.8 AIC/N =    1.928
---------------------------------------
            Log likelihood R-sqrd R2Adj
Constants only  -1181.0605  .0928 .0730
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
---------------------------------------
Using robust VC matrix, V = <H>*GtG<<G>
Response data are given as ind. choices
Number of obs.=  1120, skipped    0 obs
```

CHOICE	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval	
CONSTANT	-1.02085***	.09370	-10.90	.0000	-1.20449	-.83720
DIM1	.02461	.02830	.87	.3846	-.03086	.08007
DIM2	-.03455	.02997	-1.15	.2490	-.09330	.02420
DIM3	-.51008***	.07144	-7.14	.0000	-.65010	-.37006
DIM4	-.24611***	.06672	-3.69	.0002	-.37689	-.11534
DIM5	-.58575***	.17377	-3.37	.0007	-.92633	-.24518
DIM6	.60689	.44149	1.37	.1692	-.25841	1.47219
DIM7	-.98901***	.19466	-5.08	.0000	-1.37054	-.60748

```
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Nov 22, 2022 at 02:03:54 PM
-----------------------------------------------------------------------------

Iterative procedure has converged
Normal exit:  70 iterations. Status=0, F=    .8920643D+03

-----------------------------------------------------------------------------
Random Parameters Multinom. Logit Model
Dependent variable               CHOICE
Log likelihood function      -892.06432
Restricted log likelihood   -1230.44576
Chi squared [ 48](P= .000)    676.76290
Significance level               .00000
McFadden Pseudo R-squared      .2750072
Estimation based on N =    1120, K =  48
Inf.Cr.AIC  =   1880.1 AIC/N =    1.679
---------------------------------------
            Log likelihood R-sqrd R2Adj
No coefficients -1230.4458  .2750 .2591
```

```
Constants only  -1181.0605  .2447 .2282
At start values -1071.4065  .1674 .1492
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
---------------------------------------
Response data are given as ind. choices
Replications for simulated probs. =1000
Used Halton sequences in simulations.
RPL model with panel has     140 groups
Fixed number of obsrvs./group=        8
Robust Covariance Matrix,  VC = <H>G<H>.
Number of obs.=  1120, skipped    0 obs
```

CHOICE	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval	
	Random parameters in utility functions					
CONSTANT	-1.30865	1.41005	-.93	.3534	-4.07230	1.45500
DIM1	-.32163	.52412	-.61	.5394	-1.34888	.70562
DIM2	-.02452	.43314	-.06	.9549	-.87346	.82443
DIM3	.62338	.58057	1.07	.2829	-.51451	1.76127
	Nonrandom parameters in utility functions					
DIM4	-.40332***	.08697	-4.64	.0000	-.57378	-.23287
DIM5	-.87973***	.27722	-3.17	.0015	-1.42307	-.33639
DIM6	1.36561**	.63164	2.16	.0306	.12761	2.60361
DIM7	-1.42316***	.24438	-5.82	.0000	-1.90213	-.94419
	Heterogeneity in mean, Parameter:Variable					
CONS:GR2	-2.29190*	1.29070	-1.78	.0758	-4.82162	.23782
CONS:GR3	-.71449	1.27524	-.56	.5753	-3.21393	1.78494
CONS:GR4	-1.38523	1.25367	-1.10	.2692	-3.84238	1.07192
CONS:H30	-.01507	.69191	-.02	.9826	-1.37119	1.34105
CONS:H40	.20572	.78920	.26	.7943	-1.34108	1.75251
CONS:N30	.46374	.84145	.55	.5816	-1.18548	2.11296
CONS:N40	.51523	.67288	.77	.4439	-.80360	1.83406
CONS:G20	-.22298	.66481	-.34	.7373	-1.52599	1.08003
CONS:G30	-1.56268	1.15770	-1.35	.1771	-3.83174	.70637
DIM1:GR2	.52248	.49607	1.05	.2922	-.44981	1.49477
DIM1:GR3	.51843	.50224	1.03	.3020	-.46595	1.50281
DIM1:GR4	.29547	.50202	.59	.5562	-.68847	1.27942
DIM1:H30	-.07855	.14400	-.55	.5854	-.36079	.20368
DIM1:H40	-.26350	.19027	-1.38	.1661	-.63642	.10942
DIM1:N30	-.10929	.18967	-.58	.5645	-.48104	.26247
DIM1:N40	-.03665	.17606	-.21	.8351	-.38172	.30842
DIM1:G20	.14248	.14677	.97	.3316	-.14518	.43014
DIM1:G30	-.01724	.26158	-.07	.9474	-.52994	.49545
DIM2:GR2	-.08454	.42186	-.20	.8412	-.91138	.74230
DIM2:GR3	.09634	.42927	.22	.8224	-.74501	.93769
DIM2:GR4	.05168	.41599	.12	.9011	-.76365	.86700
DIM2:H30	-.15224	.13649	-1.12	.2647	-.41976	.11528
DIM2:H40	.02071	.17421	.12	.9054	-.32074	.36216
DIM2:N30	.12870	.16667	.77	.4400	-.19796	.45536
DIM2:N40	.03624	.14963	.24	.8086	-.25704	.32951
DIM2:G20	-.05694	.12774	-.45	.6558	-.30730	.19343
DIM2:G30	.15924	.23645	.67	.5006	-.30419	.62267
DIM3:GR2	-1.91969***	.49764	-3.86	.0001	-2.89505	-.94433
DIM3:GR3	-1.84931***	.49022	-3.77	.0002	-2.81013	-.88850
DIM3:GR4	-1.31122***	.46123	-2.84	.0045	-2.21521	-.40722
DIM3:H30	-.42029	.31791	-1.32	.1862	-1.04339	.20281
DIM3:H40	.29394	.42956	.68	.4938	-.54799	1.13587
DIM3:N30	.53569	.40752	1.31	.1887	-.26302	1.33441
DIM3:N40	-.03506	.36534	-.10	.9235	-.75111	.68098
DIM3:G20	.17831	.31322	.57	.5692	-.43558	.79221
DIM3:G30	.51506	.54562	.94	.3452	-.55435	1.58446
	Distns. of RPs. Std.Devs or limits of triangular					
NsCONSTA	2.75379***	.34221	8.05	.0000	2.08307	3.42452
NsDIM1	.51217***	.08122	6.31	.0000	.35299	.67135

```
  NsDIM2|     .44020***      .08754     5.03  .0000      .26863    .61177
  NsDIM3|    1.08108***      .16553     6.53  .0000      .75665   1.40552
--------+--------------------------------------------------------------------
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Nov 22, 2022 at 03:04:06 PM
-----------------------------------------------------------------------------
```

Appendix XV – ML model including statements; attitude, social norm & perceived behavioural control

```
|-> Nlogit
    ; Lhs = CHOICE
    ; choices=0,1,2
    ; RHS = CONSTANT, DIM1, DIM2, DIM3, DIM4, DIM5, DIM6, DIM7,
    ; RPL = A4C,A5C,
    A3G,A4G,
    S2N,S3N,
    P3BC,P4BC
    ; Fcn = CONSTANT (n), DIM1 (n), DIM2 (n), DIM3 (n)
    ; halton
    ; pts=1000
    ; pds=8
    ; robust$
Iterative procedure has converged
Normal exit:   5 iterations. Status=0, F=    .1071406D+04

-----------------------------------------------------------------------------
Start values obtained using MNL model
Dependent variable                Choice
Log likelihood function     -1071.40649
Estimation based on N =   1120, K =   8
Inf.Cr.AIC  =   2158.8 AIC/N =    1.928
---------------------------------------
            Log likelihood R-sqrd R2Adj
Constants only  -1181.0605  .0928 .0747
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
---------------------------------------
Using robust VC matrix, V = <H>*GtG<<G>
Response data are given as ind. choices
Number of obs.=  1120, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
CONSTANT|   -1.02085***      .09370   -10.90  .0000    -1.20449   -.83720
    DIM1|     .02461         .02830      .87  .3846     -.03086    .08007
    DIM2|    -.03455         .02997    -1.15  .2490     -.09330    .02420
    DIM3|    -.51008***      .07144    -7.14  .0000     -.65010   -.37006
    DIM4|    -.24611***      .06672    -3.69  .0002     -.37689   -.11534
    DIM5|    -.58575***      .17377    -3.37  .0007     -.92633   -.24518
    DIM6|     .60689         .44149     1.37  .1692     -.25841   1.47219
    DIM7|    -.98901***      .19466    -5.08  .0000    -1.37054   -.60748
--------+--------------------------------------------------------------------
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Nov 20, 2022 at 09:37:07 PM
-----------------------------------------------------------------------------

Iterative procedure has converged
Normal exit:  65 iterations. Status=0, F=    .8935386D+03

-----------------------------------------------------------------------------
Random Parameters Multinom. Logit Model
Dependent variable                CHOICE
Log likelihood function      -893.53861
Restricted log likelihood   -1230.44576
Chi squared [ 44](P= .000)    673.81431
Significance level               .00000
McFadden Pseudo R-squared      .2738090
Estimation based on N =   1120, K =  44
Inf.Cr.AIC  =   1875.1 AIC/N =    1.674
---------------------------------------
            Log likelihood R-sqrd R2Adj
```

```
No coefficients -1230.4458  .2738 .2593
Constants only  -1181.0605  .2434 .2283
At start values -1071.4065  .1660 .1493
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
---------------------------------------
Response data are given as ind. choices
Replications for simulated probs. =1000
Used Halton sequences in simulations.
RPL model with panel has     140 groups
Fixed number of obsrvs./group=        8
Robust Covariance Matrix,  VC = <H>G<H>.
Number of obs.=  1120, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
        |Random parameters in utility functions..............................
CONSTANT|   -1.82864***      .68462    -2.67  .0076    -3.17047   -.48681
    DIM1|     .54912*        .28143     1.95  .0510     -.00248   1.10071
    DIM2|    -.00789         .26063     -.03  .9759     -.51871    .50293
    DIM3|   -1.37708*        .71550    -1.92  .0543    -2.77944    .02528
        |Nonrandom parameters in utility functions...........................
    DIM4|    -.40039***      .08624    -4.64  .0000     -.56941   -.23137
    DIM5|    -.87645***      .26926    -3.26  .0011    -1.40419   -.34871
    DIM6|    1.37493**       .63001     2.18  .0291      .14013   2.60973
    DIM7|   -1.44339***      .24864    -5.81  .0000    -1.93072   -.95606
        |Heterogeneity in mean, Parameter:Variable...........................
CONS:A4C|     .06618         .87817      .08  .9399    -1.65501   1.78737
CONS:A5C|    -.45495         .97577     -.47  .6410    -2.36743   1.45754
CONS:A3G|     .00809         .80910      .01  .9920    -1.57772   1.59390
CONS:A4G|   -1.59700        1.00206    -1.59  .1110    -3.56100    .36699
CONS:S2N|     .25496         .66494      .38  .7014    -1.04830   1.55822
CONS:S3N|    1.60393        1.20049     1.34  .1815     -.74898   3.95683
CONS:P3B|    -.43614         .75166     -.58  .5618    -1.90937   1.03708
CONS:P4B|    -.84163        1.00083     -.84  .4004    -2.80322   1.11995
DIM1:A4C|    -.15085         .22194     -.68  .4967     -.58585    .28414
DIM1:A5C|    -.09334         .22569     -.41  .6792     -.53569    .34902
DIM1:A3G|    -.25658         .19352    -1.33  .1849     -.63588    .12272
DIM1:A4G|    -.48741**       .22423    -2.17  .0297     -.92689   -.04794
DIM1:S2N|     .09827         .13297      .74  .4599     -.16235    .35890
DIM1:S3N|     .10163         .32624      .31  .7554     -.53779    .74105
DIM1:P3B|    -.14874         .18586     -.80  .4236     -.51303    .21555
DIM1:P4B|    -.23323         .21822    -1.07  .2852     -.66094    .19448
DIM2:A4C|    -.29868         .25151    -1.19  .2350     -.79164    .19427
DIM2:A5C|    -.23755         .24086     -.99  .3240     -.70962    .23453
DIM2:A3G|     .29949         .20012     1.50  .1345     -.09273    .69171
DIM2:A4G|     .34955*        .20035     1.74  .0810     -.04312    .74223
DIM2:S2N|    -.07836         .12564     -.62  .5329     -.32461    .16789
DIM2:S3N|     .03141         .27748      .11  .9099     -.51243    .57525
DIM2:P3B|     .01530         .17379      .09  .9298     -.32532    .35593
DIM2:P4B|    -.18581         .22006     -.84  .3985     -.61711    .24550
DIM3:A4C|     .32477         .61170      .53  .5955     -.87414   1.52368
DIM3:A5C|     .14951         .61434      .24  .8077    -1.05457   1.35359
DIM3:A3G|     .05362         .48902      .11  .9127     -.90484   1.01207
DIM3:A4G|    -.03095         .56728     -.05  .9565    -1.14280   1.08091
DIM3:S2N|    -.42450         .32864    -1.29  .1965    -1.06863    .21962
DIM3:S3N|   -1.10565         .77356    -1.43  .1529    -2.62180    .41050
DIM3:P3B|     .60617         .42489     1.43  .1537     -.22660   1.43894
DIM3:P4B|     .62540         .53983     1.16  .2467     -.43264   1.68344
        |Distns. of RPs. Std.Devs or limits of triangular....................
NsCONSTA|    2.62290***      .29812     8.80  .0000     2.03859   3.20721
  NsDIM1|     .50401***      .08075     6.24  .0000      .34574    .66227
  NsDIM2|     .43949***      .07923     5.55  .0000      .28420    .59478
  NsDIM3|    1.21892***      .19377     6.29  .0000      .83914   1.59870
--------+--------------------------------------------------------------------
```

```
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Nov 20, 2022 at 10:13:48 PM
-----------------------------------------------------------------------------
Rho² = 0.274        Rho² adj. = 0.310
```

Appendix XVI – ML model including socio-demographics, context variables and statements

```
|-> Nlogit
    ; lhs = CHOICE
    ; choices =0,1,2
    ; RHS = CONSTANT, DIM1, DIM2, DIM3, DIM4, DIM5, DIM6, DIM7,
    ; RPL = X3, X6, E4, E5, GR2, GR3, GR4, A4G
    ; Fcn = CONSTANT (n), DIM1 (n),DIM2 (n), DIM3 (n)
    ; halton
    ; pts=1000
    ; pds=8
    ; robust$
Iterative procedure has converged
Normal exit:   5 iterations. Status=0, F=    .1071406D+04

-----------------------------------------------------------------------------
Start values obtained using MNL model
Dependent variable               Choice
Log likelihood function     -1071.40649
Estimation based on N =   1120, K =   8
Inf.Cr.AIC  =   2158.8 AIC/N =    1.928
---------------------------------------
            Log likelihood R-sqrd R2Adj
Constants only  -1181.0605  .0928 .0747
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
---------------------------------------
Using robust VC matrix, V = <H>*GtG<<G>
Response data are given as ind. choices
Number of obs.=  1120, skipped    0 obs
```

CHOICE	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval	
CONSTANT	-1.02085***	.09370	-10.90	.0000	-1.20449	-.83720
DIM1	.02461	.02830	.87	.3846	-.03086	.08007
DIM2	-.03455	.02997	-1.15	.2490	-.09330	.02420
DIM3	-.51008***	.07144	-7.14	.0000	-.65010	-.37006
DIM4	-.24611***	.06672	-3.69	.0002	-.37689	-.11534
DIM5	-.58575***	.17377	-3.37	.0007	-.92633	-.24518
DIM6	.60689	.44149	1.37	.1692	-.25841	1.47219
DIM7	-.98901***	.19466	-5.08	.0000	-1.37054	-.60748

```
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Nov 22, 2022 at 03:07:01 PM
-----------------------------------------------------------------------------

Iterative procedure has converged
Normal exit:  63 iterations. Status=0, F=    .8697541D+03

-----------------------------------------------------------------------------
Random Parameters Multinom. Logit Model
Dependent variable               CHOICE
Log likelihood function      -869.75410
Restricted log likelihood   -1230.44576
Chi squared [ 44](P= .000)    721.38332
Significance level               .00000
McFadden Pseudo R-squared      .2931390
Estimation based on N =   1120, K =  44
Inf.Cr.AIC  =   1827.5 AIC/N =    1.632
---------------------------------------
            Log likelihood R-sqrd R2Adj
No coefficients -1230.4458  .2931 .2790
Constants only  -1181.0605  .2636 .2488
At start values -1071.4065  .1882 .1719
```

Note: R-sqrd = 1 - logL/Logl(constants)
Warning: Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.

Response data are given as ind. choices
Replications for simulated probs. =1000
Used Halton sequences in simulations.
RPL model with panel has 140 groups
Fixed number of obsrvs./group= 8
Robust Covariance Matrix, VC = <H>G<H>.
Number of obs.= 1120, skipped 0 obs

CHOICE	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval	
	Random parameters in utility functions.............................					
CONSTANT	1.14255	1.61444	.71	.4791	-2.02169	4.30679
DIM1	-.35405	.47793	-.74	.4588	-1.29078	.58268
DIM2	-.25004	.43715	-.57	.5673	-1.10684	.60676
DIM3	.06674	.72338	.09	.9265	-1.35106	1.48454
	Nonrandom parameters in utility functions..........................					
DIM4	-.40548***	.08679	-4.67	.0000	-.57559	-.23537
DIM5	-.88996***	.27419	-3.25	.0012	-1.42736	-.35257
DIM6	1.35569**	.62854	2.16	.0310	.12378	2.58760
DIM7	-1.42335***	.24560	-5.80	.0000	-1.90473	-.94198
	Heterogeneity in mean, Parameter:Variable..........................					
CONS:X3	-2.49891***	.90382	-2.76	.0057	-4.27036	-.72745
CONS:X6	.06439	.81246	.08	.9368	-1.52799	1.65677
CONS:E4	-1.24924	.77776	-1.61	.1082	-2.77361	.27514
CONS:E5	-2.22938***	.79610	-2.80	.0051	-3.78971	-.66906
CONS:GR2	-2.10024	1.58330	-1.33	.1847	-5.20346	1.00298
CONS:GR3	-.59302	1.56470	-.38	.7047	-3.65978	2.47375
CONS:GR4	-1.59035	1.52222	-1.04	.2961	-4.57385	1.39315
CONS:A4G	-1.54038	.94647	-1.63	.1036	-3.39542	.31466
DIM1:X3	-.42332***	.15706	-2.70	.0070	-.73116	-.11548
DIM1:X6	-.59023**	.24047	-2.45	.0141	-1.06155	-.11891
DIM1:E4	.05632	.18995	.30	.7669	-.31597	.42861
DIM1:E5	.04351	.18552	.23	.8146	-.32009	.40712
DIM1:GR2	.73339	.45386	1.62	.1061	-.15616	1.62294
DIM1:GR3	.71428	.46307	1.54	.1230	-.19333	1.62188
DIM1:GR4	.42620	.45444	.94	.3483	-.46449	1.31688
DIM1:A4G	-.29027**	.13697	-2.12	.0341	-.55872	-.02182
DIM2:X3	.26064	.16230	1.61	.1083	-.05746	.57874
DIM2:X6	.51329***	.18051	2.84	.0045	.15951	.86708
DIM2:E4	.25013	.19497	1.28	.1995	-.13201	.63227
DIM2:E5	.06211	.18659	.33	.7392	-.30360	.42782
DIM2:GR2	-.17062	.40421	-.42	.6730	-.96286	.62163
DIM2:GR3	.08275	.41542	.20	.8421	-.73145	.89696
DIM2:GR4	.01825	.40625	.04	.9642	-.77800	.81449
DIM2:A4G	.02594	.11947	.22	.8281	-.20822	.26010
DIM3:X3	.52424	.43040	1.22	.2232	-.31933	1.36781
DIM3:X6	.64638	.54759	1.18	.2378	-.42686	1.71963
DIM3:E4	.77643*	.46377	1.67	.0941	-.13255	1.68541
DIM3:E5	.44651	.46309	.96	.3349	-.46113	1.35414
DIM3:GR2	-1.84257***	.68005	-2.71	.0067	-3.17544	-.50970
DIM3:GR3	-1.72824**	.69443	-2.49	.0128	-3.08930	-.36717
DIM3:GR4	-1.27823**	.63787	-2.00	.0451	-2.52844	-.02802
DIM3:A4G	-.13615	.35445	-.38	.7009	-.83086	.55856
	Distns. of RPs. Std.Devs or limits of triangular...................					
NsCONSTA	2.32005***	.29578	7.84	.0000	1.74034	2.89976
NsDIM1	.46905***	.08050	5.83	.0000	.31128	.62683
NsDIM2	.40365***	.08478	4.76	.0000	.23749	.56981
NsDIM3	1.15948***	.18147	6.39	.0000	.80381	1.51514

***, **, * ==> Significance at 1%, 5%, 10% level.
Model was estimated on Nov 22, 2022 at 03:56:09 PM