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Master's Thesis - master Energy Science

Naturally, Gas Free: Using Socio-Demographic Data to Optimize Civic-Engagement in the Dutch Heat Transition

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Abstract

The Dutch National Climate Agreement requires a 49% emission reduction in 2030 compared to 1990 levels. To achieve this target, the Dutch built sector must achieve a 3.4Mt emission reduction by making 1.5 million buildings natural gas-free and well-insulated. A major bottleneck in this transition is the limited cooperation of building occupants. Getting occupants involved in the heat transition is challenging due to the diversity of preferences and capabilities they possess with regard to the heat transition. The aim of this research was thus to determine whether socio-demographic characteristics of occupants can help predict an effective role division between the municipality and its residents in the heat transition.

First, the research aimed to identify how socio-demographic characteristics of residents influence the level of ambition and responsibility that residents are willing and able to take on. Based on a review of literature, hypotheses were developed regarding the relationship between residents' socio-demographic characteristics and their preferences. The choice of relevant preferences and capabilities was based on an existing framework by Ebskamp and Verbraak (2019), who developed a set of considerations based on which the level of ambition and distribution of responsibilities within the heat transition can be defined. To test the hypotheses, logistic regressions were performed on relevant data from the LISS (Longitudinal Internet Studies for the Social sciences) panel administered by CentERdata (Tilburg University, The Netherlands). The resulting explanatory model indicates that certain socio-demographic characteristics are significantly associated with residents' perceptions and capabilities with regard to the heat transition. Accordingly, socio-demographic characteristics can influence the level of ambition and responsibility that residents are willing and able to take on.

Next, the research aimed to identify whether socio-demographic characteristics can be used to predict an effective ambition level and responsibility distribution. Again, logistic regressions were used to test the relationship between respondents' socio-demographic characteristics and their preferences and capabilities with regard to the heat transition. These models were optimized for predictive purposes. Based on measures of calibration, discrimination and cross-validation it was concluded that the models have insufficient predictive power to predict a municipal strategic role based on socio-demographic characteristics of residents.

Given the failure of the predictive model, recommendations were made based entirely on the explanatory model. Municipalities were recommended to consider how the spatial distribution of socio-demographic characteristics between districts may impact the preferences and capabilities of residents. Given that the distribution of socio-demographic characteristics, and thus the preferences and capabilities of residents, generally varies between districts, municipalities can consider altering their strategic role accordingly.

Contents

1 Preface

While obtaining my Bachelor of Science at the University College of Maastricht, I developed a keen interest in sustainable energy. I was determined to deepen my knowledge on this subject and applied to the master's program in Energy Science here at Utrecht University. I was pleasantly surprised to find that the master's program was very data-oriented. I quickly realized that data-driven research on sustainability and energy was something I could envision myself doing full-time. When Arthur Vankan, a partner and senior advisor at the research and consultancy firm Dialogic, gave a guest lecture about the endless uses of data, I was curious to find out whether Dialogic could help me realize this vision.

At the first meeting with Dialogic, I explained that I was interested in developing a data-driven solution to an issue pertaining to energy or sustainability. A topic that instantly sparked enthusiasm among both parties was the Dutch heat transition. After a few brainstorm sessions, we concluded that it would be interesting to investigate whether socio-demographic characteristics of residents are relevant when deciding the means of citizen involvement in the heat transition. The aim of the research would be to determine whether the choice of participation strategy could be predicted based on socio-demographic characteristics.

Ultimately, it took months to finalize the research objective. It quickly became apparent that there were no existing frameworks that specify different means of citizen participation in the heat transition. Accordingly, the focus of the research was altered. Rather than focusing on means of citizen participation, a broader approach was taken to identify how municipalities can define an ambition level and role division within the heat transition depending on the preferences and capabilities of their residents. The final research objective was thus to determine whether socio-demographic characteristics can help predict an effective role division between a municipality and its residents in the heat transition.

2 Introduction

According to the 2015 Paris Climate Agreement, global warming should be limited to less than two degrees Celsius above pre-industrial levels, with a preferred limit of 1.5 degrees (United Nations Framework Convention on Climate Change 2015). The EU is a front-runner in the effort to fight climate change, with a Nationally Determined Contribution (NDC) aimed at reducing emissions by 40% in 2030 compared to 1990 levels. The Dutch National Climate Agreement requires a more ambitious reduction of 49% compared to 1990 levels (Government of the Netherlands 2019a).

To achieve the ambitious emission reduction target set by the Dutch government, sectoral decarbonization targets have been defined. In the built environment, a CO2 reduction target of 3.4Mt by 2030 requires rapid elimination of natural gas use in buildings (Government of the Netherlands 2019a). The Dutch building stock currently consists of 7 million homes and 1 million buildings that are heated by natural gas and are moderately to poorly insulated (Government of the Netherlands 2019a; Ministry of Economic Affairs and Climate 2020; Scholte et al. 2020). To achieve a 3.4Mt emission reduction by 2030, 1.5 million buildings must become natural gas-free and be adequately insulated (Ministry of Economic Affairs and Climate 2020; Scholte et al. 2020). By 2050, the entire building stock must adhere to these standards.

To attain the aforementioned standards, the heat transition requires both demand and supply side changes. On the one hand, the demand for heat must be reduced through proper insulation, while on the other hand, the emissions of the supplied heat must be reduced by using sustainable energy sources (Brouwer 2019; Lehmann 2008; Scholte et al. 2020). A major challenge in the heat transition is that each district is unique and that the built sector includes a wide range of stakeholders with different interests (X. Chen et al. 2020; Salvad, Villeneuve, and Masson 2019). Accordingly, each district requires an individual transition strategy to cope with its respective demand and supply side challenges.

While an individual strategy for each district is optimal, it also requires a significant amount of time and resources to develop. In response to this issue, research has focused on simplifying the process for municipalities by creating models that determine techno-economically optimal strategies (X. Chen et al. 2020; Salvad, Villeneuve, and Masson 2019). While these models simplify the decision making process for municipalities, a techno-economically optimal strategy is not the only requirement for success. The social system involved in creating energy efficient buildings is ignored in these models, even though it plays a large role in the success of a heat transition (X. Chen et al. 2020; Eon et al. 2019; P. Westin and Lagergren 2002).

As was mentioned previously, there are many stakeholders involved in the transition process, including the residents. Projects that do not sufficiently take residents into account are generally less successful (Programma Aardgasvrije Wijken 2020a; J. Atkinson et al. 2019). The UK, for example, has struggled to introduce energy efficient retrofitting in homes because of the strict top-down approach that often excluded occupants from the decision making process (J. Atkinson et al. 2019). It has become evident that residents are essential to consider in the decision making process, and close coordination with occupants is necessary to understand their demands and desires (J. Atkinson et al. 2019; X. Chen et al. 2020; Rezbuild 2017; Dignum et al. 2021).

Examples where citizen involvement contributed to the success of the heat transition include the low-carbon districts of Samsø in Denmark and Feldheim in Germany. Both low-carbon districts experienced high acceptance, because citizen involvement resulted in distributive and procedural justice (Mundaca, Busch, and Schwer 2018). Similarly, a retrofitting project in the district of Gårdsten in Sweden received acceptance due to the active involvement and consideration of citizens and their wishes (Femenías and Lindén 2010). Another successful Swedish example is the Ectogrid in Lund, where people were actively informed and involved in the planning of a district heat network (Ectogrid 2020; Lettenbichler and Provaggi 2019). In Móstoles, in Spain, heating systems were individualized based on the desires of citizens in order to guarantee support for the heat transition (Lettenbichler and Provaggi 2019). These projects recognized

that occupants are an integral part of the home and must be considered when planning, designing and implementing changes to a home and its energy sources (Eon et al. 2019; Mundaca, Busch, and Schwer 2018).

Examples of Dutch heat transition experiences also point to the importance of citizen involvement to promote acceptance and progress in the heat transition. The natural gas-free test-beds that were launched by the Dutch government have indicated that people understand the need for a heat transition, but that they are concerned about the affordability, comfort and fairness of the transition (Government of the Netherlands 2019a; Programma Aardgasvrije Wijken 2020a). The Program for Natural Gas-Free Districts (PAW) emphasized the need for citizen involvement in order to cope with the concerns, preferences and capabilities of residents (Ministry of Economic Affairs and Climate 2020; Dignum et al. 2021).

While citizen involvement is essential, the diversity of concerns, preferences and capabilities among residents poses a major challenge in the heat transition (Dignum et al. 2021). While some residents wish to be unburdened completely, others may wish to actively participate or completely take matters into their own hands. Meanwhile, some residents may not be capable of dealing with the organizational and financial burdens associated with the heat transition (Ebskamp and Verbraak 2019; Scholte et al. 2020; Dignum et al. 2021). Municipalities must take these preferences and capabilities into account when deciding upon the means of involving residents. The municipality may experience resistance if they announce an elaborate plan without considering residents, but may also lose support and motivation among residents if a plan is completely lacking (Dignum et al. 2021]).

Research has suggested that the socio-demographic characteristics of residents may help uncover a suitable level of citizen involvement, in the same way that techno-economic models simplify the choice between various heat transition technologies. This idea is based on the premise that residents' socio-demographic characteristics shape their preferences and capabilities in the heat transition (J. Atkinson et al. 2019; Ericsson and Svenningsson 2009; Mundaca, Busch, and Schwer 2018; Scholte et al. 2020).

This premise is based on prior experiences that have pointed out the importance of socio-demographic characteristics in the heat transition. For example, research has pointed out that socio-demographic characteristics shape a person's environmental concern, support for heat transition policy, motivation to engage in the heat transition and actual engagement in the heat transition (Scholte et al. 2020; Hornback 1974; Buttel 1979; Mohai and Twight 1987; Dietz, Stern, and Guagnano 1998; Hamilton 2011; De Witt and Schmeets 2018; Curtis, McCoy, and Aravena 2018; Ebrahimigharehbaghi et al. 2019; Prasad Koirala et al. 2018; Das, Richman, and Brown 2018; Kollmuss and Agyeman 2002). Socio-demographic characteristics have also been linked to other factors that may help define a role division in the heat transition (Government of the Netherlands 2019b; Dekker and Ridder 2020; Arends and Schmeets 2015; Uslaner 2012; Siebers, Gradus, and Grotens 2019) For example, studies have shown that trust in others and in the municipality is essential for the acceptance of strict heat transition measures by the municipality (Ebskamp and Verbraak 2019; Montalvo 2010; Government of the Netherlands 2019b; Cologna and Siegrist 2020; Abreu, Oliveira, and Lopes 2017; McCabe 2012; Christoforou 2011; Stein 2014; Letki 2008; Roumeliotou and Rontos 2009). Additionally, a sense of community contributes to the cohesion and cooperation that are required to collectively achieve heat transition targets (Mundaca, Busch, and Schwer 2018; Baldassare 1985).

The summarized literature suggests many ways in which socio-demographic characteristics can shape the preferences and capabilities of residents. If municipalities can predict the preferences and capabilities of their residents, they may be able to identify a desired level of citizen involvement among diverse residents in the community. These findings highlight the potential added value of considering socio-demographic characteristics when defining a role division between the municipality and residents.

2.1 Research Aim

The aim of this research is thus to determine whether socio-demographic characteristics can help predict an effective role division between a municipality and its residents in the heat transition. The research will specify how municipalities can adapt their strategic role in the heat transition so that the ambition level and responsibility distribution suit the preferences and capabilities of their residents. The strategic roles that are considered in this research will be addressed in the theoretical background.

To address the research aim, two separate research questions were developed:

1. How do socio-demographic characteristics of residents influence the preferred level of ambition and distribution of responsibility within the heat transition?

2. Can socio-demographic characteristics of residents be used to predict an effective strategic municipal role within the Dutch heat transition?

The first research question aims to uncover how socio-demographic characteristics of residents impact their preferences and capabilities within the heat transition. Their preferences and capabilities then determine the level of ambition that can be set by the municipality and the responsibility that residents can be given for the execution of the municipality's ambitions. This question is addressed by testing hypotheses regarding the relationship between socio-demographic characteristics and various indicators for residents' preferences and capabilities in the heat transition. These hypotheses will be defined in the theoretical background. Municipalities can use the results of the first research question to understand how the distribution of socio-demographic characteristics within their municipalities might impact the choice of strategic role in various districts.

The second question aims to determine whether the relationships that were uncovered by the first research question are strong enough for predictive purposes. This question is addressed by developing a predictive model and testing the accuracy of its predictions. If socio-demographic characteristics have sufficient predictive power, the model can be used to predict municipal strategic roles in the heat transition based on the socio-demographic makeup of municipalities.

The results of this study will determine whether it is possible to simplify the choice of municipal strategic role based upon the socio-demographic makeup of municipalities. A positive outcome could have significant implications for municipalities by reducing the number of challenges associated with citizen involvement. Though citizen involvement can never be eliminated completely, this research may help municipalities identify and suggest an effective means of citizen involvement prior to consultations with residents.

While this study focuses on citizen involvement in the Dutch heat transition, the results can potentially be applied outside of this context. If the study finds that there is value in considering socio-demographic characteristics to determine the preferences and capabilities of residents, this may have implications for other social issues that require active citizen engagement. For example, this study can be replicated to determine how municipalities can consider socio-demographic characteristics to define district level strategies to improve safety, livability or community participation. Of course, the content of these studies would be different, but the underlying assumption that socio-demographic characteristics impact the preferences and capabilities of residents would provide the foundation for such studies. Additionally, a positive outcome in this study would suggest that it can be replicated in other countries, where the heat transition tasks and the corresponding preferences and capabilities of residents vary.

This thesis will continue by specifying the theoretical background on which this research is founded. First, municipal strategic roles are defined based on existing frameworks. Second, the relevant literature on socio-demographic characteristics is summarized and hypotheses are developed. Next, the methodology will specify the approach taken to answer each research

question. This section will also describe the data that is used and the processing and analysis techniques that were applied. Next, the research results are summarized, followed by a discussion of their limitations and implications. The discussion also includes recommendations for municipalities. Finally, the paper concludes by summarizing the main findings suggesting areas for further research.

3 Theoretical Background

3.1 Municipal Strategic Roles in the Heat Transition

Multiple frameworks have defined potential strategic roles that municipalities can adhere to in the heat transition. These frameworks generally distinguish municipal roles based on the extent to which the municipality prescribes a clear vision for the heat transition and the extent to which it actively contributes to achieving that vision. These two aspects correspond to the previously mentioned ambition level and responsibility distribution that are associated with various strategic roles.

The established frameworks generally specify how municipalities can choose a suitable strategic role based on certain contextual factors. To be relevant for this research, a framework must specify how residents ought to be considered in the choice of strategic role. Without this information, it is not possible determine how socio-demographic characteristics contribute to this choice. Before describing the framework that was chosen for this research, a brief overview of existing frameworks is provided.

Alsema et al. (2020) define four strategic roles that can be adopted by municipalities during the heat transition. This study focuses specifically on the role that municipalities should take on with respect to homeowners. The roles are defined based upon a two-axis model that distinguishes between top-down and bottom-up approaches, as well as individual and collective approaches. The choice of approach is said to be dependent on the resources and capabilities of the municipality, as well as the characteristics of the neighborhood. The main considerations include the financial and organizational means that municipalities have to enforce a top-down approach and the organizational capacity that homeowners have to either individually or collectively come up with heat transition initiatives.

The four largest municipalities in the Netherlands (Amsterdam, Rotterdam, the Hague and Utrecht) collaborated with the Netherlands Organisation for applied scientific research (TNO) to define three roles that municipalities can take on based on their vision of the heat transition (Woestenburg et al. 2020). These roles can be distinguished based on the extent to which the municipality takes a top-down or bottom-up approach to the heat transition. Each role specifies the required knowledge, collaboration and decision making processes municipalities should adhere to. Municipalities must decide which role to adopt based on public interests and the ability of the municipality to fulfil each role. The authors chose to exclude the level of citizen involvement from their model based on the claim that this is sufficiently addressed in other literature.

The next framework was developed by the Argumentenfabriek, a strategic consultancy firm, that defined six potential roles that a municipality can take on in the heat transition (Ebskamp and Verbraak 2019). Again, a two-axis model is used that distinguishes municipal strategic roles based on the extent to which they are top-down or bottom-up, and the extent to which the municipality or the market is responsible for the execution of the heat transition. Aside from specifying the roles, the framework also mentions what considerations ought to be made when choosing a municipal strategic role. These considerations include the scope of the heat transition task, the political and economic playing field, the existing level of citizen participation, and the organizational capabilities of the municipalities. Combined these considerations take into account the preferences and capabilities of the municipality, market actors and residents.

This last framework by Ebskamp and Verbraak (2019) is most comprehensive in its definition of considerations that municipalities ought to make when choosing a strategic role. Moreover, it most accurately specifies how residents ought to be considered. Accordingly, this framework provides the most comprehensive foundation for this research. By isolating the considerations that address the preferences and capabilities of residents, it is possible to determine whether socio-demographic characteristics of individuals can be used to explain and predict a manageable ambition level and responsibility distribution within the heat transition.

3.2 Framework by Ebskamp and Verbraak (2019)

The framework defining strategic municipal roles by Ebskamp and Verbraak (2019) was developed in assignment of ten Dutch municipalities, who wanted to tackle strategic issues in the heat transition. The municipalities wanted to know how municipalities can define their role in the energy transition and asked the authors at the Argumentenfabriek to come up with a workable solution. Based on brainstorm sessions with the municipalities, grid operators, energy corporations, Dutch ministries, housing corporations, provinces and scientists, the framework containing six municipal roles was defined.

As was previously mentioned, the strategic municipal roles were defined based on two characteristics that were modelled on Cartesian plane. This two-axis model is shown in Figure 1. The vertical axis defines the ambition level in the heat transition, which concerns the extent to which the municipality steers towards results or leaves results open. The former requires that the municipality has a clear vision regarding the outcome of the heat transition, while the latter leaves results up to the ambition of residents and market parties (Ebskamp and Verbraak 2019). The horizontal axis defines the responsibility distribution, which determines the extent to which the municipality takes responsibility for the execution of the heat transition. On the left end of the scale, the municipality assigns the responsibility for the execution to the residents and the market, while the right end of the scale corresponds to complete execution by the municipality (Ebskamp and Verbraak 2019).

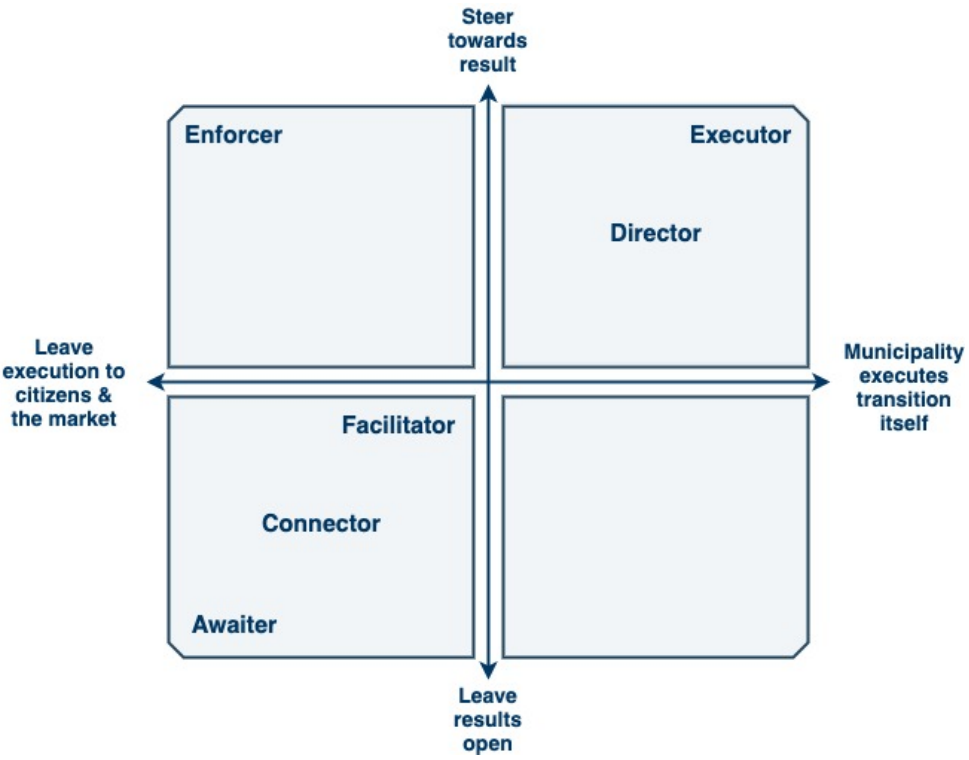

Figure 1: Municpal strategic roles defined by Ebskamp and Verbraak (2019) based on the ambition level and responsibility distribution

There are three roles in which the municipality does not actively steer towards results (Ebskamp and Verbraak 2019). When the municipality takes on the role of an 'awaiter', the municipality does not define heat transition targets nor does it contribute to the heat transition as long as innovation and market-development continues and lock-in risks remain. When the municipality acts as a 'connector', it leaves the ambition level and corresponding responsibility for the execution up to market parties, but supports their initiatives by bringing active parties together. As a 'facilitator', the municipality again leaves ambition level and the corresponding responsibility for the execution up to market parties, but supports their initiatives by removing potential barriers. This role is similar to the connector, however the municipality takes a more active role in accommodating heat transition initiatives.

The other three strategic roles require a steering role by the municipality, suggesting that it defines an ambition level and corresponding targets for the heat transition (Ebskamp and Verbraak 2019). When the municipality acts as a 'director', it steers market actors to contribute to a desired outcome by coordinating heat transition initiatives. The 'executor' has a comparable role to the 'director', but makes a more significant contribution to the heat transition initiatives. As an 'enforcer' the municipality determines the pace and outcome of the heat transition, but does not contribute to the execution. Instead, the municipality defines standards and monitors whether residents and the market adhere to them. If the municipality so desires, 'enforcers' can also have the ambition to prevent the heat transition. In this case, the municipality is not involved in the heat transition and can even actively obstruct it.

The characteristics of each role in terms of results and the division of responsibilities and tasks are summarized in Table 1. It is important to note that the table refers to the responsibility distribution among all relevant stakeholders, while this study will only focus on responsibilities of the municipality and residents.

As was previously mentioned, the reason that the framework by Ebskamp and Verbraak (2019) is valuable for this study is that it defines a set of considerations on which municipalities can choose their strategic role. These considerations are designed to emphasize the advantages and disadvantages of various strategic municipal roles under different circumstances. This allows municipalities to make an informed choice of strategic role depending on the context in which the heat transition occurs.

Figure 2 shows the inhabitant-specific considerations that Ebskamp and Verbraak (2019) define. The complete set of considerations, pertaining also to the preferences and capabilities of the municipality and other stakeholders, can be found in Appendix 10.1. Though all considerations are relevant when choosing a strategic role, only the considerations pertaining to residents are of interest to this study. These considerations include the extent to which residents support (1) the heat transition and (2) the municipality, (3) the extent to which residents can contribute financially and organizationally, (4) the extent to which residents have a shared vision of the heat transition, (5) the extent to which residents have previously participated in the heat transition and (6) the extent to which they are motivated to contribute in the future.

The first and second inhabitant-specific consideration respectively concern the general public support for the heat transition and the municipality. If support for either is lacking among residents, it is not wise for the government to take a strict and ambitious stance in the heat transition, because social acceptance will likely be compromised. Support for the heat transition and the municipality thus influence the choice of ambition level in the heat transition. If support is lacking, the municipality may wish to take on the role of 'connector', 'facilitator' or 'awaiter' to improve support.

Table 1: Summary of municipal roles and the corresponding heat transition result and task division (derived from Ebskamp and Verbraak, 2019)

Role	Ambition Level	Responsibility Distribution
Awaiter	The municipality does not define heat transition targets and relies on market development and citizen initiatives.	Citizens and companies are entirely responsible for the realization and execution of their own ambitions and initiatives.
Connector	The municipality does not define targets, but expects that collaboration between market parties will result in heat transition initiatives.	Citizens and companies are responsible for the execution of their own plans. The municipality brings parties together to encourage initiatives.
Facilitator	The municipality does not define targets, but expects that the market will take heat transition initiatives if barriers to these initiatives are removed.	Citizens and companies are responsible for the execution of their initiatives. The municipality removes barriers towards these initiatives, for example through a supportive policy environment.
Director	The municipality has a certain ambition for the heat transition and wants all parties to contribute to this outcome.	The municipality is involved in the execution by coordinating activities and supporting the contributions of citizens and companies.
Executor	The municipality has a certain ambition for the heat transition and is largely responsible for attaining the desired outcome.	The municipality executes a significant portion of the transition activities and coordinates the remaining activities.
Positive Enforcer	The municipality has a certain ambition for the heat transition and makes the market responsible for attaining results.	Citizens and companies are responsible for the execution of the municipality's plans. The municipality only monitors progress.
Negative Enforcer	The municipality opposes heat transition ambitions	The municipality is not involved in the execution of the heat transition and potentially obstructs other parties from contributing.

The third inhabitant-specific consideration considers whether residents have the financial and organizational capabilities to take initiatives in the heat transition. In case residents cannot cover the costs of the transition, the government should take a more active role in the execution of the heat transition. If residents do have the means to finance the transition, the municipality can take on fewer responsibilities and tasks, and simply ensure that collaboration is facilitated.

Accordingly, the financial and organizational capabilities of residents influence the choice of responsibility distribution.

The fourth inhabitant-specific consideration asks whether individuals have a similar vision regarding the heat transition. A shared vision simplifies collaboration among individuals which is conducive to a less active role by the municipality. Accordingly, the presence or absence of a shared vision influences the choice of strategic role based on the corresponding responsibility distribution. If shared vision is lacking the municipality should take on the responsibility of facilitating collaboration within the community or take a more active role in the execution of the heat transition. The fifth inhabitant-specific consideration asks how motivated residents are to take initiative in the heat transition. If motivation is present, the municipality can leave the responsibility and execution of the transition up to the residents. When motivation is lacking, the municipality ought to take more responsibility for achieving their ambitions.

The final inhabitant specific consideration asks whether inhabitants have previously participated in the heat transition in terms of planning, executing or financing initiatives. If residents have participated in planning, financing or executing the heat transition, the municipality can choose any ambition level, but is not obligated to take a large responsibility towards attaining the chosen ambition level. If people are not actively participating in the heat transition based on their own initiatives, the municipality may wish to take on more responsibility.

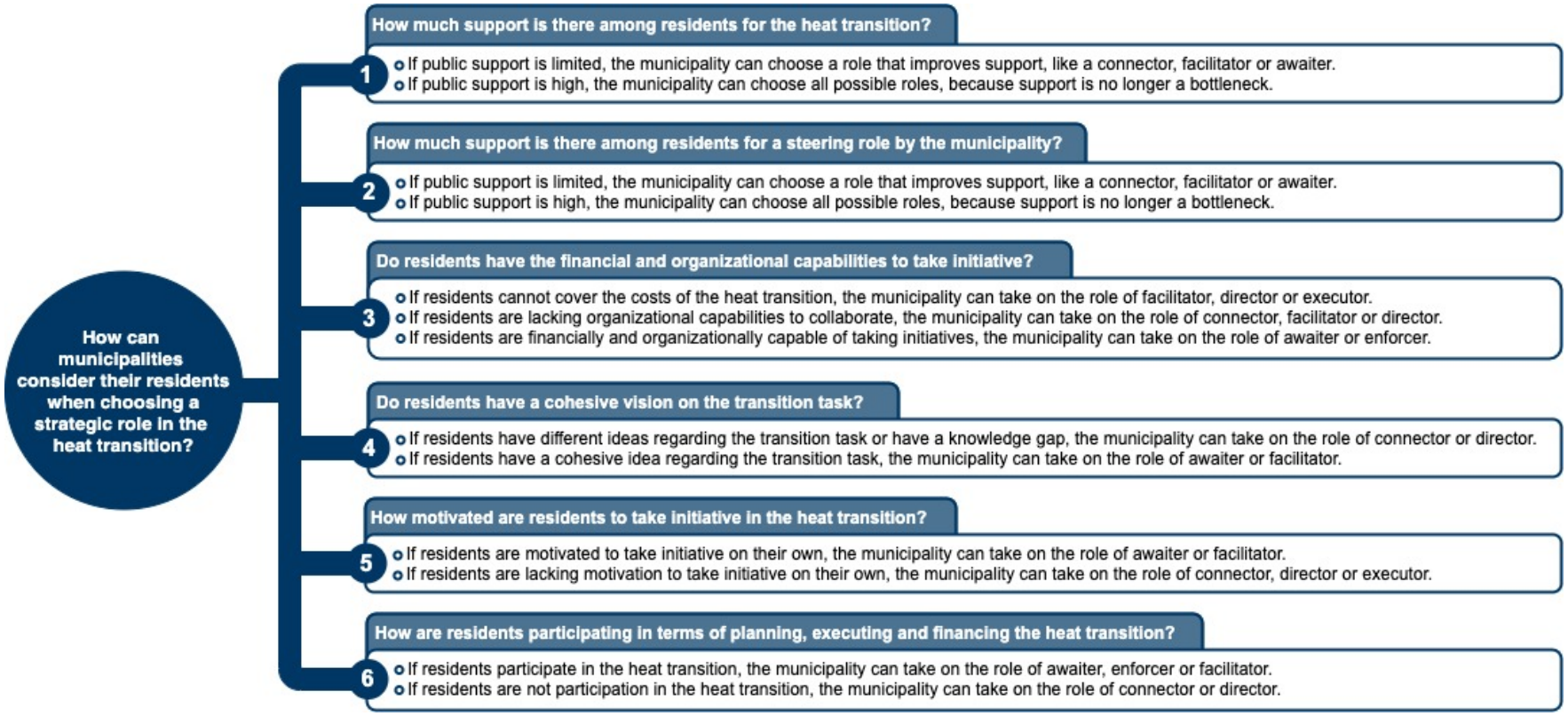

Figure 2: Summary of inhabitant-specific considerations used to choose a municipal strategic role (Ebskamp and Verbraak 2019)

3.3 The Impact of Socio-Demographic Characteristics

This section will briefly summarize previous research concerning the impact of socio-demographic characteristics on the inhabitant-specific considerations by Ebskamp and Verbraak (2019). As was mentioned in the introduction, multiple studies have investigated the role of socio-demographic characteristics in the heat transition. Age, gender, education level, income, ethnicity, household composition and urbanity have previously been related to people's motivation and ability to contribute. Based on previous findings, hypotheses will be made regarding the relationship between these socio-demographic characteristics and the inhabitant-specific considerations by Ebskamp and Verbraak (2019).

This study will also consider the impact of homeownership on the inhabitant-specific considerations, because it is expected that the greater financial and organizational burden for homeowners in the heat transition will impact their preferences (Scholte et al. 2020; International Energy Agency 2017). The difference in financial and organization burden stems from the fact that renters are not responsible for any large energy efficient renovations to their home, because this is the responsibility of the landlord. This implies that the ability of renters to contribute to the heat transition may be less relevant to municipalities than the capability of homeowners. The reason that renters are still included in this study is because the preferences of renters must also be considered when defining a municipal strategic role. In buildings with more than ten homes, landlords are only allowed to make large renovations to their property if 70% of the occupants approve. In buildings with fewer homes, all residents must agree with the proposed renovations. Accordingly, it is essential that the preferences of renters are considered in the municipality's heat transition vision in order to prevent a lack of approval among renters. The distribution of responsibility between the municipality and housing corporations is not considered in the scope of this study.

3.3.1 Support for Natural Gas-Free Policy

This section summarizes existing literature on the relationship between socio-demographic characteristics and support for natural-gas free policy, climate policy in general, and environmental concern. Environmental concern is often considered in tandem with climate policy and heat transition support because problem identification is closely correlated with support for these policies (Scholte et al. 2020; Vasseur and Kemp 2015a; Prasad Koirala et al. 2018; Scholte et al. 2020; Li et al. 2019; Michelsen and Madlener 2013). Many studies have investigated the level of environmental concern among people of various socio-demographic backgrounds and found that some socio-demographic characteristics are at least correlated with - and perhaps even have a direct impact on - environmental concern and support for climate policy.

Age

Previous research on the relationship between age and environmental concern has consistently concluded that age is negatively correlated with environmental concern (Buttel 1979; Hornback 1974; Mohai and Twight 1987; Dietz, Stern, and Guagnano 1998; Hamilton 2011). Early studies suggest that aging effects (i.e. the biological, psychological and social changes that occur as a person ages) and cohort effects (i.e. the impact of the historical and economic context in which a generation is raised) are responsible for this trend (Buttel 1979; Hornback 1974; Mohai and Twight 1987). Hornback (1974) argued that aging effects are responsible for decreased environmental concern, stating that the commitment to certain values and the accumulation of material and social resources breeds conservatism. Contrarily, Mohai and Twight (1987) claimed that cohort effects are the most likely cause for decreased environmental concern among older generations, based on literature that disproves the claim that aging necessarily leads to conservatism.

Interestingly, the Central Bureau for Statistics (CBS) found that environmental concern is con-

sistently higher among older generations in the Netherlands (De Witt and Schmeets 2018; Van Dalen and Henkens 2019). Despite these findings, younger generations are consistently more positive regarding climate and heat transition policy in the Netherlands (Dekker, Muis, et al. 2019; Dekker and Ridder 2020; Van Dalen and Henkens 2019; De Witt and Schmeets 2018; Scholte et al. 2020). The Netherlands Institute for Social Research (SCP) claims that this trend is most likely due to aging effects, because younger generations are generally more open towards strict climate policy measures (Scholte et al. 2020).

In line with previous studies on the impact of age on environmental concern and climate policy, *this study expects that there is a negative relationship between age and support for natural gas-free policy.*

Gender

Studies that investigate the impact of gender on environmental concern and policy support provide inconsistent results, though studies have more often indicated a stronger environmentalist orientation among women (Castro 2006; Dietz, Stern, and Guagnano 1998; Hamilton 2011). Gender socialization theory is one of the theories used to describe the potentially higher environmental concern among women (McCright 2010; Scholte et al. 2020). This theory suggests that men and women take on different behaviors from a young age, because women are expected to be more caring, while men are expected to be more unemotional (McCright 2010). However, inconsistencies between studies put into question the applicability of the gender socialization theory in the context of environmental concern.

In the Netherlands, the gender socialization theory is not corroborated in the context of environmental concern and policy support. Studies have indicated that men are slightly more supportive of climate spending and heat transition policy than women (Dekker and Ridder 2020). However, when looking specifically at natural gas-free policy, women were found to be more supportive than men (Scholte et al. 2020).

Despite inconsistencies, the majority of studies find a more pro-environmental stance among women. Accordingly, *this study expects that women are more supportive of natural gas-free policy than men.*

Education Level

Research consistently concludes that education level is positively correlated with environmental concern and support for climate policy (Castro 2006; Hamilton 2011; Van Dalen and Henkens 2019; De Witt and Schmeets 2018). Early studies on environmental concern have indicated that environmental concern increases due to increased problem awareness (Buttel 1979; Mohai and Twight 1987; Dietz, Stern, and Guagnano 1998). Studies in the Netherlands also find that climate and heat transition policy support increases with education level (Dekker, Muis, et al. 2019; Dekker and Ridder 2020; Scholte et al. 2020; Steenbekkers, Vermeij, and Houwelingen 2017). This effect is attributed to a greater problem perception among higher-educated individuals, which results in the belief that the climate ought to be a political priority.

In line with the findings of previous research, *this study expects that there will be a positive relationship between education level and a person's environmental concern and support for natural gas-free policy.*

Income

Research on the effect of income on environmentalism yields inconsistent results. Some research suggests that environmentalist values may increase with income based on Inglehart's post-materialist values thesis. This thesis suggests that people are able to pursue post-materialistic values when their income increases and their basic needs are met (Scholte et al. 2020; Inglehart 1981). However, only two studies were identified that find a significant relationship between income and environmental concern, suggesting there is little support for Inglehart's theory (Schultz

and Zelezny 1999; Mohai and Twight 1987; Drews and Van Den Bergh 2016). The majority of studies do not find a significant relationship between income and environmental concern (Dietz, Stern, and Guagnano 1998; Drews and Van Den Bergh 2016; Kollmuss and Agyeman 2002; Bradley et al. 2020).

In the Netherlands, the share of individuals who believe sustainable energy is required increases among higher income quantiles, however this effect is attributed to the high correlation between income and education level (De Witt and Schmeets 2018). The SCP also was unable to find a significant relationship between income and natural gas-free policy support, but found that the ability to live off of one's income impacts support (Scholte et al. 2020). The SCP argues that this effect exists because natural gas-free policy has a greater impact on a person's way of life when they struggle to live off of their income.

This study hypothesizes that income does not have a direct effect on a person's environmental concern, but that the ability to live off of one's income is positively associated with natural gas-free policy support.

Ethnic Background

There is little evidence suggesting that ethnicity plays a role in environmental concern. Some studies have suggested that culture may impact environmental concern, however to the author's knowledge, these have not been tested and verified (Schultz and Zelezny 1999; Dietz, Stern, and Guagnano 1998). Empirical research in the Netherlands has indicated that people with a non-Western migration background have higher odds of being concerned about the environment than Dutch natives and Western immigrants, though this effect was attributed to the younger average age of non-Western immigrants (De Witt and Schmeets 2018).

Based on the lack of evidence suggesting that ethnicity impacts environmental concern or climate policy support, *this study does not expect that ethnicity has a significant impact on support for natural gas-free policy.*

Household Composition

To the author's knowledge, little research has been done on the relationship between household composition and environmental concern. Dietz et al. (1998) suggest that parenthood increases environmental concern among women, while it decreases environmental concern among men. The CBS found that households with children are more likely to agree that sustainable energy is necessary than households without children, but this effect disappears when correcting for other demographics (De Witt and Schmeets 2018).

Based on the limited data available, *this study expects that household composition does not impact environmental concern or support for natural gas-free policy.*

Urbanity

Previous research on the relationship between urbanity and environmental concern consistently finds that urbanity is positively associated with environmental concern (Drews and Van Den Bergh 2016; Buttel 1979; Mohai and Twight 1987; Dietz, Stern, and Guagnano 1998). Early studies indicated that increased exposure to pollution and climate hazards in urban areas leads to increased problem awareness and thus increased environmental concern among urban residents (Buttel 1979; Mohai and Twight 1987; Dietz, Stern, and Guagnano 1998). This increase in environmental concern may also be explained by the generally younger and higher educated population in urban areas (Scholte et al. 2020; Leidelmeijer, Schulenberg, and Noordhuizen 2015). Moreover, urban residents are more likely to view nature as an attraction, while rural residents are more likely to view it as a resource, which may shape environmental concern (Scholte et al. 2020).

This study expects that increased urbanity is associated with increased environmental concern

and natural gas-free policy support.

Homeownership

Little research has been done on the relationship between homeownership and support for the heat transition. Most findings were uncovered during studies of the natural gas-free test beds in the Netherlands. These have indicated that homeowners are more concerned about the financial implications of the heat transition, because homeowners carry more responsibility for the modification of their home (Programma Aardgasvrije Wijken 2020a; Programma Aardgasvrije Wijken 2020b). While renters have less freedom to decide whether and how to participate in the heat transition, they also generally do not carry the financial and organizational burden associated with heat transition initiatives (Programma Aardgasvrije Wijken 2020b; Stotz 2019).

Based on these experiences, *this study expects that homeowners will be less supportive of natural gas-free policy than renters.*

3.3.2 Support for the Municipality

This section summarizes existing literature on the relationship between socio-demographic characteristics and support for the municipality. Support for and satisfaction with the municipality are closely correlated to a person's trust in the municipality, therefore previous research on trust in the municipality will also be considered (Montalvo 2010). Trust in the municipality is said to be shaped largely by its capabilities, its ability to act in everyone's interest, its ability to act justly, and its openness to the concerns and desires of its citizens (Coolen 2017). Additionally, representation may play a role, because those who are under-represented may not feel heard and understood (Government of the Netherlands 2019b). A range of empirical findings describing the impact of socio-demographic characteristics on municipal support and trust are further addressed.

Age

Studies investigating the impact of age on support for and trust in the municipality generally find that trust in the municipality is positively associated with age (Government of the Netherlands 2019b; Siebers, Gradus, and Grotens 2019; Montalvo 2010; Freitag and Ackermann 2016; Dekker and Ridder 2020). The Dutch government explains this effect based on the under-representation of younger generations within the municipality, which leads to dissatisfaction (Government of the Netherlands 2019b). In Dutch municipalities, the average age of those in office is 51, where the average councilor is 48 years old and the average mayor is 57 years old (Government of the Netherlands 2019b).

Given that most studies suggest a positive correlation between age an trust and that under-representation may be an issue for younger generations, *this study hypothesizes that there will be a positive relationship between age and trust in the municipality.*

Gender

Studies investigating the impact of gender on support for and trust in the municipality generally find that trust in the municipality is higher among men than women (Government of the Netherlands 2019b; Ulbig 2002; Christensen, Yamamoto, and Aoyagi 2008; Wennekers et al. 2019). Only one study did not find a significant relationship between citizens' gender and their trust in the municipality (Siebers, Gradus, and Grotens 2019). Again, studies suggest that under-representation of women may be the leading explanation for this effect, because legitimacy of the municipality is compromised if legislation does not respond to the concerns of the female population (Ulbig 2002; Schwindt-Bayer and Mishler 2005). In Dutch municipalities, 69% of councilors, 74% of aldermen and 74% of all mayors are male, suggesting that under-representation is present (Government of the Netherlands 2019b).

Given that most studies suggest that women trust the municipality less and that under-representation is an issue, *this study expects that men will be more trusting in the municipality than women.*

Education Level

There are many theories regarding the impact of education level on trust in the municipality. A materialist approach suggest that a privileged socio-economic position results in trust, while an informational approach suggests that a thorough understanding of politics can either improve or decrease trust depending on the performance of the municipality (Noordzij, Van der Waal, and De Koster 2019; Christensen, Yamamoto, and Aoyagi 2008). Another theory is that under-representation of lower-educated groups results in a status-based conflict, where lower socio-economic groups feel looked down upon (Noordzij, Van der Waal, and De Koster 2019). .

In the Netherlands, studies on people's trust in their municipality have indicated that trust increases with education level (Government of the Netherlands 2019b; Coolen 2017; Wennekers et al. 2019). Considering that 78% of councilors, 83% of aldermen and 90% of all mayors are highly educated, all three described theories may be relevant in the Netherlands (Government of the Netherlands 2019b). It is interesting to note that studies in other countries may yield different results due to different representation within and performance of their municipalities (Montalvo 2010; Christensen, Yamamoto, and Aoyagi 2008; Freitag and Ackermann 2016) In the Netherlands, only one study does not find a significant relationship between education level and trust (Siebers, Gradus, and Grotens 2019).

Given that previous studies in the Netherlands generally corroborate the explained theories, *this study expects that trust in the municipality increases with increased education level.*

Income

Considering the materialist approach that was specified by Noordzij (2019), it may be assumed that trust in the municipality increases with income. Two studies in the Netherlands found that a higher income, or the ability to make ends meet, indeed results in greater support for the municipality (Scholte et al. 2020; Wennekers et al. 2019). Another study was unable to find a significant relationship (Coolen 2017).

Despite limited empirical support for the materialist approach, *this study expects a positive relationship between income and trust in the municipality.*

Ethnic Background

Studies have found that ethnic diversity within a municipality may reduce trust due to the inability of the municipality to cater to the needs of all its residents (Baldassare 1985; Ulbig 2007). Improved representation of minorities within the municipality can result in empowerment and improved trust (Banducci, Donovan, and Karp 2004; Ulbig 2005). On a national level, 16.5% of the Dutch population consists of ethnic minorities, and 12% of parliament is made up of ethnic minorities (Van Der Zwan, Lubbers, and Eisinga 2019). The most common ethnic minorities in the Netherlands, namely those from Morocco and Turkey, are relatively well represented in the Netherlands while other ethnic minorities are under-represented. Due to the diversity in municipalities, it is difficult to determine the level of representation at the municipal level.

Assuming that under-representation remains an issue at the municipal level, *this study expects that ethnic minorities will have less trust in their municipality than native Dutch residents.*

Household Composition

To the author's knowledge, no empirical or theoretical research has been done to explain the impact of household composition on trust in the municipality. Accordingly, this study will not hypothesize regarding the impact of household composition on municipal trust.

Urbanity

Research has consistently shown that increased population size within a municipality results in lower trust (Siebers, Gradus, and Grotens 2019; Montalvo 2010; Baldassare 1985; Christensen, Yamamoto, and Aoyagi 2008). In the Netherlands, smaller rural municipalities also received more trust than larger urban municipalities (Government of the Netherlands 2019b). This increased trust is often attributed to a community feeling and increased opportunity for participation in the democratic process (Assche et al. 2007; Siebers, Gradus, and Grotens 2019).

Based on these findings, *this study expects that increased urbanity will result in lower trust in the municipality.*

Homeownership

To the author's knowledge, there are no studies investigating the impact of homeownership on trust in the municipality. Accordingly, this study will not hypothesize regarding the impact of homeownership on municipal trust.

3.3.3 Financial Capability

While the framework by Ebskamp and Verbraak (2019) explains the importance of considering residents' financial and organizational capabilities in the heat transition, this section only summarizes literature on the relationship between socio-demographic characteristics and financial capability. The reason that organizational capability is excluded from this study is because it is deemed unlikely that socio-demographic characteristics can explain the skills and expertise people have pertaining specifically to the heat transition. Meanwhile, the SCP found that a person's financial capability - the ability to live off of one's income - is an important indicator of a person's ability and willingness to contribute to the heat transition (Scholte et al. 2020).

Aside from income, research has suggested that other socio-demographic characteristics contribute to financial capability. While income is often correlated with other socio-demographic characteristics like age, education level and even gender, this study is interested in determining whether socio-demographic characteristics can shape financial capability in other ways as well, for example through changes in living expenses and other spending behavior.

Age

Studies in the Netherlands have found that people's satisfaction with their income increases with age (Dekker, Muis, et al. 2019; Dekker and Ridder 2020). Meanwhile, disposable income does not increase linearly with age. The average disposable income is the highest among 45-55 year old individuals and is almost double that of individuals over 75 years old and more than triple that of individuals under 25 years old (Arts et al. 2019). The discrepancy between a person's income and income satisfaction can perhaps be attributed to aging effects, because spending behavior adapts as a person grows older (Xiao and C. Chen 2015; Allen, Albertone, and Redpath 2018).

The youngest generation is least satisfied with their income, has the lowest disposable income and simultaneously tends to have the highest housing costs and least favorable spending behavior (Xiao and C. Chen 2015; Allen, Albertone, and Redpath 2018). One reason that satisfaction increases with age may be explained by decreased debt related behavior, because potential mortgages and debts are increasingly paid off (Xiao and C. Chen 2015). Why satisfaction keeps increasing even though disposable income generally decreases beyond the age of 55 can perhaps be explained by the trend that responsible spending behavior tends to improve beyond this age (Xiao and C. Chen 2015).

Despite the fact that satisfaction with one's income may increase with age, the SCP pointed

out that the ability to contribute to the heat transition may decrease upon retirement (Scholte et al. 2020). This stems from the fact that savings may decrease over time, thus preventing large investments. Moreover, any investments that are made may not yield a return within the remaining lifetime of older individuals.

While the ability to contribute to the heat transition may decrease beyond retirement age due to the poor financial prospects, this effect will be difficult to measure. Accordingly, *this study expects that financial capability will generally increase with age.*

Gender

No research was found to suggest that women and men differ significantly in terms of spending behavior (Taylor 2011). Of course, there is still plenty of evidence to suggest that women generally earn less than men for a variety of reasons (Arts et al. 2019; Allen, Albertone, and Redpath 2018; Wennekers et al. 2019; Galvin 2019). This would suggest that gender may impact income, but does not independently affect a person's financial capability.

Based on this knowledge, *it is hypothesized that gender does not have an independent effect on a person's ability to contribute financially to the heat transition.*

Education Level

No research was found to suggest that education level significantly impacts spending behavior. There is a wide range of evidence, however, to suggest that education level and income are closely correlated (Dekker, Muis, et al. 2019; Allen, Albertone, and Redpath 2018; Arts et al. 2019; Wennekers et al. 2019; Bahmani-Oskooee, Hegerty, and Wilmeth 2008). This suggests that education level impacts a person's income, but does not independently impact a person's financial capability.

Accordingly, *it is expected that education level does not have an independent effect on a person's ability to contribute financially to the heat transition.*

Income

It seems evident that income is the variable that most considerably shapes financial capability. Among the highest income quintile, individuals save on average 29% of their disposable income, while the lowest quintile is, on average, 20% short, suggesting that the average household in this category spends 20% more than their disposable income (Arts et al. 2019). This suggests that the share of disposable income that can be saved increases with income, which would improve a person's ability to contribute financially to the heat transition. Accordingly, *this study expects that there is a strong positive correlation between income and the ability to contribute financially to the heat transition.*

Ethnic Background

No evidence was found to suggest that there is a direct link between ethnic background and financial capability. Studies have found that individuals with a non-Western background generally have a lower income than native individuals, while people with a Western background generally earn a similar income to Dutch natives (Arts et al. 2019; Ooijervaar, Bloemendal, and Boerdam 2016; Allen, Albertone, and Redpath 2018; Olsthoorn, Koot, and Hoff 2020; Wennekers et al. 2019; Mundaca, Busch, and Schwer 2018). The difference in income can largely be explained by other socio-demographic factors, like age, education level and family composition. Additionally, discrimination results in lower response rates for job applications and lower salaries for the same work (Arts et al. 2019).

Given that ethnicity has been found to effect financial capability though income, *this study expects that ethnicity does not have an independent effect on financial capability.*

Household Composition

Research suggests that household composition has a significant impact on financial capability. Couples without children have the highest disposable income and are most satisfied with their income. Meanwhile, single parents have the lowest disposable income, are at the highest risk of poverty and are least satisfied with their income (Arts et al. 2019; Allen, Albertone, and Redpath 2018; Wennekers et al. 2019). In general, having children decreases satisfaction with one's income and increases the risk of poverty (Arts et al. 2019; Allen, Albertone, and Redpath 2018; Olsthoorn, Koot, and Hoff 2020; Wennekers et al. 2019). Having a partner increases disposable income and income satisfaction compared to, though this is only true if both partners contribute to the household income (Allen, Albertone, and Redpath 2018; Wennekers et al. 2019).

Based on these findings, *this study expects that having children generally decreases financial capability, while having a partner generally increases financial capability.*

Urbanity

No evidence has been found to suggest that urbanity impacts the ability to contribute financially to the heat transition. Some studies suggest that wealth may be concentrated in urban or rural areas, however financial capability is never mentioned as the result of living in an urban or rural area (Allen, Albertone, and Redpath 2018; Bahmani-Oskooee, Hegerty, and Wilmeth 2008).

Accordingly, *this study expects that urbanity does not impact a person's ability to contribute financially to the heat transition.*

Homeownership

Studies generally find a positive relationship between homeownership and financial capability (Oh 2004; Haurin et al. 2002; Rohe and Lindblad 2013; Stotz 2019). This is based on the fact that homes make up a significant investment and financial asset, which requires initial financial stability. Meanwhile, some studies argue that financial capability is lower among homeowners due to large financial risk involved in purchasing a home (Brounen, Cox, and Neuteboom 2012; Rohe and Lindblad 2013; Stotz 2019). These risks are associated with potentially decreasing housing prices, high maintenance costs and mortgage payments. However, Dutch rental prices are continually increasing, which means that monthly mortgage payments, which largely contribute to your own equity, are financially favorable over high rental fees.

Based on these findings, *this study expects that homeowners have a greater ability to financially contribute to the heat transition.*

3.3.4 Shared Vision

While the previous sections addressed the relationship between socio-demographic characteristics and the inhabitant-specific considerations, this section cannot directly address this relationship. This is because no research has been done on the relationship between socio-demographic characteristics and a person's heat transition vision. A person's vision is personal and can be very extensive or completely lacking, which makes it difficult, if not impossible to measure. The reason that Ebskamp and Verbraak (2019) consider this variable anyways, is because they claim that a shared vision facilitates collaboration on heat transition initiatives. Knowing that collaboration is the outcome that Ebskamp and Verbraak (2019) are interested in, this study has found an alternative proxy variable to determine the level of collaboration that residents can engage in.

Research has indicated that social trust is an important factor in the heat transition, in particular to facilitate collaboration (Abreu, Oliveira, and Lopes 2017; Prasad Koirala et al. 2018). This stems from the fact that people are more likely to contribute if others are also contribut-

ing their respective share in the heat transition (Cologna and Siegrist 2020; Koon, Chan, and Sharma 2020; Roumeliotou and Rontos 2009). A trusting environment facilitates communication, collaboration and decision making (Dinesen and Sønderskov 2012; Abreu, Oliveira, and Lopes 2017; McCabe 2012; Christoforou 2011; Stein 2014; Letki 2008; Roumeliotou and Rontos 2009). It is thus easier for a municipality to stimulate collaboration in a community where social trust is present, than in a neighborhood where social trust is lacking. Accordingly, this study will focus on social trust as means to define the collaborative abilities of respondents.

Though social trust is the broadest requirement for municipalities to facilitate collaboration on heat transition initiatives, the presence of general social trust does not provide any information regarding social dynamics within a neighborhood. While social trust is shaped by a lifetime of socialization and accumulation of knowledge and resources, the neighborhood context may also impact the ability and willingness of people to collaborate (Welch et al. 2005). Information regarding people's connection to their neighborhood provides additional insights regarding the effort that is required by municipalities to facilitate collaboration. If people feel connected to their neighborhood they become more motivated to contribute to it, and the corresponding cohesion facilitates cooperation among residents (Baldassare 1985; Mundaca, Busch, and Schwer 2018; Wentink et al. 2018; Letki 2008; Christensen, Yamamoto, and Aoyagi 2008; Assche et al. 2007; Pei 2019).

Age

Studies regarding the effect of age on social trust provide inconsistent results. The majority of studies in the Netherlands indicate that generalized social trust decreases with age (Dekker and Ridder 2020; Schmeets 2018; Arends and Schmeets 2015). However, a literature review by Roumeliotou et al. (2009) finds that most studies find a non-linear relationship between age and social trust. These studies suggest that the youngest and oldest generations are least trusting, but that social trust generally increases with age.

Considering that this study focuses on the Dutch population, *it is expected that social trust will decrease with age.*

When looking at the neighborhood level, research suggests that older generations are more connected to their neighborhood (Letki 2008; Wickes et al. 2013). People generally move less once they age and thus stay in one place longer, which may explain a greater neighborhood connection. This finding suggests that lower levels of generalized trust among older individuals may be compensated by a greater connection to the neighborhood.

This study expects that a person's connection to their neighborhood is positively associated with age.

Gender

Results regarding the impact of gender on social trust are inconsistent. The most common result in previous studies finds that women are slightly less trusting than men, which has previously been explained based on an innately higher risk aversion among women (Schmeets 2018; McCabe 2012; Roumeliotou and Rontos 2009; Arends and Schmeets 2015). A review by Roumeliotou et al. (2009) points out that multiple studies also find the opposite or no significant result. Still, Dutch studies have indicated that women tend to be less trusting (Schmeets 2018; Arends and Schmeets 2015).

In line with previous studies in the Netherlands, *this study expects that women have lower social trust than men.*

Contrary to social trust, one study found that women feel more connected to their neighborhood than men and are more willing to work together to improve the neighborhood (Wickes et al. 2013). Given that there is little evidence to support this theory, this study will not hypothesize regarding the impact of gender on a person's connection to the neighborhood

Education Level

Social trust is generally found to improve with increased education level (Schmeets 2018; McCabe 2012; Van Beuningen and Schmeets 2013; Roumeliotou and Rontos 2009; Tolsma and Gesthuizen 2009; Arends and Schmeets 2015). One study suggests that education level is the strongest indicator of social trust, because the associated economic wellness, skills and resources reduce perceived competition with others (Roumeliotou and Rontos 2009; Tolsma and Gesthuizen 2009).

Based on these findings, *this study expects that social trust increases with education level.*

When looking at the impact of education level on a person's connection to their neighborhood, the results are less concrete. While studies tend to agree that the attitude towards neighborhood cohesion improves with education level, studies generally indicate that lower educated individuals have stronger links with the neighborhood and participate more actively. (Letki 2008; Wickes et al. 2013; Tolsma and Gesthuizen 2009).

Accordingly, *this study expects that a person's connection to the neighborhood decreases with education level.*

Income

Research has indicated that there is a positive relationship between income and social trust (Roumeliotou and Rontos 2009; Tolsma and Gesthuizen 2009; Arends and Schmeets 2015; Schmeets 2018; McCabe 2012; Uslaner 2012). Higher income neighborhoods often have more spending on local public goods which foster community development and trust (Roumeliotou and Rontos 2009). Meanwhile, lower income neighborhoods often obtain less help and have a lower self-efficacy, which means little is invested in the improvement of the neighborhood and community development (Tolsma and Gesthuizen 2009). Moreover, individuals with a high income tend to move to neighborhoods that suit their preferences, while lower income groups are often bound to their neighborhood by economic necessity (Tolsma and Gesthuizen 2009).

Income inequality within neighborhoods also decreases trust, because people tend to trust in-group members at the expense of generalized trust (McCabe 2012; Uslaner 2012). For the purpose of this research, income inequality within a neighborhood is not considered as an indicator of social trust, because this is not a socio-demographic characteristic inherent to individuals.

Based on these findings, *this study expects a strong positive correlation between income and social trust.*

People's connection to their neighborhood reflects the same trend as that of social trust. Low income neighborhoods experience less connection among residents than high income neighborhoods (Laméris, Hipp, and Tolsma 2018; Letki 2008; Wickes et al. 2013; Tolsma and Gesthuizen 2009). Again, this effect can be explained by fewer investments in the community, resulting in reduced interaction opportunities.

Based on this result, *this study expects that a person's connection to the neighborhood increases with income.*

Ethnic Background

Studies that investigate the effect of ethnic background on social trust yield different results. Studies all seem to conclude that ethnicity alone does not shape social trust, but that the interaction between ethnic minorities and majorities may result in trust or tension.

Putnam's conflict theory suggests that ethnic diversity reduces cohesion and social trust, because of potentially conflicting values and economic interests (Wickes et al. 2013; Phan, Blumer, and Demaiter 2009; Havekes et al. 2014; Gorbunova, Ambrasat, and Scheve 2015; Baldassare 1985; Mundaca, Busch, and Schwer 2018). Meanwhile, Uslaner suggests that segregation reduces trust

in out-groups, while diversity within a community promotes interaction and generalized social trust (Gorbunova, Ambrasat, and Scheve 2015; Uslaner 2012).

Studies have found that ethnic heterogeneity in neighborhoods has a negative impact on generalized trust (Tolsma and Gesthuizen 2009; Havekes et al. 2014; Dinesen and Sønderskov 2012; Mundaca, Busch, and Schwer 2018). Moreover, ethnic minorities in the Netherlands were found to have lower trust than Dutch natives (Arends and Schmeets 2015; Van Beuningen and Schmeets 2013; Schmeets 2018; Den Ridder et al. 2019). The SCP explains this based on the finding that immigrants often feel segregated (Den Ridder et al. 2019).

Based on these findings, *this study also expects that social trust is lower among Western and non-Western immigrants than among Dutch natives.*

Conflict theory can also be applied to residents' neighborhood connection, suggesting that neighborhood connections are more challenging in neighborhoods with diverse ethnic backgrounds and values (Letki 2008; Xiao and C. Chen 2015; Havekes et al. 2014).

Accordingly, *a person's connection to the neighborhood is expected to be lower for immigrants than for Dutch natives.*

Household Composition

Some studies have suggested that household composition has a significant effect on social trust and connection to the neighborhood, however these effects disappear when controlling for other socio-demographic variables (Schmeets 2018; McCabe 2012; Wickes et al. 2013; Arends and Schmeets 2015). One study suggested that certain life phases might promote an improved neighborhood connection, for example that women with children may seek company of other women with children, however these specific instances are difficult to isolate (Sanders 2010).

Accordingly, *this study does not expect to find any relationship between a person's household composition and their social trust or neighborhood connection.*

Urbanity

Studies have found that a person's social trust and neighborhood connection are higher in smaller rural municipalities than in urban municipalities (Steenbekkers, Vermeij, and Houwelingen 2017; Siebers, Gradus, and Grotens 2019; Baldassare 1985; McCabe 2012; Stein 2014; Roumeliotou and Rontos 2009). The connection to the neighborhood is often higher in rural areas because people tend to stay in one place longer and are thus more dedicated to the community (Den Ridder et al. 2019). Once the size of municipality increases, it decreases the sense of community and the motivation to cooperate as a social unit (Siebers, Gradus, and Grotens 2019; Baldassare 1985; Stein 2014). The absence of a community feeling tends to decrease generalized trust, which is why social trust also tends to be lower in urban municipalities (Roumeliotou and Rontos 2009).

Based on these findings, *this study expects that social trust and people's connection to their neighborhood decrease with increased urbanity.*

Homeownership

Many studies have investigated the impact of homeownership on people's connection to their neighborhood, but few studies have investigated the impact on generalized social trust. One study found that homeownership increases trust in neighbors and improves the neighborhood connection, but that it does not impact social trust in general (McCabe 2012).

Based on the limited information available, *this study does not expect to find a significant relationship between homeownership and social trust.*

Studies generally do conclude that homeownership increases a person's connection to the neigh-

borhood (McCabe 2012; McCabe 2013; Oh 2004; Haurin et al. 2002; Rohe and Lindblad 2013; Brounen, Cox, and Neuteboom 2012; Stotz 2019; Yamamura 2011). This is based on the theory that homeownership creates residential stability, meaning that people are less likely to move and thus more likely to invest time in their social network and in their connection to the neighborhood.

Accordingly, *this study expects that homeowners likely have a greater connection to their neighborhood than renters.*

3.3.5 Motivation to Contribute to the Heat Transition

This section summarizes existing literature on the relationship between socio-demographic characteristics and the motivation to contribute to planning, financing or executing the heat transition. According to the Theory of Planned Behavior (TPB), the primary antecedent to a certain behavior is the intention to perform the behavior, which is shaped by the attitude towards the behavior, the social pressure experienced to perform the behavior, and the perceived self-efficacy to perform the behavior (Ajzen 1985; Arli et al. 2019; M.-f. Chen 2016; Kollmuss and Agyeman 2002). Based on this theory, the attitude towards a specific sustainable behavior is more important than support for pro-environmental action in general (Kollmuss and Agyeman 2002). This suggests that the motivation of citizens to contribute to planning, financing or executing the heat transition provides important insights for municipalities to determine the likelihood that individuals will actively contribute to the heat transition.

Some studies suggest that the TPB does not explain large investment decisions, like installing solar panels, isolating your home or replacing your heating system (Azizi, Nair, and Olofsson 2019). Instead, these studies suggest that the TPB can explain low-cost behaviors that result in energy savings, like closing doors and windows, turning off lights and wearing warmer clothes. This would suggest that motivation to contribute to the heat transition does not tell municipalities whether people will actually contribute. However, given that Ebskamp and Verbraak (2019) emphasize the importance of motivation when deciding the extent to which residents and the municipality execute the heat transition, this study will assume that the theory of planned behavior is applicable in this context.

Under this assumption, the summarized literature explains how socio-demographic characteristics shape to the intention to contribute to the heat transition. The literature summary focuses specifically on the intention to purchase sustainable and energy efficient technologies in and around the home. Whenever possible, the building blocks of intent, namely a person's attitude towards heat transition initiatives, their perception of social pressure and their perceived self-efficacy, will be discussed.

Age

Studies generally find that the motivation to invest in sustainable and energy efficient technologies decreases with age (Scholte et al. 2020; Haren, Huizen, and Schilder 2019; Hornback 1974; März 2018; Mortensen, Heiselberg, and Knudstrup 2014; Weiss, Dunkelberg, and Vogelpohl 2012; Bjørneboe, Svendsen, and Heller 2018; Azizi, Nair, and Olofsson 2019; Li et al. 2019). Studies argue that younger generations have a more positive attitude towards the adoption of energy efficient technologies and tend to ascribe more responsibility to themselves (Scholte et al. 2020; Haren, Huizen, and Schilder 2019). Meanwhile, older generations are less eager to invest in these technologies because of lack of capital availability, long payback times, satisfaction with their accumulated resources, risk aversion and the associated organizational burden (Bjørneboe, Svendsen, and Heller 2018; Weiss, Dunkelberg, and Vogelpohl 2012; Mortensen, Heiselberg, and Knudstrup 2014; März 2018; Hornback 1974; Haren, Huizen, and Schilder 2019).

Based on these findings, *this study expects that the motivation to contribute to the heat transition decreases with age.*

Gender

Studies investigating the effect of gender on the motivation to adopt sustainable and energy efficient technologies yield inconsistent conclusions. Some studies suggest that women have a higher willingness to make sustainable purchases due to stronger pro-environmental attitudes, but most studies do not find a significant relationship (Scholte et al. 2020; Mortensen, Heiselberg, and Knudstrup 2014; Kollmuss and Agyeman 2002; Petrovich, Hille, and Wüstenhagen 2019; Arroyo and Carrete 2019; Li et al. 2019).

Based on these findings, *this study hypothesized that there is no significant difference in motivation to contribute to the heat transition among men and women.*

Education Level

Studies generally indicate that the intention to adopt sustainable and energy efficient technologies increases with education level (Scholte et al. 2020; Weiss, Dunkelberg, and Vogelpohl 2012; Arroyo and Carrete 2019; Prasad Koirala et al. 2018; Azizi, Nair, and Olofsson 2019; Li et al. 2019). One study suggests that education level increases knowledge on environmental issues, but that it does not necessarily result in increased sustainable behavior (Kollmuss and Agyeman 2002). This may be an example where the cost of purchasing sustainable technologies impacts the self-efficacy of lower and higher educated individuals. While all groups are capable of performing low-cost sustainable behaviors, the financial burden associated with energy efficient technologies may not be manageable by households with a lower education level and a generally lower income.

Given that this study focuses on the motivation to contribute to the heat transition, which is generally a costly endeavor, *this study expects that the motivation to contribute increases with education level.* It is also expected that this effect may no longer be visible when controlling for income, due to the correlation between the two variables.

Income

As was mentioned previously, the role that income has on the intention to adopt sustainable behaviors is dependent largely on the cost that is associated with the behavior. Accordingly, studies find that the motivation to invest in energy efficient technologies increases with income (Scholte et al. 2020; Weiss, Dunkelberg, and Vogelpohl 2012; Arroyo and Carrete 2019; Prasad Koirala et al. 2018; Ebrahimigharehbaghi et al. 2019; Azizi, Nair, and Olofsson 2019). Meanwhile, low income groups are more motivated to perform low-cost sustainable behaviors that save energy and result in lower energy bills (Organ, Proverbs, and Squires 2013). These households also indicate that this behavior is considered a cost-saving behavior rather than a pro-environmental behavior (De Witt and Schmeets 2018; Organ, Proverbs, and Squires 2013).

Again, the focus of this study is on the motivation to contribute to the heat transition. Accordingly, *it is expected that the motivation to contribute to this costly endeavor increases with income.*

Ethnic Background

There is little evidence to suggest that ethnicity impacts a person's motivation to adopt sustainable or energy efficient technologies. One study proposed that people from countries with a communal culture are more willing to pay for environmentally friendly products, because the environment is a communal resource that ought to be protected (Gregory-smith, Manika, and Demirel 2017).

Given that there is no empirical evidence to support this hypothesis, *this study expects that ethnicity does not shape a person's motivation to contribute to the heat transition.*

Household Composition

There is little evidence to suggest that household composition impacts the motivation to purchase energy efficient technologies. One study suggests the presence of children or elderly in the household may result in the motivation to make energy efficient renovations to improve thermal comfort (Abreu, Oliveira, and Lopes 2017). Another study suggests that the motivation to adopt energy efficient renovations is lower among people who live alone, due to the financial risk associated with such an investment (Scholte et al. 2020).

Given that there is little evidence to support either theory, *this study expects that household composition does not have a significant effect on the motivation to contribute to the heat transition.*

Urbanity

No evidence has been found to suggest that urbanity impacts the motivation to purchase energy efficient technologies. Accordingly, *this study does not expect a significant relationship between urbanity and the motivation to contribute to the heat transition.*

Homeownership

As was mentioned previously, homeowners are more concerned about the financial and organizational burden of implementing natural-gas free heating than renters (Programma Aardgasvrije Wijken 2020a; Programma Aardgasvrije Wijken 2020b). Meanwhile, renters who are willing to contribute to the heat transition are likely unable to, because the responsibility lies with the owner (2019; 2012). Moreover, it is not rational for renters to invest in their home, because the investment will not yield a financial return Stotz 2019.

Given that homeowners and renters cannot be compared in terms of their motivation, *this study does not expect a significant difference in motivation to adopt natural-gas free heating among homeowners and renters.*

3.3.6 Previous Participation in the Heat Transition

This section summarizes existing literature on the relationship between socio-demographic characteristics and previous participation in heat transition, either in the form of planning, financing or personally executing initiatives. Again, the Theory of Planned Behavior claims that intention to perform a behavior is the main driver towards actual performance of the behavior (Ajzen 1985; Arli et al. 2019; M.-f. Chen 2016). If this is generally the case, we should find that the socio-demographic characteristics of those individuals who have previously contributed to the heat transition are the same as those who are motivated to contribute. Knowing whether people have previously contributed to the heat transition provides valuable information to municipalities, because previous energy efficient purchases are positively associated with the intention to make sustainable purchases in the future (Scholte et al. 2020).

Age

A majority of studies have found that the likelihood of adopting sustainable or energy efficient technologies decreases with age. (Scholte et al. 2020; Curtis, McCoy, and Aravena 2018; Jansson 2011; Chattopadhyay Mukherjee and Ryan 2020; Petrovich, Hille, and Wüstenhagen 2019; Jacksohn et al. 2019; He and Veronesi 2017). Meanwhile, one study suggests that the adoption rate of energy efficient technologies increases until retirement age, but decreases beyond that point (Das, Richman, and Brown 2018). When looking specifically at energy efficient home renovations, the SCP finds that the likelihood of adopting energy efficient renovations generally decreases with age (Scholte et al. 2020). Meanwhile, another study on energy efficient renovation finds that the youngest generation of Dutch homeowners is 2.5 times less likely to renovate their

home than people older than 35, which can be attributed to a lower average income within this group (Ebrahimigharehbaghi et al. 2019).

Based on these findings, *this study expects that the likelihood of having participated in the heat transition decreases with age, though an exception may be visible in the youngest age category.*

Gender

Studies that investigate whether the likelihood of purchasing energy efficient technologies varies between men and women generally find that there is no significant difference in purchase behavior (Prasad Koirala et al. 2018; Jansson 2011; Chattopadhyay Mukherjee and Ryan 2020; He and Veronesi 2017; Vasseur and Kemp 2015a). Some studies propose that women are more likely to act sustainably due to stronger pro-environmental attitudes, however there are more studies that conclude that there is no effect or even that men engage more in sustainable purchases (Arroyo and Carrete 2019; Prasad Koirala et al. 2018; Jansson 2011; Jacksohn et al. 2019; K. Westin, Jansson, and Nordlund 2018).

Given that most studies do not find a relationship between gender and previous participation in energy efficient purchases, *this study expects that men and women are equally likely to have previously participated in the heat transition.*

Education Level

Studies consistently conclude that the likelihood of adopting sustainable and energy efficient technologies increases with education level (Scholte et al. 2020; Curtis, McCoy, and Aravena 2018; Arroyo and Carrete 2019; Das, Richman, and Brown 2018; Jansson 2011; Jansson, Marell, and Nordlund 2011; Chattopadhyay Mukherjee and Ryan 2020; Jacksohn et al. 2019; Petrovich, Hille, and Wüstenhagen 2019; Vasseur and Kemp 2015a; Vasseur and Kemp 2015b; K. Westin, Jansson, and Nordlund 2018; J. Atkinson et al. 2019). This effect is generally explained by a greater openness and curiosity towards new technologies among higher educated individuals, in combination with a higher environmental concern (Jansson, Marell, and Nordlund 2011; Das, Richman, and Brown 2018).

Based on this finding, *this study expects that the likelihood of having previously contributed to the heat transition increases with education level.*

Income

In general, studies find that there is a positive relationship between income and the purchase of energy efficient technologies (Scholte et al. 2020; Galvin 2019; Das, Richman, and Brown 2018; Jansson 2011; Chattopadhyay Mukherjee and Ryan 2020; Petrovich, Hille, and Wüstenhagen 2019; Jacksohn et al. 2019; He and Veronesi 2017; Vasseur and Kemp 2015a; Vasseur and Kemp 2015b; K. Westin, Jansson, and Nordlund 2018; J. Atkinson et al. 2019). A higher disposable income provides more financial freedom to invest in costly sustainable technologies. To the author's knowledge, only one study finds a negative relationship between income and previous adoption of energy efficient renovations, but potential reasons for this counter-intuitive finding are not specified (Ebrahimigharehbaghi et al. 2019).

Based on these findings, *this study expects a positive relationship between income and previous participation in the heat transition.*

Ethnic Background

There is little evidence to suggest that ethnic background is associated with previous purchasing of energy efficient technologies. Again, some studies suggest that countries with a communal culture have stronger pro-environmental ideals and are thus more likely to behave sustainably (Gregory-smith, Manika, and Demirel 2017; Castillo, Cabanillas, and Leiva 2019). Still, there is little evidence to support this theory, especially when it concerns high cost behaviors like the

adoption of energy efficient technologies.

Accordingly, *this study does not expect a significant relationship between ethnic background and previous participation in the heat transition.*

Household Composition

The likelihood of adopting energy efficient technologies generally increases with an increased household size (Chattopadhyay Mukherjee and Ryan 2020; Petrovich, Hille, and Wüstenhagen 2019; Das, Richman, and Brown 2018; Vasseur and Kemp 2015a). This can be explained by a generally higher disposable income in households with two incomes, but also by the relatively greater energy savings that are possible in large households (Scholte et al. 2020; Das, Richman, and Brown 2018).

Accordingly, *this study expects that previous participation is more likely in households with a partner and perhaps children.*

Urbanity

Some studies suggest that there is a difference in purchasing behavior among urban and rural areas. More frequent adoption of electric vehicles, for example, can be explained by a more dispersed lifestyle in rural areas compared to urban areas (Chattopadhyay Mukherjee and Ryan 2020; K. Westin, Jansson, and Nordlund 2018). Another example is that adoption of solar technology is more likely in ground-bound homes, which are more common in rural areas than in cities (Vasseur and Kemp 2015a). No studies were found regarding the previous performance of energy efficient renovations. On the one hand, these renovations may be easier in rural areas based on the larger quantity of privately owned and ground-bound homes. On the other hand, extremely urban residential buildings are generally older than rural infrastructure and thus require more energy efficient renovations.

Given the absence of previous literature on this matter, this study will not hypothesize regarding the relationship between urbanity and previous energy efficient renovations.

Homeownership

As was previously mentioned, it is not rational for renters to invest in costly energy efficient modifications to their home, because the investment will not yield a financial return (Stotz 2019). While low-cost modifications, like energy efficient lighting, may be worthwhile for renters, *this study expects that homeowners are more likely to have previously made energy efficient modifications to their home.*

3.3.7 Summary of Hypotheses

Figure 3 provides a visual summary of the hypotheses that were defined. The relationship between each socio-demographic variable and each inhabitant-specific consideration is summarized by a plus sign, minus sign, or a zero. A plus and minus sign respectively indicate a positive or a negative relationship between the variables, while a zero indicates that no significant relationship is expected. When the socio-demographic characteristic is categorical in nature (e.g. gender, ethnic background, partner) the symbol indicates whether a positive, negative or insignificant difference is expected compared to the reference category (i.e. male, Dutch native, no partner). In instances where no hypotheses were developed, the corresponding cell is empty.

	Support for Natural Gas-free Policy	Support for the Municipality	Financial Capability	Social Trust	Connection to the Neighborhood	Motivation to Contribute to the Heat Transition	Previous Participation in the Heat Transition
Age	-	+	+	-	+	-	-
Female	+	-	0	-		0	0
Education Level	+	+	0	+	-	+	+
Income Level	0	+	+	+	+	+	+
Western	0	-	0	-	-	0	0
Non-Western	0	-	-	-	-	0	0
Partner	0		+	0	0	0	+
Number of Children	0		-	0	0	0	+
Urbanity	+	-	0	-	-	0	0
Homeowner	-		+	0	+	0	+

Figure 3: Summary of Hypotheses

4 Methodology

4.1 Methodological Approach

To determine whether socio-demographic characteristics can help explain and predict the choice of municipal role in the heat transition, a quantitative approach was used. Using a large, representative sample of the Dutch population and survey questions that resemble the inhabitant-specific considerations summarized in the framework by Ebskamp and Verbraak (2019), it is possible to determine how the socio-demographic characteristics of respondents impact their expected response to various municipal strategic roles in the heat transition. Two models were developed, each addressing one of the research questions.

The aim of the first model is to understand how socio-demographic characteristics influence the level of ambition and responsibility that residents are willing and able to take on in the heat transition. This is done by testing the relationship between socio-demographic characteristics and each inhabitant-specific consideration in the framework by Ebskamp and Verbraak (2019). The first model thus addresses the first research question and is explanatory in nature, meaning that it identifies what relationships are present between the variables in question (Sriboonchitta et al. 2018). In addition to testing the hypotheses that were defined in the theoretical background, the explanatory model will identify whether there are mediating effects between the dependent variables and two additional mediator variables that will be introduced in the following section. The mediating effects in the explanatory model are used to explain why the relationships between socio-demographic characteristics and the inhabitant-specific considerations are visible. Ultimately, the full explanatory model can be used to identify how residents' reactions to various municipal strategic roles change depending on their socio-demographic background.

The aim of the second model is to determine if it is possible for municipalities to predict an effective municipal strategic role in the heat transition based on the socio-demographic characteristics of their inhabitants. The second model thus addresses the second research question and is predictive in nature, meaning that the model is optimized to make predictions on new and future data. The model performance will determine whether socio-demographic predictors have sufficient predictive power to be used by municipalities when defining their strategic role. If the model performance is good, municipalities can use the predictive model to determine how their citizens would respond to various municipal roles in the heat transition and alter their strategic role accordingly.

To properly address each research question, the models are developed in a different manner. While both models are developed using logistic regressions, the content of each model varies. The explanatory model uses all socio-demographic characteristics as independent variables to uncover which relationships are present in the data. Meanwhile, the predictive model only uses predictors that significantly contribute to the goodness of fit of the model (Sriboonchitta et al. 2018). This distinction is made because the overall model performance of predictive models is more important than the significant coefficients, as is the case in explanatory models (Sainani 2014). The predictive model also does not consider mediating variables, because it is only interested in predicting outcomes based on socio-demographic characteristics. Lastly, the explanatory model regresses each dependent variable in the form that it was initially measured, while the predictive model uses binary derivatives of the initial measurements. This choice was made based on two considerations.

First, the predictive model is developed to simplify the inhabitant-specific considerations that must be made by municipalities. Ebskamp and Verbraak (2019) define two possible answers for each inhabitant-specific consideration and define which municipal role is most suitable in case of either answer. As an example, the first inhabitant-specific consideration asks whether there is support for the heat transition among residents. The model should be able to predict, based on socio-demographic characteristics, whether support is likely to be present or absent. The framework by Ebskamp and Verbraak (2019) does not consider the degree to which support is

present when defining the optimal strategic role.

The second reason that binary derivatives of the dependent variables are used is to improve model performance. Making predictions of ordinal and continuous data is more difficult than predicting a binary outcome, because the model must use the same data to discriminate between more possible outcomes (Harrell 2015). For example, it is easier to distinguish whether support is present or absent among certain socio-demographics, than it is to distinguish between high support, moderate support, limited support and no support for the heat transition.

4.2 Data & Sampling

In any study that quantitatively assesses the effect of socio-demographic characteristics on an outcome variable, a large and diverse dataset is required to ensure that all existing socio-demographic backgrounds are sufficiently represented. In this paper, data is used from the LISS (Longitudinal Internet Studies for the Social sciences) panel administered by CentERdata (Tilburg University, The Netherlands).

The LISS panel is a representative sample of Dutch individuals who participate in monthly Internet surveys. The panel is based on a true probability sample of households drawn from the population register. Households that could not otherwise participate are provided with a computer and Internet connection. A longitudinal survey is fielded in the panel every year, covering a large variety of domains including work, education, income, housing, time use, political views, values and personality. The socio-demographic independent variables that were discussed in the theoretical background, namely age, gender, education level, income, ethnic background, household composition, urbanity and homeownership, are all recorded in the LISS panel. Table 2 summarizes the socio-demographic independent variables that were used in this study. The variables in this table have already been processed to fit the purpose of this study. Appendix 10.2 indicates where the original data can be found and section 4.3 indicates how the data was processed to obtain the variables and responses depicted in Table 2.

In addition to the socio-demographic independent variables, proxy variables were required for each inhabitant-specific consideration that Ebskamp and Verbraak (2019) defined for choosing a strategic municipal role. The following sections summarize the chosen proxy variables and define the binary derivatives that were used in the predictive model. In addition to the proxy variables, two mediator variables will be introduced. The choice of variables used in this study was largely dependent on the availability of data in the LISS archive. Accordingly, some proxies more closely resemble the inhabitant-specific considerations than others. The implications of the discrepancies between the inhabitant-specific considerations and the chosen proxy variables will be addressed in the discussion. A summary of the used datasets and variables is provided in Appendix 10.2 and 10.3 respectively.

4.2.1 Proxy for Heat Transition Support

The first inhabitant-specific consideration that was defined by Ebskamp and Verbraak (2019) is the presence or lack of heat transition support among inhabitants. To determine how socio-demographic characteristics affect this consideration, support for the heat transition must be measured on an individual level. In 2019, individual support for natural-gas free policy was directly measured in a study by the SCP that was administered on the LISS panel (Scholte et al. 2020). The SCP asked respondents to what extent they are for or against the plan that all homes must be natural gas-free by 2050. Respondents were asked to rank their support on a seven-point ordinal scale that ranges from "1 = completely against" to "7 = completely for". In total, 1,665 people provided a response to this survey question.

Table 2: Summary of the socio-demographic variables used in this study after data processing

Variable	Question	Response
positie	Position within the household	1) Household head 2) Wedded partner 3) Unwedded partner 4) Parent (in law) 5) Child living at home 6) Housemate 7) Family member of boarder 9) Unknown (missing)
woning	Type of dwelling that the household inhabits	0) No self-owned dwelling 1) Self-owned dwelling
geslacht	Gender	1) Male 2) Female
lftdcat	Age in CBS (Statistics Netherlands) categories	1) 14 years and younger 2) 15-24 years 3) 25-34 years 4) 35-44 years 5) 45-54 years 6) 55-64 years 7) 65 years and older
oplcat	Level of education in CBS (Statistics Netherlands) categories	1) primary school 2) vmbo (intermediate secondary education) 3) havo/vwo (higher secondary education) 4) mbo (intermediate vocational education) 5) hbo (higher vocational education) 6) wo (university)
nettocat (derived from nettohh_f)	Net monthly household income in CBS categories	0) No income 1) EUR 500 or less 2) EUR 501 to EUR 1000 3) EUR 1001 to EUR 1500 4) EUR 1501 to EUR 2000 5) EUR 2001 to EUR 2500 6) EUR 2501 to EUR 3000 7) EUR 3001 to EUR 3500 8) EUR 3501 to EUR 4000 9) EUR 4001 to EUR 4500 10) EUR 4501 to EUR 5000 11) EUR 5001 to EUR 7500 12) More than EUR 7500

Table 2 continued: Summary of the socio-demographic variables used in this study after data processing

herkomstgroep	Origin	0) Dutch background 1) First and second generation foreign, Western background 2) First and second generation foreign, non-Western background
woonvorm	Domestic situation of the household head	1) Single 2) (Un)married co-habitation, without child(ren) 3) (Un)married co-habitation, with child(ren) 4) Single, with child(ren) 5) Other
aantalki	Number of living-at-home children in the household, children of the household head or his/her partner	1) One child 2) Two children 3) Three children 4) Four children 5) Five children 6) Six children 7) Seven children 8) Eight children 9) Nine children or more
partner	The household head lives together with a partner (wedded or unwedded)	0) No 1) Yes
sted	Urban character of place of residence	1) Not urban (<500 per km2) 2) Slightly urban (500-1000 per km2) 3) Moderately urban (1000-1500 per km2) 4) Very urban (1500-2500 per km2) 5) Extremely urban (>2500 per km2)

In the predictive model, this dependent variable must answer the question whether support for the heat transition is present or absent among inhabitants. Ebskamp and Verbraak (2019) claim that a lack of support poses challenges to the smooth implementation of the heat transition thus limiting the possible ambition level, while the presence of support allows for ambitious plans. Based on this statement, only the responses 'somewhat for' (SF), 'for' (F) and 'completely for' (CF) are considered to be conducive to ambitious plans. Accordingly, support is considered to be present for these responses, while support is absent if respondents are 'not for/not against' (NF/NA), 'somewhat against' (SA), 'against' (A), or 'completely against' (CA) natural gas-free policy.

4.2.2 Proxy for Support of the Municipality

The next inhabitant-specific consideration that was defined by Ebskamp and Verbraak (2019) is the presence or lack of support for the municipality among inhabitants. To determine how socio-demographic characteristics affect this consideration, support for the municipality must be measured on an individual level. As was mentioned in the theoretical background, support for the municipality is closely correlated with trust in the municipality, which is why trust in the municipality is used as a proxy (Montalvo 2010). In a 2016 survey, respondents were asked to indicate how much trust they have for four different municipal institutions: the mayor, the municipal executive, the municipal council and municipal civil servants. Respondents were asked to rank their trust on a four-point ordinal scale that ranges from "1 = none at all" to "4 = very much". To develop a single proxy variable, the rounded average of the four responses was taken. In total, 1,340 people provided a response to these survey questions.

In the predictive model, this dependent variable must answer the question whether support for the municipality is present or absent among inhabitants. Again, Ebskamp and Verbraak (2019) claim that a lack of support poses challenges to the smooth implementation of the heat transition thus limiting the possible ambition level. Based on this statement, only the responses where people trust the municipality 'very much' and 'fairly much' are considered to be conducive to ambitious plans. Support is considered to be present for these responses, while support for the municipality is absent if respondents do 'not at all' or 'not very much' trust their municipality.

4.2.3 Proxy for the Ability to Contribute Financially

The ability of inhabitants to financially contribute to the heat transition is the next inhabitant-specific consideration that was defined by Ebskamp and Verbraak (2019). Financial capability was operationalized as the respondents' perceived ability to live off of their income. In an annual study on the economic situation of LISS panel members, respondents were asked to indicate on a scale from zero to ten, how easy it is for them to live off of their income, where zero is "very hard" and ten is "very easy". In 2019, 2,961 people provided a response to this survey question.

In the predictive model, this dependent variable must answer the question whether inhabitants are or are not able to contribute financially to the heat transition. Ebskamp and Verbraak (2019) claim that a lack of financial capability requires a more financially active role by the municipality, because inhabitants do not have the means to take action on their own. Based on this statement, inhabitants who assign a failing grade (<6) to their ability to live off of their income, are categorized as 'unable to contribute financially'. Any respondent who ranks their ability to live off of their income a six or higher is assumed to be able to contribute at least somewhat to the heat transition, and are thus categorized as 'able to contribute financially'.

4.2.4 Proxy for the Ability to Collaborate

The next inhabitant-specific consideration that was defined by Ebskamp and Verbraak (2019) is the presence or lack of a shared vision among inhabitants regarding the implementation of the heat transition. The reason that Ebskamp and Verbraak (2019) consider the importance of a shared vision, is because they claim that it facilitates collaboration on heat transition initiatives. As was discussed in the theoretical background, this vision is very personal and difficult to measure, which is confirmed by the lack of data associated with this inhabitant-specific consideration in the LISS archive. Accordingly, a person's social trust and a connection to the neighborhood were recommended as alternatives, based on the premise that these variables are important indicators of a person's ability to collaborate on heat transition initiatives.

This study will focus on social trust as a proxy for a person's ability to collaborate. Though a person's neighborhood connection will also be considered in this study, it is believed that a

person's connection to their neighborhood is less intrinsic than social trust. While a person's neighborhood connection is readily influenced by their environment and can likely be improved by the municipality, social trust is the result of a lifetime of socialization, lifestyle changes and accumulation of knowledge and resources (Welch et al. 2005). Accordingly, a person's social trust is harder to influence and thus has stronger implications on a person's ability to collaborate. In an annual study on the personality of LISS panel members, respondents were asked to indicate on a scale from zero to ten, whether they believe most people can generally be trusted, where zero means "you can't be too careful" and ten means "most people can be trusted". In 2019, 5,067 people provided a response to this survey question.

In the predictive model, this dependent variable must answer the question whether inhabitants are or are not expected to collaborate effectively. Ebskamp and Verbraak (2019) claim that a shared vision of the heat transition is conducive to a less active role by the municipality, because collaborative initiatives among inhabitants are more probable. Using social trust as a proxy, it is also assumed that collaborative initiatives are more probable when social trust is high. Based on this reasoning, any respondent who ranks their general trust a six or higher is expected to collaborate more effectively than anyone who assigns a failing grade (<6) to their level of trust. Accordingly, those who generally trust others (>6) are expected to collaborate effectively while the remainder is not expected to collaborate effectively.

4.2.5 Proxy for Previous Participation in the Heat Transition

Previous participation in the heat transition, either through planning, implementing or financially supporting sustainable initiatives is the next inhabitant-specific consideration that was defined by Ebskamp and Verbraak (2019). There was only one question in the LISS data archive that directly addresses respondents' participation in the heat transition. In a 2009 study, respondents were asked to indicate whether or not they had previously made energy efficient modifications to their home on account of environmental considerations. In total, 1,401 people provided a response to this survey question.

The proxy for participation in the heat transition is the only dependent variable that is initially measured as a binary variable. Those who respond 'yes' to the question whether they have previously made energy efficient modifications to their home have participated in the heat transition, while those who answered 'no' have not. Ebskamp and Verbraak (2019) claim that municipalities can assign more responsibility to residents who have previously participated in the heat transition.

4.2.6 Proxy for Motivation to Contribute to the Heat Transition

The last inhabitant-specific consideration that was defined by Ebskamp and Verbraak (2019) asks whether citizens are motivated to take initiative in the heat transition. In 2019, individual intention to adopt natural-gas free heating was measured in a study by the SCP (Scholte et al. 2020). Respondents were asked to what extent they agree with the statement that they are considering replacing their current heating system with a natural gas-free alternative once it is broken. Respondents were asked to rank their agreement on a seven-point ordinal scale that ranges from "1 = completely disagree" to "7 = completely agree". In total, 941 people provided a response to this survey question.

In the predictive model, this dependent variable must answer the question whether motivation to take initiative in the heat transition is present or absent among inhabitants. Ebskamp and Verbraak (2019) claim that a lack of motivation among inhabitants requires an active role by the municipality to ensure progress is made in the heat transition. Based on this statement, motivation is assumed to be absent when inhabitants respond that they 'don't agree/don't disagree' (DA/DD), 'somewhat disagree' (SD), 'disagree' (D), or 'completely disagree' (CD)

with the statement that they are considering replacing their heating system with a natural gas-free alternative. In this case, an active role by the municipality is required, while the responses 'somewhat agree' (SA), 'agree' (A) and 'completely agree' (CA) are conducive to a less active role by the municipality.

4.2.7 Mediating Variables

While the discussed proxies were expected to provide adequate information regarding the relationship between socio-demographic characteristics and the inhabitant-specific considerations by Ebskamp and Verbraak (2019), two additional variables were considered in an attempt explain why the relationships between socio-demographic characteristics and the inhabitant specific considerations are visible. These variables, which will henceforth be referred to as mediator variables, include the respondents' connection to their neighborhood and their environmental concern. The choice to include these variables in the explanatory model is discussed below.

Connection to the Neighborhood

As was previously mentioned, research has indicated that a person's connection to their neighborhood may play an important role in the heat transition (Wentink et al. 2018; Letki 2008; Christensen, Yamamoto, and Aoyagi 2008; Assche et al. 2007). Two studies find that a sense of community improves trust in the municipality (Assche et al. 2007; Christensen, Yamamoto, and Aoyagi 2008). Additionally, a connection to the neighborhood, in combination with social trust, has been found to improve participation and collaboration in the community (Letki 2008). Moreover, Wentink et al. (2018) find that a connection to the neighborhood is essential to collaborative initiatives pertaining to the heat transition. Pei (2019) finds that a connection to the neighborhood increases people's incentive to sacrifice for the common good of the neighborhood, which is conducive to collective initiatives in the heat transition. Based on these findings, it is expected that people's perceived connection to the neighborhood adds valuable information to the model regarding people's collaborative abilities and perhaps has a mediating effect on the relationship between a person's socio-demographic background and their municipal trust.

In a 2018 study on identity, respondents were asked to what extent they feel connected to their neighborhood or village. Respondents were asked to rank their level of connection on a four-point ordinal scale that ranges from "1 = not at all connected" to "4 = very connected". In total, 3,142 people provided a response to this survey question.

Environmental Concern

As was previously mentioned, research has suggested that people's support for natural gas-free policy and their intention to adopt natural-gas free alternatives may be largely mediated by their environmental concern (Scholte et al. 2020; Vasseur and Kemp 2015a; Prasad Koirala et al. 2018; Scholte et al. 2020; Li et al. 2019; Michelsen and Madlener 2013). While studies generally agree that environmental concern impacts support for natural gas-free policy, studies are divided on the impact of environmental concern and sustainable behavior. Many studies find that economic considerations are leading when deciding to make a sustainable purchase, for example to make one's home natural gas-free (Hamzah and Sya 2020; Abreu, Oliveira, and Lopes 2017; Organ, Proverbs, and Squires 2013; Curtis, McCoy, and Aravena 2018). While environmental concern is found to increase the intention to act and purchase sustainably, costs are leading in the choice to act sustainably or not (De Witt and Schmeets 2018; Abreu, Oliveira, and Lopes 2017; Organ, Proverbs, and Squires 2013; Curtis, McCoy, and Aravena 2018).

Based on these findings, environmental concern may provide useful information regarding the relationship between socio-demographic characteristics and heat transition support, previous energy efficient home modifications and the intention to adopt natural gas-free heating. It is thus included as a mediator variable in the final model. Specifically, it is used to investigate how environmental concern mediates the relationship between socio-demographic characteristics and

their performance of previous energy efficient home modifications. The effect that environmental concern has on a person's support for natural gas-free policy or their motivation to adopt natural-gas free heating cannot be assessed in this study. These effects could not be included because the data for these variables was collected in a different decade and therefore cannot be compared to environmental concern data which was collected in 2009.

In this 2009 survey, respondents were asked to what extent they agree with the statement that the earth's climate problem is grossly exaggerated. This survey question is commonly used as a proxy for environmental concern. Respondents were asked to rank agreement with the previous statement on a five-point ordinal scale that ranges from "1 = agree completely" to "5 = disagree completely". In total, 1,451 people provided a response to this survey question.

4.3 Data Processing

Prior to loading the previously described data into R, the R-environment was prepared for the data collection and analysis. First, the working directory including all datasets was set using the *setwd()* function in the R *base* package. Next the required packages were loaded into R using the *library()* function in the R *base* package. A summary of the required packages can be found in Appendix 10.4, which also summarizes the R-code used for data processing.

Next, a new function is defined to replace the *round()* function in the R *base* package. This *round()* function can round numbers to the nearest integer, however unconventionally rounds down when the given value is 0.5. The *round2()* function that is defined in Appendix 10.4 rounds up any value of 0.5 or higher.

Using the *read_sav()* function from the *haven* package, the datasets were uploaded into the R-environment. A summary of the required SAV files can be found in Appendix 10.2. This section continues by describing how the independent, dependent and mediator variables were processed before merging the data into the final datasets.

4.3.1 Socio-Demographic Independent Variables

First, the relevant data was selected from each dataset. The columns containing socio-demographic data that are not relevant to this research were removed from the data. Moreover, using the *filter()* function from the *dplyr* package, the socio-demographic data was filtered based on the position of each respondent in the household. For each household, only the household head was selected so as to obtain only one response per household. The household head is the person whose name is on the rent contract or purchase deed. If there is more than one name, the household head is the person with the highest income.

Next, some socio-demographic variables were recoded to simplify the data analysis. First, the income variable (nettohh_f) was altered from a continuous numeric variable to an ordinal scale based on the income categories defined by the Dutch Central Bureau of Statistics (CBS). The code used to create the income levels is summarized in Appendix 10.4. Even though the categorization of continuous variables is often contested, this study aims to identify differences between socio-demographic groups, which is why categorization of income facilitates usability of the results (Harrell 2015).

Second, the homeownership variable (woning) was recoded to a binary variable using the *recode()* function in the *dplyr* package. Respondents who own their dwelling receive a '1' while any other response is assigned a '0'.

Third, the urbanity variable (sted) is recoded so that the ordinal scale increases with increasing urbanity. Accordingly, an 'extremely urban' place of residence receives a '5', while a place of

residence that is 'not urban' receives a '1'. Previously, the scale was measured in the opposite direction.

Fourth, the ethnicity variable (herkomstgroep) was recoded so that it no longer distinguishes between first and second generation foreigners. This was done to increase the number of responses in the foreign categories, thus increasing the likelihood of obtaining statistically significant results.

Finally, the variables for gender (geslacht), partner, ethnicity (herkomstgroep) and household composition (woonvorm) were converted to factors using the *as.factor()* function in the R *base* package. All other socio-demographic variables were coded as numeric variables. It is standard practice to treat ordinal independent variables as continuous under the assumption that the interval between each level is the same.

4.3.2 Dependent & Mediating Variable Data

Like the socio-demographic datasets, the datasets containing responses for each dependent and mediator variable were also filtered to contain only relevant data. Only the respondent ID and the previously discussed proxy variables were kept. The names of the variables that were extracted from each dataset are summarized in Appendix 10.3. Using the *rename()* function from the *dplyr* package, the names of the dependent variables were simplified.

Next, all instances where respondents could answer 'don't know' or 'no opinion' were filtered out of the data using the *filter()* function. These responses are not ordinal in nature and do not help address the research questions. As such, this research is not interested in these responses.

The next step was to ensure that all dependent variables directly address the research questions. While the variables that measure heat transition support, financial capability, social trust, previous energy efficient home modifications and intention to adopt natural gas-free heating are directly measured, the remaining variables need to be computed or adjusted to effectively address the research question.

First, the variable for trust in the municipality was computed. As was mentioned previously, trust in the municipality is operationalized as the rounded average of a respondent's trust in the mayor, municipal council, municipal executive and municipal civil servants. Accordingly, the average level of trust was found and rounded off to the nearest integer using the *round2()* function that was defined earlier.

Next, the variables that measure a respondents' connection to their neighborhood and their environmental concern were recoded. In both instances, the bottom end of the ordinal scale corresponds to high municipal trust and high concern, while the upper end of the scale corresponds to low municipal trust and environmental concern. Using the *recode()* function, the direction of the ordinal scale was inversed.

A summary of the independent, mediating and dependent variables post-data processing can be found in Appendix 10.3. After simplifying these datasets, they were merged. Each dataset containing dependent or mediating variables was merged with a dataset of socio-demographic characteristics that was collected in the same year. Accordingly, eight datasets were obtained: six datasets containing data on each of the dependent variables, and two containing data on the mediating variables.

4.3.3 Combined datasets

To develop a conceptual model including all dependent and mediating variables, it must be possible to determine the relationship between these variables. Currently, all dependent and

mediating variables have a separate dataset, meaning that it is not possible to regress the dependent and mediating variables onto one another. To facilitate these regressions, additional merged datasets were made wherever possible.

Given that data on the dependent and mediating variables was collected in different years, it was not possible to regress all dependent and mediating variables onto one another. Only dependent and mediating variables that were collected in the same year could be merged into new datasets. Accordingly, five models were developed to test the interrelationship between mediating and dependent variables that were collected in the same year. These models are summarized in Table 3.

Table 3 indicates which datasets have been merged and which relationships will be tested. As was mentioned in section 4.2, the data on financial capability and social trust was obtained from annual studies. Accordingly, additional datasets from 2016 could be downloaded and merged with models 3 and 4. It is also important to note that, while models 3 and 4 contain socio-demographic data from 2016, data pertaining to people's connection to the neighborhood was measured in 2018. After an unsuccessful attempt to extrapolate the data from 2018 onto the socio-demographic characteristics of 2016, the choice was made to combine the responses from 2018 with the socio-demographics data from 2016. This choice was made under the assumption that most socio-demographic characteristics do not change significantly within this time-frame. The validity and implications of this assumption will be addressed further in the discussion.

Table 3: Summary of extended models

Model	Dependent Variable	Independent Variables	Year	Sample
1	Intention to adopt NG-free heating	Support or NG-free policy Social trust Financial capability	2019	839
2	Support or NG-free policy	Social trust Financial capability	2019	1,545
3	Social trust	Trust in the municipality Financial capability Connection to neighborhood*	2016	856
4	Trust in the municipality	Social trust Financial capability Connection to neighborhood*	2016	856
5	Sustainable behavior	Environmental concern	2009	1.272

** Data on connection to the neighborhood was measured in 2018*

4.4 Data Analysis

Before creating the explanatory and predictive models, some univariate statistics were performed to determine the distribution of responses for each dependent variable. Given that the dependent variables are ordinal and binary in nature, bar charts were created using the *ggplot2* package in R to display the frequency of each response. Moreover, summary functions were used to determine the mean and standard deviation of the distributions. These univariate statistics are later considered in the interpretation of the results and analysis of the models.

4.4.1 Explanatory Model

As was previously mentioned, an explanatory model aims to uncover significant relationships between variables. This study is interested in the relationship between socio-demographic characteristics and the dependent variables. Moreover, to gain a more comprehensive understanding of how people may respond to various municipal roles, the study is interested in the relationship between the dependent and mediator variables. With an understanding of all the interrelations, a conceptual model can be developed. To create the conceptual model, the following set of steps was repeated for each dependent variable:

Step 1: A bivariate regression was performed to determine the effect of each socio-demographic characteristic on the dependent variable in question.

Step 2: A multiple regression was performed to determine the combined effect of all socio-demographic characteristics on the dependent variable in question.

Step 3: A bivariate regression was performed to determine the effect of other dependent and mediating variables on the dependent variable in question.

Step 4: A multiple regression was performed to determine the combined effect of all other dependent and mediating variables on the dependent variable in question.

Step 5: A multiple regression was performed to determine the combined effect of all socio-demographic, dependent and mediating variables on the dependent variable in question.

Step 6: The mediating effects in each model were identified.

Step 7: The 'step 5' and 'step 6' results for each dependent variable were combined into a single conceptual model.

The results from the second step are ultimately used to verify or reject the hypotheses specified in the theoretical background. The results from the seventh step are used to explain why the effects between socio-demographic characteristics and the inhabitant-specific considerations are visible by discussing the relationships between the dependent and mediator variables.

This section continues by explaining these steps in more detail. The R code associated with these steps is summarized in Appendix 10.5.

Step 1:

The first step towards developing the explanatory model was to perform bivariate regressions between each socio-demographic characteristic and each dependent variable individually. Figure 4 visualizes an example of such a bivariate regression. In this example, the relationship between age and natural gas-free policy support is tested. This step was repeated for all socio-demographic characteristics and dependent variables.

Figure 4: Example of a 'Step 1' bivariate regression that determines the effect of age on natural gas-free policy support.

Using *polr()* function from the *MASS* package in R, a proportional odds logistic regression was done to test the relationship between socio-demographic characteristics and each ordinal dependent variable. For the binary dependent variable which measured previous energy efficient home modifications, the *glm()* function from the *stats* package in R was used to perform a binary logistic regression. Each significant coefficient that is found in step 1 indicates that there is a relationship between the socio-demographic characteristic and the dependent variable, though it is not yet possible to conclude whether this is a direct effect.

Step 2:

The second step towards obtaining the explanatory model was to control for other socio-demographic characteristics. Rather than performing a bivariate regression with a single independent variable, a multiple regression was performed including all socio-demographic variables. Figure 5 visualizes the relationships that are tested in step 2 using natural-gas free policy support as an example.

The number of significant coefficients that are found in step 2 is likely lower than in step 1, which is explained by collinearity of the independent variables. Collinearity refers to the presence of correlations between independent variables. In this case, both variables may have a significant effect on the dependent variable in a bivariate regression, but their collinearity may cause either or both variables to lose their significance in a multiple regression model. When an independent variable loses its statistical significance, it is unable to independently explain the dependent variable.

Ultimately, step 2 indicates which socio-demographic characteristics can independently explain the dependent variables. Accordingly, the results from step 2 will be used to test the hypotheses that were defined in 3.3. To make the 'step 2' results interpretable, the exponent of each significant coefficient was taken to obtain the corresponding odds ratio.

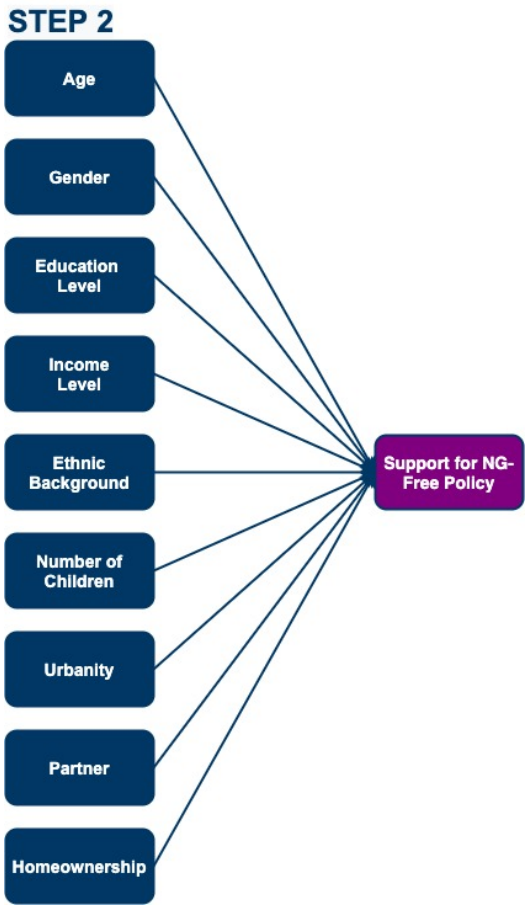

Figure 5: Example of a 'Step 2' multiple regression that determines the combined effect of all socio-demographic characteristics on natural gas-free policy support.

Step 3:

The regression models that are derived from step 1 and 2 do not yet indicate if and how the dependent variables are associated with or mediated by one another. Understanding the relationship between mediator and dependent variables is required to create a single conceptual model and to help explain the relationship between socio-demographic characteristics and the inhabitant-specific considerations. Step 3, 4 and 5 indicate how the model is expanded to include the relationships between dependent and mediator variables.

Step 3 aims to determine whether there are relationships between the dependent and mediator variables. Using the merged datasets that were defined in section 4.3.3, the relationship between the dependent and mediator variables was tested using bivariate logistic regressions. Figure 6 summarizes the relationships that were tested for each model.

Step 4:

In step 4, a multiple logistic regression was performed for each model. For now, only the dependent and mediator variables were included, to determine whether there is collinearity between the these variables. Figure 7 summarizes the relationships that were tested for each model.

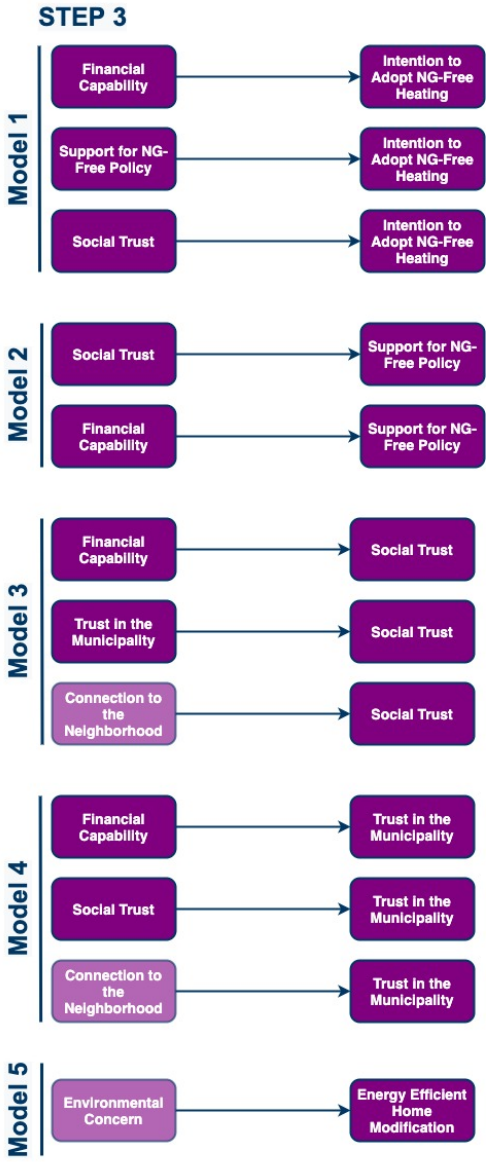

Figure 6: 'Step 3' bivariate regression analyses for each combined model.

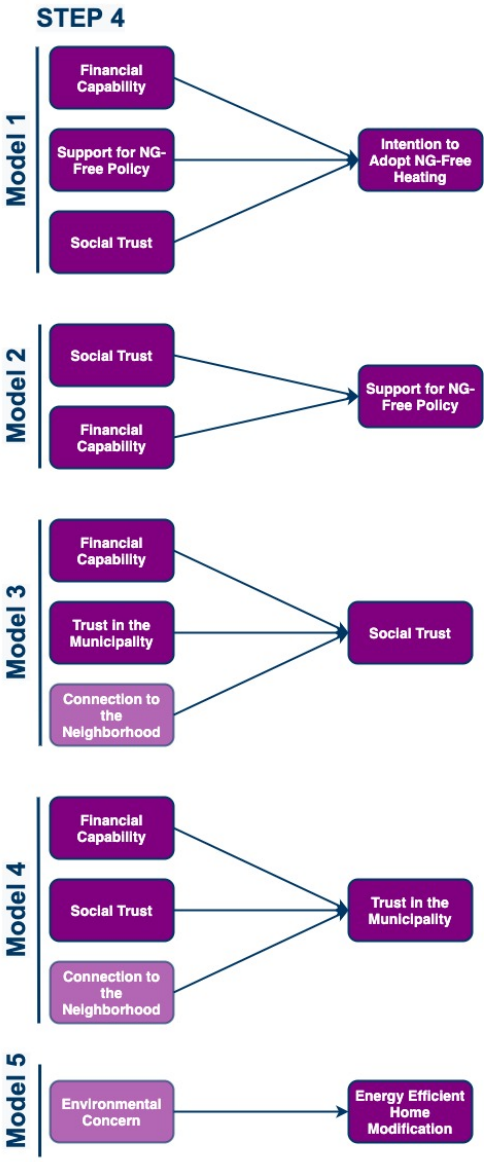

Figure 7: 'Step 4' multiple regression analyses for each combined model

The results from step 4 indicate which dependent and mediator variables can independently explain the dependent variable that is studied in each model. Variables that no longer yield a significant coefficient are correlated with other dependent or mediator variables and are thus unable to independently explain the dependent variable in question.

Step 5:

In step 5, the multiple regression models are expanded to include all variables, including socio-demographic characteristics. Figure 8 visualizes the relationships that are tested in step 5 using model 2, which focuses on natural-gas free policy support, as an example. This step is repeated for each model.

The results from step 5 indicate which variables have a significant direct effect on the dependent variable in question. Further analysis is required to determine which indirect relationships exist between the socio-demographic characteristics and the inhabitant-specific considerations.

Step 6:

To uncover indirect effects between socio-demographic characteristics and the dependent variables, step 6 aims to determine whether there are mediating effects in 'step 5' models. Each dependent or mediator variable that is significantly associated with the dependent variable in question can potentially exert a mediating effect on that variable. Mediation is assumed to be present when (1) a socio-demographic characteristic has a significant total effect on the dependent variable (i.e. it has a significant effect on the dependent variable when the mediator is not included in the regression), (2) the socio-demographic characteristic has a significant effect on the mediator and (3) the mediator has a significant effect on the dependent variable when the socio-demographic characteristic and mediator are both included as independent variables in the model. To identify whether mediation is present, three models were required to test whether each of these conditions are met.

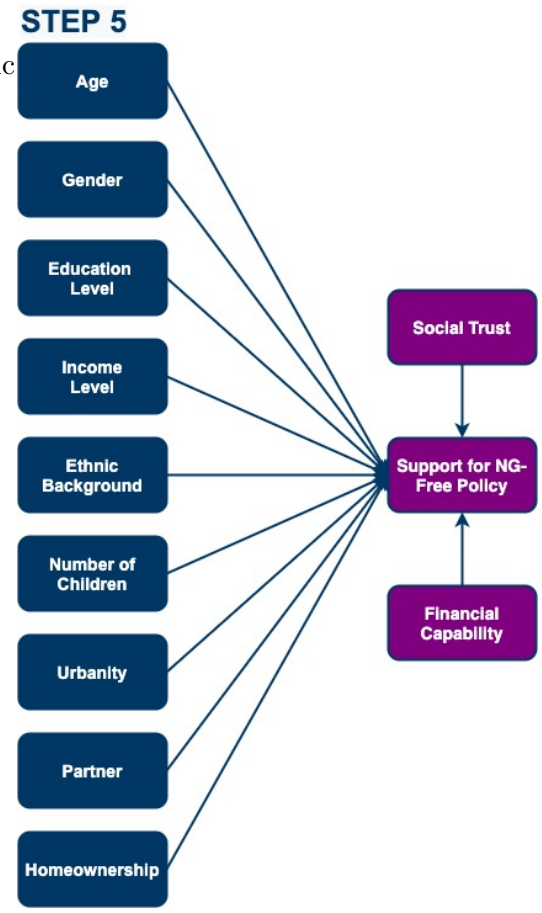

Figure 8: Example of a 'Step 5' multiple regression that determines the combined effect of all socio-demographic, dependent and mediating on natural gas-free policy support.

To test the first condition, a 'constrained' model was developed for each dependent variable that was studied in 'step 5'. The 'constrained' model tests the relationship between socio-demographic characteristics and the dependent variable in question. Accordingly, each 'constrained' model corresponds to the 'step 2' multiple regression model for that dependent variable. An exception was made if any dependent or mediator variables did not have a significant effect on the dependent variable in the 'step 5' results. In this case, the dependent or mediator variables were included as independent variables in the 'constrained' model, because they do not have a potential mediating effect on the dependent variable in question.

To test the second condition, a 'mediator' model was created for each variable that has a potential mediating effect on the dependent variable in question. Any dependent or mediator variable that was significantly associated with the dependent variable in the 'step 5' models can potentially have a mediating effect. The 'mediator' model regresses the mediating variable onto all socio-demographic independent variables. Again, if all dependent and mediator variables in the 'step 5' model have a potential mediating effect, then the 'mediator' model can be replicated from the 'step 2' results for that variable. However, if some dependent or mediator variables did not have a significant effect on the dependent variable in the 'step 5' results, these variables were included as independent variables in the 'mediator' model.

To test the final condition, a 'full' model was developed to determine which variables have a direct effect on the dependent variable when socio-demographic characteristics, potentially mediating variables and non-mediating variables are all included in the model. A 'full' model is developed for each potential mediating variable. If there is only one potentially mediating variable, then the 'full' model corresponds to the 'step 5' model.

Figure 9 visualizes the relationships that are tested in the 'constrained', 'mediator' and 'full' models, using the mediating effects of social trust on natural gas-free policy support as an example. These models ought to be replicated for each variable that can have a potential mediating effect in the 'step 5' models.

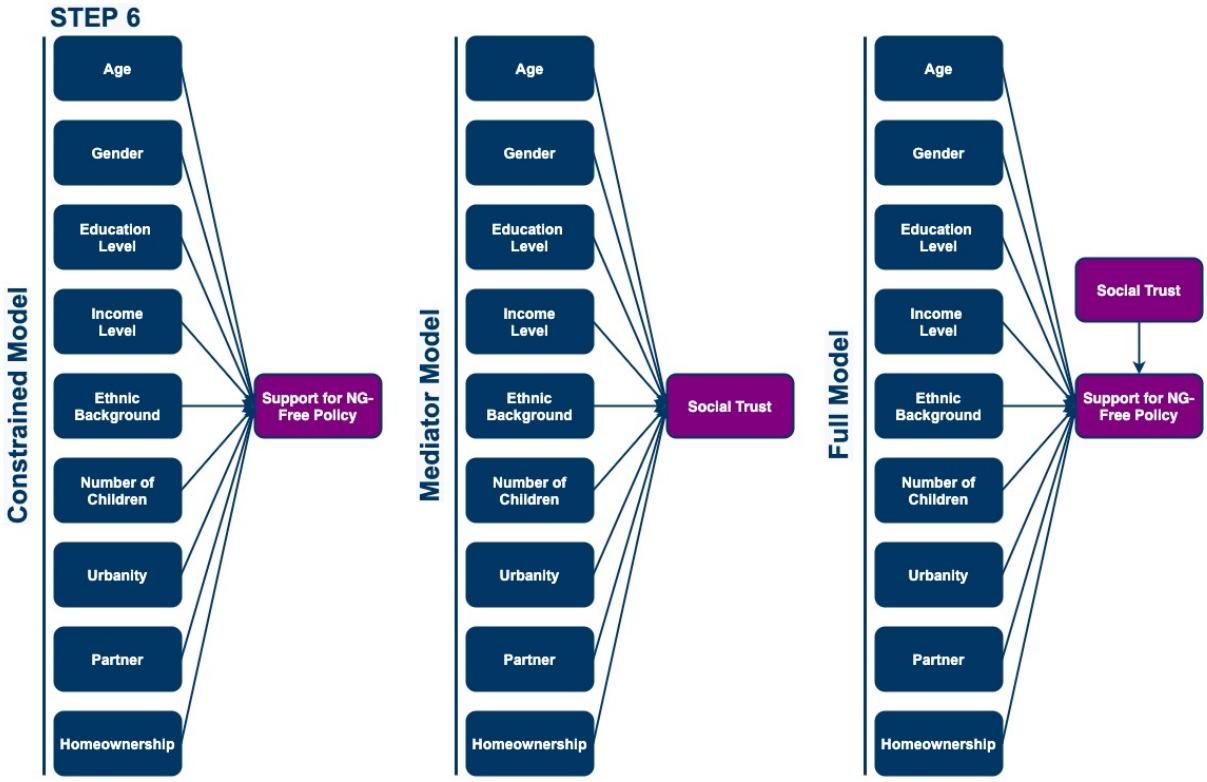

Figure 9: Example of 'Step 6' full, constrained and mediator models that are used to determine mediating effects of social trust on natural gas-free policy support.

To determine whether mediation is present, the three previously mentioned conditions are tested. The third condition, namely that the mediator has a significant effect on the dependent variable, is inherently true because only potential mediators were selected for the mediation analysis. To adhere to the other two conditions, the coefficient for a socio-demographic characteristic must be significant in both the 'constrained' and 'mediator' models. If the coefficient is also significant in the 'full' model, then partial mediation occurs, whereas full mediation occurs when the coefficient is not significant in the 'full' model.

Step 7:

The direct effects that were identified in step 5 and mediation results from step 6 together explain the nature of the relationship between each socio-demographic variable and dependent variable. By combining the models for each dependent variable, a single conceptual model was created that visualizes how socio-demographic characteristics shape people's response to the inhabitant-specific considerations by Ebskamp and Verbraak (2019). This conceptual model was created on the empty framework depicted in Figure 10, by adding arrows to represent each significant direct relationship in the model and adding dashed arrows to depict full mediation.

To make the relationships within the conceptual model interpretable, the exponent of each significant coefficient in the 'step 5' model was taken to obtain corresponding odds ratios.

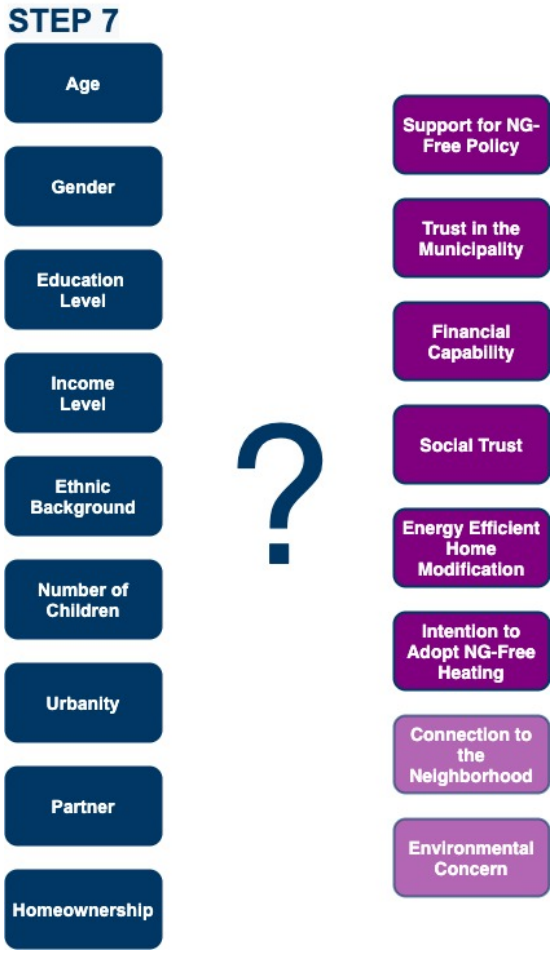

Figure 10: Empty framework on which the final conceptual model was built in step 7.

4.4.2 Predictive Model

Besides understanding the relationship between socio-demographic characteristics and the inhabitant-specific considerations by Ebskamp and Verbraak (2019), this study was also interested in developing a model that can predict an optimal municipal strategic role in the heat transition based on socio-demographic characteristics. As such, the second part of this methodology focuses on the development of such a predictive model. The R code used to develop the predictive model is summarized in Appendix 10.5.

Creating Binary Variables

As was explained previously, the predictive model uses binary derivatives of the dependent variables to create a more useful model for municipalities and to improve the model's goodness of fit. While the choice of cut-off point for each response to be categorized as a "1" or a "0" was explained in section 4.2, the cut-off values are summarized in Table 4. Based on the cut-off point defined in Table 4, the binary variables were created.

Table 4: Cut-off values used to create binary derivatives of the dependent variables

	Negative cut-off	Positive cut-off
Intention to adopt natural gas-free heating	<5	>4
Support for natural gas-free policy	<5	>4
Social trust	<6	>5
Financial capability	<6	>5
Trust in the municipality	<3	>2

Training and Testing Data

After creating the binary dependent variables, the next step towards developing a predictive model was to divide each dataset into a random training and testing dataset for cross-validation. Cross-validation is a statistical technique in which a model is developed on a training dataset and validated on a test dataset. Cross-validation is used to detect whether over- or underfitting is present in the model or whether the model accurately predicts the data. Overfitting refers to the phenomenon in which the model fits noise that is specific to the sample (Scheinost et al. 2019; Sainani 2014). Overfitting is detected if the predicted outcomes for the training dataset are significantly more accurate than the predictions made for the test dataset. The odds of overfitting occurring increases with the number of predictors, therefore predictive models do not necessarily include all predictors (Scheinost et al. 2019). On the contrary, underfitting occurs when the model does not sufficiently explain the relationship between the predictors and the outcome variable. When underfitting is present, predictive accuracy on both the test and training dataset is low.

For this study, a random sample containing 80% of each dataset was used as the training dataset, and the remaining 20% were used as the test dataset. The *createDataPartition()* function from the *caret* package in R was used to split each dataset into two random subsets. To ensure replicability of the data split, the *set.seed()* function from the R base package was used.

Predictive Model

Once the training and testing datasets were created, a multiple logistic regression was performed on each training dataset using the *glm()* function from the *stats* package in R. To determine whether each model was a significant improvement over the null model, the *lrtest()* function was used.

Next, predictors to be included in the model were selected using an automated selection procedure (Sainani 2014). The optimal number of predictors was found using the *stepAIC()* function from the *MASS* package in R. This function finds and runs the nested model which has the lowest Akaike Information Criterion (AIC) value. The lowest AIC value belongs to the model that optimizes the trade-off between the goodness of fit and information loss. In other words, selecting the lowest AIC value minimizes the risk of over- or underfitting the model.

While the best predictive model was found for each proxy, the actual performance of the model was not yet tested. Before cross-validation, more information was collected to determine the model goodness of fit (Harrell 2015). This was done by testing model calibration and discrimination (Sainani 2014).

Calibration refers to the agreement between observed and predicted probabilities (Shipe et al. 2019; Steyerberg et al. 2010; Sainani 2014; Harrell 2015). The observed probability represents the probability, based on the data, that a person with certain characteristics will respond "1". Meanwhile, the predicted probability represents the probability, according to the model, that a person will respond "1". Accordingly, a well calibrated model would accurately predict what

share of people with similar socio-demographic characteristics would respond "0" or "1". As an example, the model would be well-calibrated if the model predicts that respondent X has a 60% probability of supporting natural gas-free policy, while in reality 60% of the respondents with socio-demographic characteristics similar to respondent X actually support natural gas-free policy.

Good calibration alone does not guarantee a good predictive model. Looking at the previous example, it is not possible to conclude whether respondent X is for or against natural gas-free policy, because the chance that respondent X is for or against natural gas-free policy is relatively similar. In this case, the model is unable to accurately distinguish who does and who does not support natural gas-free policy. The ability of a model to separate respondents with different outcomes is referred to as discrimination (Shipe et al. 2019; Steyerberg et al. 2010; Sainani 2014; Harrell 2015). To be able to discriminate between respondents with different outcomes, the predicted probability would ideally be close to 0 or 100, with limited overlap between the distribution of predicted probabilities of individuals who responded "1" or "0".

To determine model calibration, the Hosmer-Lemeshow test was used. This test determines the calibration between predicted and actual probabilities across each decile of predicted probabilities (Shipe et al. 2019; Steyerberg et al. 2010). The *hoslem.test()* function from the *ResourceSelection* package in R determines whether there are significant differences between the fitted and actual response rates. The null hypothesis of the Hosmer-Lemeshow test is that the model is calibrated. Accordingly, if the test returns a significant p-value, it suggests that null hypothesis is rejected and that there is clear absence of calibration in the model.

The Hosmer-Lemeshow test does not indicate the extent of model calibration, but this can be inferred from a calibration plot, which visualizes the fitted and observed probability for each decile on a Cartesian plane (Shipe et al. 2019). This plot was developed using the *ggplot()* function from the *ggplot2* package in R. When fitting a linear regression to a perfectly calibrated model, the slope of the regression line is 1 and the intercept is 0. Based on this knowledge, it is possible to determine whether the model structurally over- or underestimates the probability in each decile.

To determine how well the model is able to discriminate, a concordance statistic (c-statistic) was calculated. The c-statistic is equal to the area under a Receiver Operating Characteristics (ROC) curve, which plots the sensitivity of the model against one minus the specificity of the model (Shipe et al. 2019; Steyerberg et al. 2010). The sensitivity is the rate of true positives, while one minus the specificity is the rate of false positives (Scheinost et al. 2019; Steyerberg et al. 2010). The area under the curve (AUC), or c-statistic, represents how well the model is able discriminate. The minimum c-statistic of 0.5 suggests that the model is unable to discriminate, while a maximum c-statistic of 1 suggests that the model can perfectly discriminate between. The ROC curve and c-statistic value were obtained using the *roc()* function from the *pROC* package in R.

Additionally, a discrimination histogram was used to display the extent to which the models were able to discriminate (Steyerberg et al. 2010). A discrimination histogram contains two separate but superimposed histograms, where one depicts the predicted probabilities for all observed "1" outcomes, and the other depicts the predicted probabilities for all observed "0" outcomes. The overlap between the two distributions, as well as their means, visualize the ability of the model to discriminate between the observed outcomes. The discrimination histogram was developed using the *ggplot()* function in the ggplot2 package in R.

After evaluating the model performance, the models were cross-validated on the test dataset. Using the *predict()* function, the predicted probabilities for the training and test dataset were determined. To obtain the predicted outcome, the *round2()* function was applied. Any predicted probability equal to or over 50% would results in a predicted outcome of "1", while any predicted probability below 50% would result in a predicted outcome of "0". The predicted outcomes were then compared to the observed outcomes to determine the predictive accuracy of the models. A lower predictive accuracy on the test dataset suggests that model overfitting is present, while

the magnitude of the predictive accuracy on both datasets indicates how well the models are able to predict outcomes based on socio-demographic characteristics.

To evaluate the model accuracy in greater depth, confusion matrices were developed. These matrices indicate the number of true or false positives and negatives that the models predicted. While the predictive accuracy of the model is dependent on the combined share of true positives and true negatives, information regarding the false outcomes is also relevant to understanding the quality of the predictive models. For example, if the majority of the population is for natural gas-free policy, the model may will have a high predictive accuracy if it predicts that the entire population is for natural gas-free policy and does not discriminate between the minority of the population that is against it. In this case, the model loses all its value because it cannot distinguish those individuals that are against natural gas-free policy, despite having a high predictive accuracy. For the purpose of this study, the predictive accuracy should be high so that municipalities can accurately predict the preferences of their citizens, however, the model must also be able to discriminate between positive and negative outcomes even when the distribution of observed outcomes is extremely skewed.

By combining information regarding the calibration, discrimination and predictive accuracy of each model, it was possible to determine whether socio-demographic characteristics can be used to predict a strategic municipal role in the heat transition.

5 Results

5.1 Univariate Statistics

The distribution of responses for each dependent and mediating variable is summarized in Table 11. When it is expected that these distributions have implications on the results of this study, these they will be addressed in detail in the discussion.

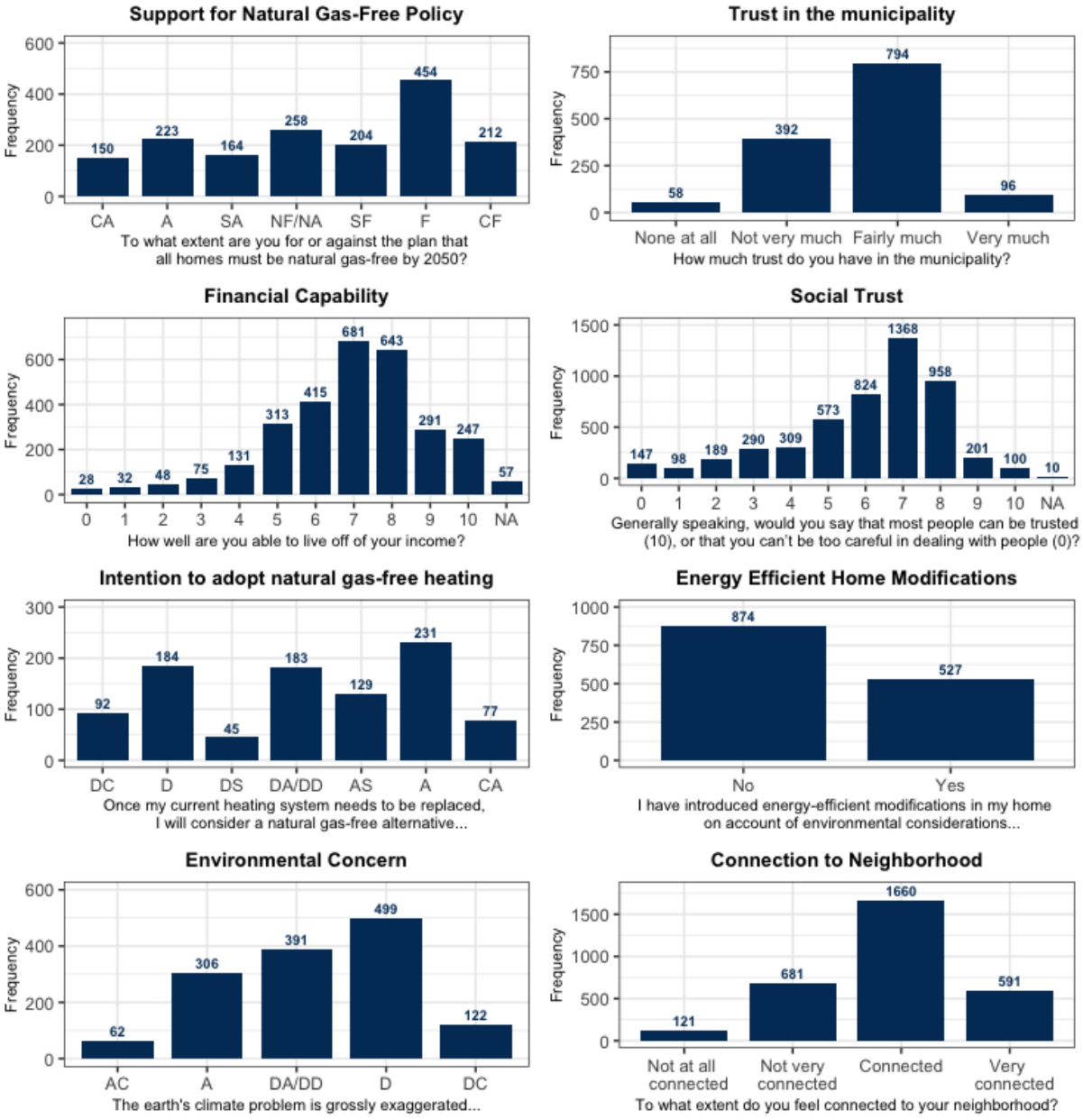

Figure 11: Distribution of responses for each dependent variable

5.2 Explanatory Model

This section summarizes the results for each step taken to develop the explanatory model. The results for each step are summarized in tables and significant results are touched upon in the text. Moreover, a visualization of each step is given to clarify how the final conceptual model

was developed. Rather than visualizing all results, only the results for natural gas-free policy support are used as an example.

Table 5: Bivariate regression results for the basic model

	Dependent variable:					
	NG-Free Policy Support	Trust in the Municipality	Financial Capability	Social Trust	Previous Energy Efficient Home Modifications	Intention to Adopt NG Alternative
Age category	−0.103***	0.146***	0.010	0.120***	−0.154***	−0.125***
	(0.030)	(0.037)	(0.022)	(0.015)	(0.041)	(0.044)
	n = 1,665	n = 1,340	n = 2,904	n = 5,057	n = 1,401	n = 941
Female	0.509***	−0.201	−0.521***	−0.084	0.062	0.577***
	(0.089)	(0.116)	(0.068)	(0.050)	(0.119)	(0.125)
	n = 1,665	n = 1,340	n = 2,904	n = 5,057	n = 1,401	n = 941
Education level	0.168***	0.101***	0.317***	0.245***	−0.050	0.164***
	(0.029)	(0.037)	(0.023)	(0.017)	(0.036)	(0.039)
	n = 1,663	n = 1,339	n = 2,898	n = 5,045	n = 1,396	n = 941
Income level	−0.015	0.073***	0.314***	0.086***	−0.026	0.025
	(0.018)	(0.021)	(0.014)	(0.009)	(0.025)	(0.024)
	n = 1,556	n = 1,260	n = 2,670	n = 4,578	n = 1,317	n = 880
Western	0.123	−0.635***	−0.823***	−0.657***		0.191
	(0.168)	(0.194)	(0.116)	(0.092)		(0.217)
	n = 1,643	n = 1,328	n = 2,864	n = 4,863		n = 936
Non−Western	0.363**	−0.061	−0.233**	−0.454***		0.224
	(0.152)	(0.205)	(0.118)	(0.091)		(0.235)
	n = 1,643	n = 1,328	n = 2,864	n = 4,863		n = 936
No. Children	−0.108	−0.095	−0.124***	−0.093***	0.058	0.060
	(0.058)	(0.057)	(0.036)	(0.023)	(0.057)	(0.069)
	n = 1,665	n = 1,340	n = 2,904	n = 5,057	n = 1,401	n = 941
Partner	−0.250***	0.300***	0.138***	0.212***	−0.214	0.044
	(0.087)	(0.109)	(0.066)	(0.053)	(0.113)	(0.116)
	n = 1,665	n = 1,340	n = 2,904	n = 5,057	n = 1,401	n = 941
Urbanity	0.122***	−0.093**	−0.049**	−0.016	0.102**	−0.007
	(0.031)	(0.043)	(0.023)	(0.018)	(0.043)	(0.041)
	n = 1,650	n = 1,330	n = 2,884	n = 5,027	n = 1,397	n = 937
Homeowner	−0.439***	0.466***	1.240***	0.509***	−0.164	
	(0.091)	(0.116)	(0.072)	(0.055)	(0.108)	
	n = 1,650	n = 1,338	n = 2,899	n = 5,054	n = 1,397	

Note: **p<0.05; ***p<0.01

Note: *the displayed values respectively represent the coefficients, standard errors and sample sizes for each model.*

Step 1

The aim of the first step was to determine which relationships exist between the independent and dependent variables by performing a bivariate regression. Table 5 contains the output of

57 bivariate logistic regression analyses between each socio-demographic independent variable and the dependent variables. Ethnicity is not included as an independent variable in the regression for previous energy efficient renovations, because this data was not available in the socio-demographic dataset. Moreover, homeownership is not included as an independent variable in the regression for people's intention to adopt natural gas-free heating because only homeowners received this survey question.

Given an alpha level of 0.05, statistically significant associations between the independent and dependent variables can be found in Table 5. Figure 12 visualizes the significant results for natural gas-free policy support in the format of the final conceptual model. Given that the bivariate regression is only used in combination with the 'step 2' results to identify which socio-demographic characteristics independently explain each dependent variable, the remainder of the 'step 1' results will be discussed in combination with the 'step 2' results.

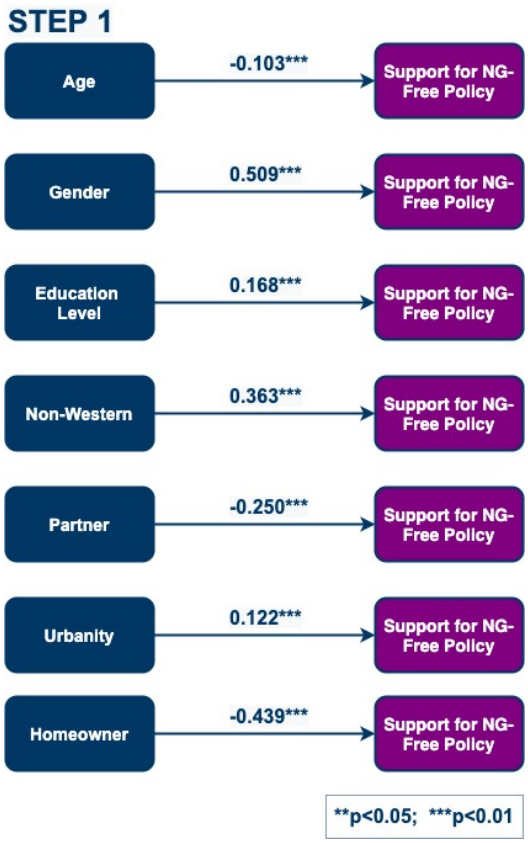

Figure 12: 'Step 1' bivariate regression results for natural gas-free policy support.

Step 2

The aim of step 2 was to determine which socio-demographic variables can independently explain the dependent variables by performing a multiple regression analysis for each dependent variable. All independent variables that have a significant coefficient can independently explain the dependent variable. Table 6 displays the odds ratios for the multiple regression analyses. The table containing the original coefficients and standard errors can be found in Appendix 10.6. This Appendix also contains the results of the 'step 2' multiple regression analyses for environmental concern and connection to the neighborhood, which will become relevant in step 7.

Table 5 indicates that a person's age, gender, education level, ethnic background, partnership, urbanity and homeownership can shape their natural gas-free policy support in the bivariate regression analysis. In the 'step 2' multiple regression analysis, age, ethnicity, partnership and urbanity are no longer significantly associated with natural gas-free policy support, suggesting that these variables do not have an independent effect.

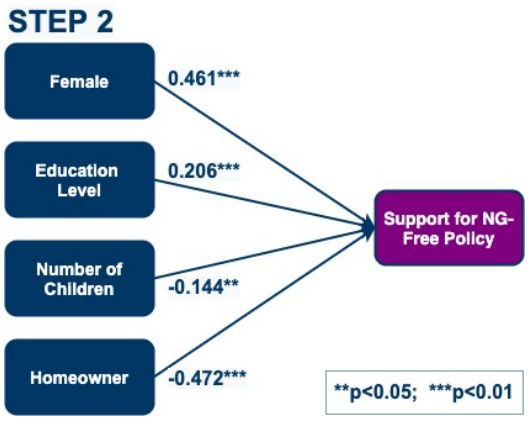

Figure 13: 'Step 2' multiple regression results for natural gas-free policy support.

Meanwhile, Table 6 indicates that the odds of being 'completely for' natural gas-free policy increases by 1.59 times when a respondent is female compared to male, holding all other variables constant. A one unit increase in education level increases the odds of being 'completely for' natural gas-free policy by 1.23 times and one unit increase in number of children decreases the odds of being 'completely for' natural gas-free policy by 0.87 times. Lastly, homeownership decreases the odds of being 'completely for' natural gas-free policy by 0.62 times.

A visualization of the significant effects is given in Figure 13. Note that this visualization refers to the original coefficients of the model rather than the previously discussed odds ratios.

Table 5 indicates that a person's age, education level, income, ethnic background, partnership, urbanity and homeownership can shape their trust in the municipality in the bivariate regression analysis. In the 'step 2' multiple regression analysis, income, ethnicity, partnership, urbanity and homeownership are no longer significantly associated with trust in the municipality, suggesting that these variables do not have an independent effect. Meanwhile, Table 6 indicates that a one unit increase in age category or education level respectively increases the odds of trusting the municipality 'very much' by 1.13 and 1.11 times, holding all other variables constant.

In terms of financial capability, Table 5 indicates that a person's gender, education level, income, ethnic background, number of children, partnership, urbanity and homeownership can shape their ability to live off of their income in the bivariate regression analysis. In the 'step 2' multiple regression analysis, urbanity is no longer significantly associated with financial capability, suggesting that this variable does not have an independent effect. Meanwhile, Table 6 indicates that a one unit increase in education level or income level respectively increases the odds of 'very easily' living off of one's income by 1.16 and 1.38 times, holding all other variables constant. Being female, a Western immigrant or living with a partner decreases the odds of 'very easily' living off of one's income by 0.79, 0.67 and 0.63 times respectively, compared to male, native Dutch and single respondents. A one unit increase in the number of children decreases the odds of 'very easily' living off of one's income by 0.70 times. Lastly, being a homeowner increases the odds of 'very easily' living off of one's income by 2.03 times.

Table 5 indicates that a person's age, education level, income, ethnic background, number of children, partnership and homeownership can shape their social trust in the bivariate regression analysis. In the 'step 2' multiple regression analysis, all these characteristics maintain their significance, suggesting that they all have an independent effect on social trust. Accordingly, Table 6 indicates that a one unit increase in age category, education level or income level respectively increases the odds of believing 'most people can be trusted' by 1.16, 1.27 and 1.07 times, holding all other variables constant. Living with a partner, being a Western immigrant, or being non-Western immigrant decreases the odds of believing 'most people can be trusted' by 0.86, 0.57 and 0.77 times respectively, compared to being single or a native Dutch respondent. A one unit increase in number of children decreases the odds of believing 'most people can be trusted' by 0.92 times. Lastly, being a homeowner increases the odds of believing 'most people can be trusted' by 1.38 times.

Table 5 indicates that a person's age and urbanity is associated with previous energy efficient home modifications in the bivariate regression. In the multiple regression, it becomes apparent that urbanity does not have an independent effect on previous adoption of energy efficient home modifications. Meanwhile, Table 6 indicates that a one unit increase in age decreases the odds having performed energy efficient home modifications by 0.96 times, holding all other variables constant.

Lastly, Table 5 indicates that a person's age, gender and education level are associated with their intention to adopt natural gas-free heating in the bivariate regression model. In the multiple regression model, age is no longer associated with the intention to adopt natural gas-free heating, thus suggesting that age does not have an independent effect. Meanwhile, Table 6 indicates that being female or living with a partner respectively increases the odds of 'completely agreeing' to consider a natural gas-free alternative by 2.12 and 1.37 times, compared to male and single respondents. Moreover, a one unit increase in education level increases the odds of 'completely agreeing' to consider a natural gas-free alternative by 1.17 times.

Table 6: Odds ratios for the multiple regression of the basic model

	Dependent variable:					
	NG-Free Policy Support	Trust in the Municipality	Financial Capability	Social Trust	Previous Energy Efficient Home Modifications	Intention to Adopt NG Alternative
Age Category		1.132***		1.155***	0.961***	
Female	1.585***		0.788***			2.107***
Education Level	1.229***	1.108**	1.155***	1.270***		1.170***
Income Level			1.376***	1.071***		
Western			0.670***	0.571***		
Non−Western				0.769***		
No. Children	0.866**		0.702***	0.921***		
Partner			0.630***	0.860**		1.360**
Urbanity						
Homeowner	0.624***		2.033***	1.383***		
Observations	1,519	1,138	2,609	4,366	1,307	872

Note: **p<0.05; ***p<0.01

Note: *the displayed values represent the significant odds ratios for each model*

Step 3

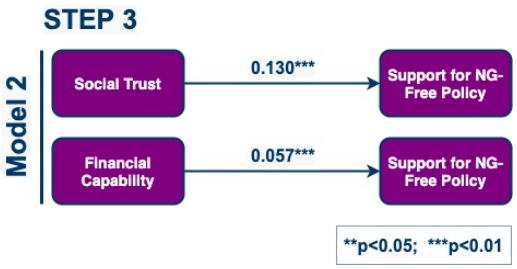

Figure 14: 'Step 3' bivariate regression results for natural gas-free policy support.

The aim of step 3 was to determine whether the dependent and mediator variables are associated with one another by performing bivariate regressions between them. All dependent and mediator variables are significantly associated with one another. Support for natural gas-free policy, social trust and financial capability are positively associated with the intention to adopt natural gas-free heating. Social trust and financial capability also positively affect support for natural gas-free policy. Financial capability and connection to the neighborhood are positively associated with social trust and trust in the municipality. Moreover, social trust and trust in the municipality are positively associated with one another. Lastly,

environmental concern is negatively associated with previous adoption of energy efficient home modifications. The quantitative results behind these relationships can be found in Appendix 10.7

Figure 14 visualizes step 3 using natural gas-free policy support as an example. As can be seen, the independent effects of financial capability and social trust on natural-gas free policy support are visualized.

Table 7: Multiple regression results for the extended models

	Dependent variable:				
	Intention to Adopt NG Alternative	NG-Free Policy Support	Social Trust	Trust in the Municipality	Previous Energy Efficient Home Modifications
NG-Free Policy Support	0.704***				
	(0.042)				
Social Trust	0.074**	0.122***		0.214***	
	(0.034)	(0.024)		(0.037)	
Financial Capability	0.009	0.023	0.247***	0.145***	
	(0.039)	(0.026)	(0.037)	(0.041)	
Trust in Municipality			0.650***		
			(0.106)		
Connection to Neighborhood			0.187**	0.409***	
			(0.095)	(0.108)	
Environmental Concern					−0.416***
					(0.057)
Observations	766	1,388	764	764	1,342
Note:					**p<0.05; ***p<0.01
Note:	*the displayed values respectively represent the coefficients and standard errors for each model.*				

Step 4

The aim of step 4 was to determine if dependent and mediator variables can independently explain the dependent variable in question. The multiple regression results are shown in Table 7. In the first and second model, the significant effect that financial capability had on a person's intention to adopt natural gas-free heating and support for natural gas-free policy disappears. This suggests that financial capability does not have an independent effect on these variables. All the other coefficients remain significant in the multiple regression models.

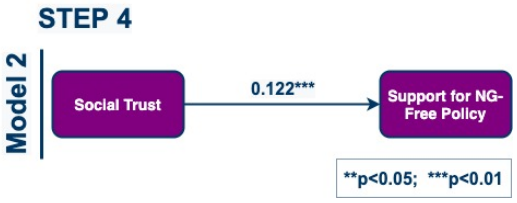

Figure 15: 'Step 4' multiple regression results for natural gas-free policy support.

Figure 15 visualizes step 4 using natural gas-free policy support as an example. As can be seen, financial capability is no longer included in this visualization because it no longer has a

significant effect on natural gas-free policy support.

Step 5

The aim of step five was to determine which socio-demographic, mediator and dependent variables have a direct effect on the dependent variables in question. The results of the 'step 5' multiple regression models are provided in Table 8. The table depicts how socio-demographic, dependent and mediator variables are associated with the dependent variable that is studied in each 'step 5' model. As an example, the 'step 5' results for natural gas-free policy support are visualized in Figure 16. For the time being, it is only important to note which variables are significantly associated with, and thus have a direct effect on, the dependent variable in each model. The direction and magnitude of these relationships will be discussed further in step 7.

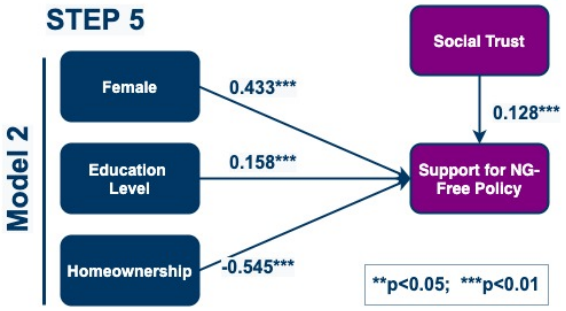

Figure 16: 'Step 5' multiple regression results for natural gas-free policy support.

The first model suggests that age, gender, support for natural gas-free policy and social trust have a significant direct effect on the intention to adopt natural gas-free alternatives. The second model suggests that gender, education level, homeownership and social trust have a significant effect on natural gas-free policy support. The third model indicates that age, education level, urbanity, financial capability and trust in the municipality are significantly and directly associated with social trust. Meanwhile, model 4 indicates that no socio-demographic characteristics have a direct effect on trust in the municipality, which is only significantly associated with social trust, financial capability and a person's connection to their neighborhood. The last model indicates that age, partnership and environmental concern are directly associated with previous energy efficient home modifications.

Table 8: Multiple regression results for the extended models including socio-demographic characteristics

	Dependent variable:				
	Intention to Adopt NG Alternative	NG-Free Policy Support	Social Trust	Trust in the Municipality	Previous Energy Efficient Home Modifications
NG-Free Policy Support	0.690***				
	(0.043)				
Social Trust	0.094***	0.128***		0.207***	
	(0.035)	(0.025)		(0.038)	
Financial Capability	0.033	0.050	0.184***	0.161***	
	(0.042)	(0.028)	(0.041)	(0.047)	
Trust in Municipality			0.655***		
			(0.105)		
Connection to Neighborhood			0.171	0.412***	
			(0.098)	(0.110)	
Environmental Concern					−0.441***
					(0.061)
Age Category	−0.155***	−0.048	0.160***	0.057	−0.200***
	(0.057)	(0.037)	(0.055)	(0.063)	(0.048)
Female	0.406**	0.433***	0.276	−0.071	−0.035
	(0.165)	(0.110)	(0.169)	(0.195)	(0.150)
Education Level	0.030	0.158***	0.179***	0.015	−0.024
	(0.051)	(0.036)	(0.049)	(0.056)	(0.044)
Income Level	−0.033	−0.013	0.051	−0.042	0.033
	(0.034)	(0.026)	(0.035)	(0.039)	(0.033)
Western	0.256	0.145	−0.266	−0.254	
	(0.268)	(0.186)	(0.237)	(0.265)	
Non−Western	−0.062	0.155	0.048	0.231	
	(0.277)	(0.175)	(0.290)	(0.316)	
Partner	0.118	0.096	−0.079	0.129	−0.318**
	(0.168)	(0.125)	(0.171)	(0.199)	(0.162)
No. Children	0.002	−0.050	−0.014	0.014	0.015
	(0.092)	(0.075)	(0.081)	(0.093)	(0.070)
Urbanity	−0.076	0.040	−0.114**	−0.021	0.071
	(0.049)	(0.036)	(0.054)	(0.062)	(0.049)
Homeowner		−0.545***	−0.041	−0.010	−0.098
		(0.116)	(0.167)	(0.194)	(0.148)
Constant					1.842***
					(0.433)
Observations	766	1,388	771	771	1,252

Note: **p<0.05; ***p<0.01

Note: *the displayed values respectively represent the coefficients and standard errors for each model.*

Step 6

The aim of step six was to identify mediating effects within the 'step 5' models. For each model, variables with a potential mediating effect were identified and corresponding 'constrained', 'mediator' and 'full' models were developed. The results from each model are qualitatively discussed, but the complete quantitative results can be found in Appendix 10.8. Specifically, the direct, partial and fully mediated effects are addressed for each model. Moreover, the direct and mediating effects in each model are visualized and constitute the building blocks for the final conceptual model in step 7.

Model 1: Mediating Effect on the Intention to Adopt Natural Gas-Free Heating

In model 1, support for natural gas-free policy and social trust were found to have a significant effect on a person's intention to adopt natural gas-free heating. As such, both variables potentially have a mediating effect on the intention to adopt natural gas-free heating. When looking at the 'constrained' model, financial capability, gender and education level have a significant effect on the intention to adopt natural gas-free heating. The results from the mediation analysis will determine whether the effect that these variables have on a person's intention to adopt natural gas-free heating is direct or mediated by the respondents' support for natural gas-free policy or social trust.

When looking at the 'full' models including support for natural gas-free policy and social trust as potential mediating variables, financial capability is no longer significantly associated with a person's intention to adopt natural gas-free heating. Meanwhile, financial capability is significantly associated with support for natural gas-free policy and social trust in both 'mediator' models. This suggests that the effect that financial capability has on a person's intention to adopt natural gas-free heating is fully mediated by their support for natural gas-free policy and their social trust.

Gender is still significantly associated with a person's intention to adopt natural gas-free heating in both 'full' models. This implies that the effect of gender on the intention to adopt natural gas-free heating is at least partially direct. Meanwhile, gender also has a significant effect in the 'mediator' model for natural gas-free policy support. Therefore, the effect that gender has on a person's intention to adopt natural gas-free heating is also partially mediated by a person's support for natural gas-free policy.

Education level is no longer significantly associated with a person's intention to adopt natural gas-free heating when support for natural gas-free policy is included in the 'full' model, however it has a significant effect in the 'mediator' model for natural gas-free policy support. This suggests that the effect of education level on a person's intention to adopt natural gas-free heating is fully mediated by their support for natural gas-free policy. Meanwhile, education level does have a significant effect in the 'full' and 'mediator' models for social trust, suggesting that social trust partially mediates the effect of a person's education level on their intention to adopt natural gas-free policy. Because the effect of education level is fully mediated by support for natural gas-free policy, the partial mediation by social trust is not visible in the 'step 5' model.

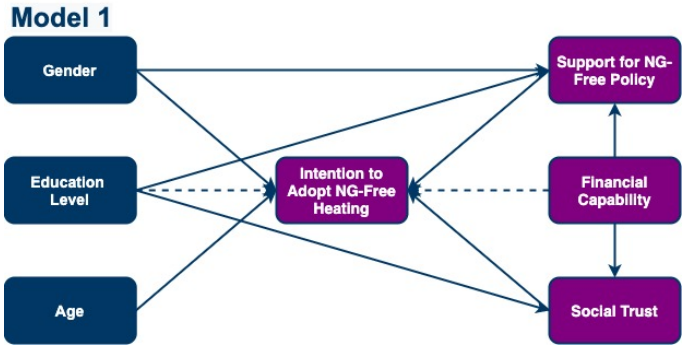

Figure 17: Conceptual model visualizing 'step 6' results for model 1

Interestingly, age does not have a significant effect on a person's intention to adopt natural

gas-free heating in the 'constrained' model, while it does in both 'full' models. This suggests age alone is unable to explain a person's intention to adopt natural gas-free heating, though it does explain a person's intention when considered simultaneously with their support for natural gas-free policy and their social trust.

The building block for the final conceptual model is visualized in Figure 17. The normal arrows represent direct effects between variables, while the dashed arrows indicate effects that are fully mediated. In the case of 'gender', where partial mediation occurs, the mediation effect is visualized by a direct arrow from 'gender' towards both the mediator and dependent variable.

Model 2: Mediating Effect on Natural Gas-Free Policy Support

In model 2, social trust was found to have a significant effect on a person's support for natural gas-free policy and was therefore considered as a potential mediator. When looking at the 'constrained' model, financial capability, gender, education level and homeownership have a significant effect on a person's support for natural gas-free policy. The results from the mediation analysis will determine whether the effect that these variables have on a person's support for natural gas-free policy is mediated by social trust.

Financial capability has a significant effect in the 'mediator' model, but does not have a significant effect in the 'full' model that includes social trust. This suggests that the effect that financial capability has on a person's support for natural gas-free policy is fully mediated by their social trust.

Gender and homeownership have a significant effect in the 'constrained' and 'full' model, but not in the 'mediator' model. As such, it can be inferred that the effect that gender and homeownership have on a person's support for natural gas-free policy is direct.

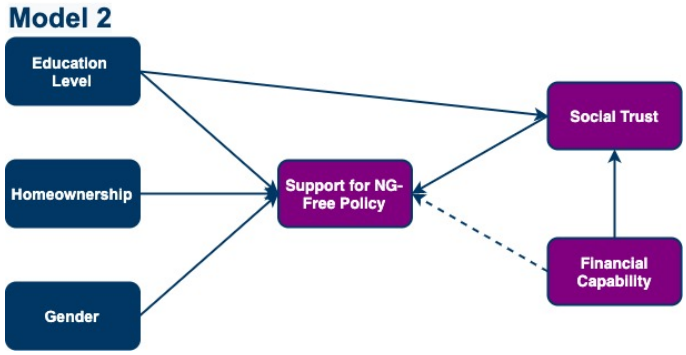

Figure 18: Conceptual model visualizing 'step 6' results for model 2

Education level has a significant effect in the 'constrained', 'full' and 'mediator' model. This suggests that the effect that education level has on a person's support for natural gas-free policy is partially mediated by their social trust and is partially direct.

The building block for the final conceptual model is visualized in Figure 18. Again, the normal arrows represent direct effects between variables, while the dashed arrows indicate effects that are fully mediated. Partial mediation of 'education level' is visualized by a direct arrow towards the mediator and dependent variable.

Model 3: Mediating Effect on Social Trust

In model 3, financial capability and trust in the municipality were found to have a significant effect on a person's social trust. Accordingly, it was assumed that these variables have a potential mediating effect on social trust. When looking at the 'constrained' model, a person's connection to the neighborhood, age category, education level, income level and urbanity have a significant effect on their social trust. The results from the mediation analysis will determine whether the effect that these variables have on a person's social trust is mediated by their financial capability and trust in the municipality.

A person's connection to the neighborhood has a significant relationship with trust in the munic-

ipality in the 'mediator' model. When trust in the municipality is included in the 'full' model, a person's connection to the neighborhood no longer has a significant effect on social trust. As such, the effect that a person's connection to the neighborhood has on social trust is fully mediated by their trust in the municipality.

In both 'full' models, age has a significant effect on social trust, which suggests that the effect of age on social trust is at least partially direct. In the 'mediator' models, age does not have a significant relationship with financial capability nor with trust in the municipality. Accordingly, it can be inferred that the effect of age on social trust is direct.

Education level also has a significant effect on social trust in both 'full' models, suggesting that the effect of education level on social trust is at least partially direct. In the 'mediator' models, education level has a significant effect on financial capability but not on trust in the municipality. It can thus be assumed that the effect of education level on social trust is partially mediated by a person's financial capability.

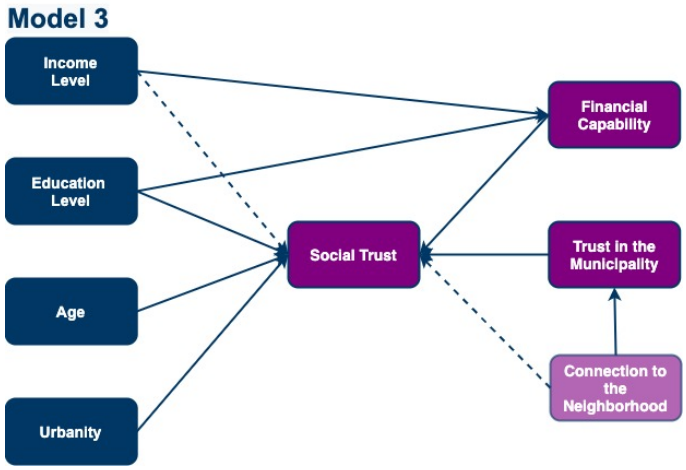

Figure 19: Conceptual model visualizing 'step 6' results for model 3

Income level is significantly associated with financial capability in the 'mediator' model, but is not significantly associated with social trust when financial capability is included in the 'full model'. This suggests that the effect that income has on social trust is fully mediated by financial capability.

Urbanity is significantly associated with social trust in both 'full' models, but does not have a significant effect in either 'mediator' model. This suggests that the effect that urbanity has on social trust is direct. Interestingly, urbanity was not significantly associated with social trust in the 'step 2' model. Potential explanations for this will be given in the discussion.

The building block for the final conceptual model is visualized in Figure 19. Again, the normal arrows represent direct effects between variables, while the dashed arrows indicate effects that are fully mediated. Partial mediation of 'education level' is visualized by a direct arrow towards the mediator and dependent variable.

Model 4: Mediating Effect on Social Trust

In Table 8, social trust, financial capability and connection to the neighborhood have a significant effect on a person's trust in the municipality. It is thus expected that these variables may have a mediating effect on a person's trust in the municipality. Table 8 also shows that there are no socio-demographic characteristics that have a direct effect on trust in the municipality. Thus, any potential mediating effects must be in the form of full mediation. When

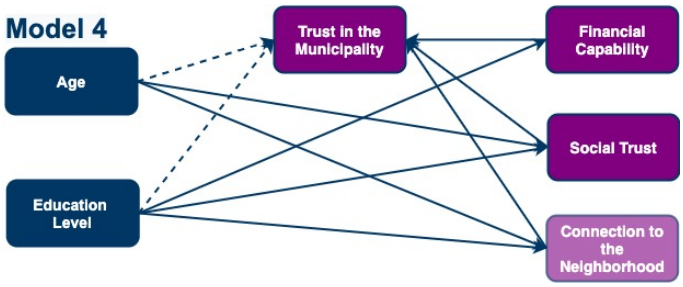

Figure 20: Conceptual model visualizing 'step 6' results for model 4

looking at the 'constrained' model,
a person's age category and education level have a significant effect on their trust in the municipality. The results from the mediation analysis will determine whether the effect that these variables have on a person's trust in the municipality is mediated by their social trust, financial capability or connection to the neighborhood.

Age no longer has a significant effect on trust in the municipality in the 'full' models containing social trust and connection to the neighborhood as independent variables. In both of the corresponding 'mediator' models, age does have a significant effect on social trust and connection to the neighborhood. This suggests that the effect that age has on a person's intention to adopt natural gas-free heating is fully mediated by their social trust and their connection to the neighborhood.

Education level does not have a significant effect on trust in the municipality in any of the 'full' models. Meanwhile, education does have a significant effect on each of the mediator variables, suggesting that the effect of education level on trust in the municipality is fully mediated by social trust, financial capability and a person's connection to their neighborhood. Interestingly, education level is negatively associated with a person's connection to their neighborhood. Still, an overall positive coefficient in the 'constrained' model suggests that the total effect of education level on trust in the municipality is more strongly shaped by its effect on social trust and financial capability.

The building block for the final conceptual model is visualized in Figure 20, where the full mediation of both age and education level is visualized with the dashed arrows.

Model 5: Mediating Effect on Previous Energy Efficient Home Modifications

In model 5, environmental concern was found to have a significant effect on previous performance of energy efficient home modifications and thus has a potential mediating effect. When looking at the 'constrained' model, a person's age has a significant effect on previous adoption of energy efficient home modification. The results from the mediation analysis will determine whether the effect that age has on previous performance of energy efficient home modifications is mediated by a person's environmental concern.

Figure 21: Conceptual model visualizing 'step 6' results for model 5

In the 'full' model, age is significantly associated with previous energy efficient home modification, which suggests that the effect of age is at least partially direct. Meanwhile, age does not have a significant effect on environmental concern in the 'mediator' model. It can thus be inferred that the effect of age on the adoption of energy efficient home modifications is direct. The building block for the final conceptual model is visualized in Figure 21.

Step 7

The building blocks developed in the 'step 6' mediation analysis were used to develop the final conceptual model depicted in Figure 22. Additionally, the results from the multiple regression analyses in 'step 2' were used to determine which socio-demographic variables are associated with financial capability, environmental concern, and a person's connection to their neighborhood. This final conceptual model depicts which variables are directly associated with one another and where mediation effects are present.

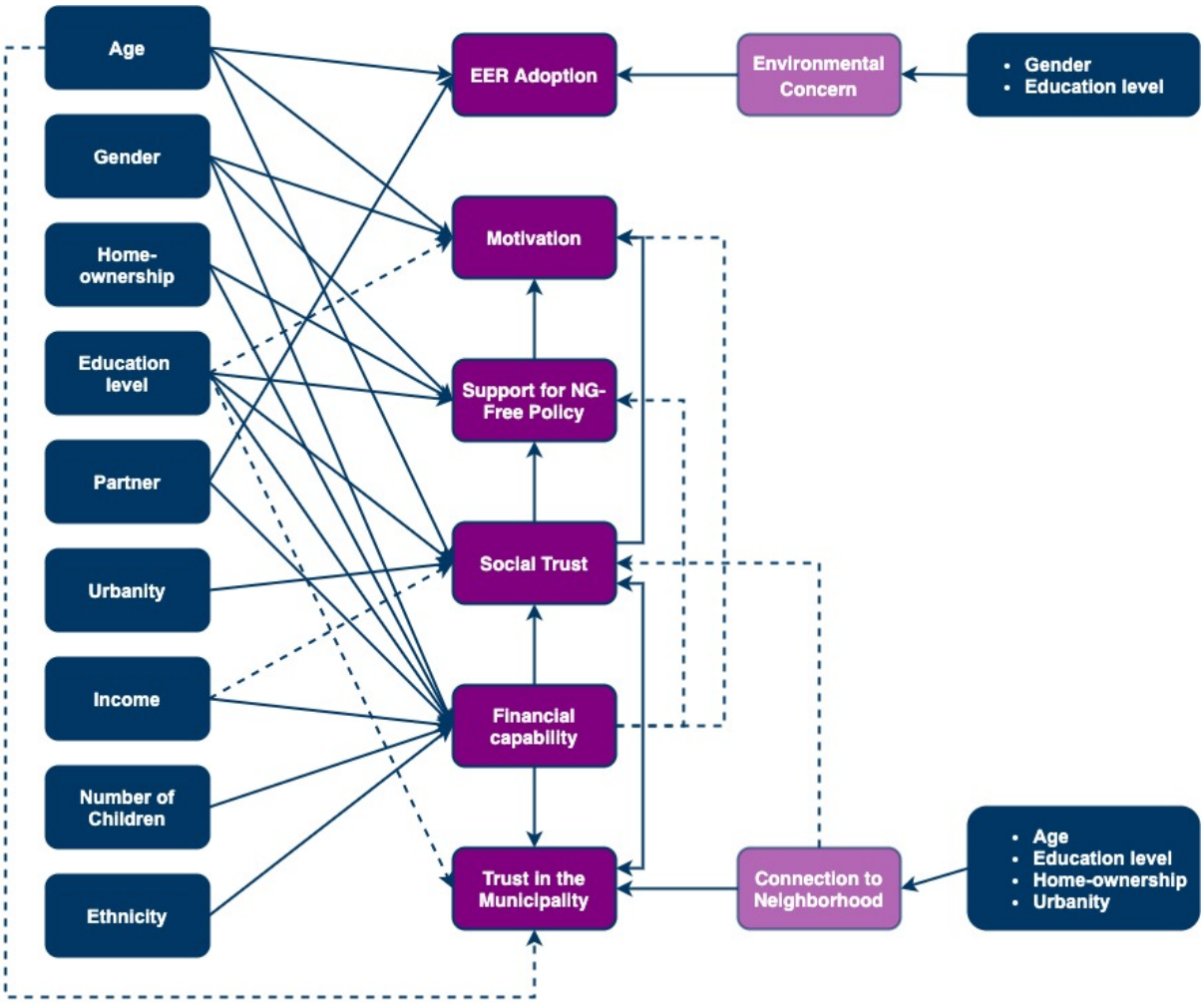

Figure 22: Conceptual model

To understand the direction and magnitude of each relationship, odds ratios were calculated based on the coefficients obtained in 'step 5'. Table 9 show the odds ratios for the final conceptual model.

Holding all other variables constant, the odds of 'completely agreeing' to consider natural gas-free heating increases by 1.99 and 1.10 times respectively with every on unit increase in natural gas-free policy support or social trust. A one unit increase in age category decreases the odds of 'completely agreeing' by 0.86 times. Lastly, the odds of 'completely agreeing' to consider a natural gas-free alternative is increased by 1.50 times when a respondent is female compared to male.

The odds of being 'completely for' natural gas-free policy is increased by 1.14 and 1.17 times respectively with every one unit increase in social trust or education level. Being female as opposed to male increases the odds of being 'completely for' natural gas-free policy by 1.54 times and homeownership decreases the odds of being 'completely for' natural gas-free policy by 0.58 times.

The odds of believing 'most people can be trusted' increases by 1.20 and 1.93 times respectively with every one unit increase in financial capability or trust in the municipality, holding all other variables constant. Moreover, one unit increase in age category or education level respectively increases the odds of believing 'most people can be trusted' by 1.17 and 1.22 times. Lastly, a one unit increase in urbanity decreases the odds of believing 'most people can be trusted' by 0.89 times.

A one unit increase in social trust, financial capability or trust in the municipality increases the odds of trusting the municipality 'very much' by 1.25, 1.18 and 1.51 times, holding all other variables constant.

A one unit increase in environmental concern or age category decreases the odds of having adopted energy efficient home modifications by 0.64 or 0.82 times respectively, holding all other variables constant. Moreover, having a partner decreases the odds of having adopted energy efficient home modifications by 0.73 times.

Considering that no new independent variables were added to the final multiple regression model for financial capability, the odds ratios remain the same as those in 'step 2'. A one unit increase in education level or income level respectively increases the odds of 'very easily' living off of one's income by 1.16 and 1.38 times, holding all other variables constant. Being female, a Western immigrant or living with a partner decreases the odds of 'very easily' living off of one's income by 0.79, 0.67 and 0.63 times respectively, compared to male, native Dutch and single respondents. A one unit increase in the number of children decreases the odds of 'very easily' living off of one's income by 0.70 times. Lastly, being a homeowner increases the odds of 'very easily' living off of one's income by 2.03 times.

In terms of a person's connection to their neighborhood, a one unit increase in age category increases the odds of feeling 'very connected' to the neighborhood by 1.10 times, holding all other variables constant. Meanwhile, a one unit increase in education level or urbanity respectively decreases the odds of feeling 'very connected' to the neighborhood by 0.92 or 0.84 times. Lastly, being a homeowner increases the odds of being 'very connected' to the neighborhood by 1.27 times.

Being female as opposed to male increases the odds of disagreeing entirely' with the statement that the earth's climate problem is grossly exaggerated by 1.52 times, holding all other variables constant. A one unit increase in education level increases the odds of 'disagreeing entirely' with this statement by 1.22 times.

Table 9: Odds ratios for extended multiple regression models

	Dependent variable:						*Mediator variable:*	
	Intention to Adopt NG Alternative	NG-Free Policy Support	Social Trust	Trust in the Municipality	Previous Energy Efficient Home Modifications	Financial Capability	Connection to Neighborhood	Environmental Concern
NG-Free Policy Support	1.994***							
Social Trust	1.099***	1.137***		1.250***				
Financial Capability			1.202***	1.175***				
Trust in Municipality			1.926***					
Connection to Neighborhood				1.510***				
Environmental Concern					0.642***			
Age Category	0.857***		1.174***		0.819***		1.101***	
Female	1.500**	1.541***				0.788***		1.523***
Education Level		1.197***	1.220***			1.155***	0.923***	1.222***
Income Level						1.376***		
Western						0.670***		
Non−Western								
Partner					0.728**	0.630***		
No. Children						0.702***		
Urbanity			0.892**				0.837***	
Homeowner		0.580***				2.033***	1.272***	
Observations	766	1,388	771	771	1,252	2,609	2,747	1,289

Note: **p<0.05; ***p<0.01

Note: *the displayed values represent the significant odds ratios for each model.*

5.3 Predictive Model

Table 10 depicts the final predictive models in which the predictors were selected based on an automated selection procedure that finds the nested model with the lowest AIC value. The likelihood ratio test yields significant Chi^2 values, thus suggesting that each model is a significant improvement over the null model.

Table 10: Final Predictive Models

	Dependent variable:					
	NG-Free Policy Support	Trust in the Municipality	Financial Capability	Social Trust	Previous Energy Efficient Home Modifications	Intention to Adopt NG Alternative
Age Category		0.040***	−0.014**	0.026***	−0.035***	
		(0.012)	(0.006)	(0.005)	(0.012)	
Female	0.518***		−0.031*		−0.071*	0.115***
	(0.127)		(0.018)		(0.038)	(0.041)
Education Level	0.291***	0.029***	0.023***	0.047***	−0.017	0.063***
	(0.043)	(0.011)	(0.006)	(0.005)	(0.010)	(0.013)
Income Level			0.032***	0.021***		
			(0.004)	(0.004)		
Western			−0.128***	−0.135***		
			(0.030)	(0.028)		
Non-Western			−0.014	−0.094***		
			(0.030)	(0.028)		
Partner				−0.052***	−0.101***	
				(0.020)	(0.035)	
No. Children	−0.169**		−0.042***	−0.023***		
	(0.082)		(0.011)	(0.009)		
Urbanity	0.083*					
	(0.044)					
Homeowner	−0.308**	0.103***	0.115***	0.067***		
	(0.137)	(0.034)	(0.020)	(0.019)		
Constant	−1.195***	0.267***	0.558***	0.259***	0.702***	0.175***
	(0.232)	(0.086)	(0.049)	(0.041)	(0.084)	(0.059)
Observations	1,212	917	2,091	3,490	991	697
Log Likelihood	−796.6	−591.4	−926.4	−2,105.9	−676.7	−490.2
L−ratio test Chi^2	80.90***	31.94***	276.39***	272.19***	19.31***	30.91***
AIC	1,605.2	1,190.9	1,870.9	4,229.8	1,363.3	986.4

Note: **p<0.05; ***p<0.01

Note: *the displayed values respectively represent the coefficients and standard errors for each model.*

The Hosmer-Lemeshow test was used to determine whether there is a lack of calibration in each model. Table 11 depicts the Hosmer-Lemeshow Chi^2 value and the corresponding p-value. None of the p-values were significant, which suggests that there is no significant absence of calibration in the models.

Table 11: Hosmer-Lemeshow tests for the predictive models

	Dependent variable:					
	NG-Free Policy Support	Trust in the Municipality	Financial Capability	Social Trust	Previous Energy Efficient Home Modifications	Intention to Adopt NG Alternative
Chi^2	2.25	12.34	−9.52	3.72	9.13	8.55
p-value	0.972	0.137	1.000	0.882	0.331	0.382

Calibration plots were used to visualize model calibration. The calibration plot for each model is given in Figure 23. The grey line represents a fictional model that is perfectly calibrated. Each point on the plot represents how the observed probability of an outcome compares to the predicted probability in each decile of predicted probabilities. The purple best fit line indicates how the slope and intercept vary from the the fictional model that is perfectly calibrated.

In the predictive models for natural gas-free policy support and social trust there are no large differences between the predicted and observed probabilities and the best fit lines are similar to that of a perfectly calibrated model. The model for previous energy efficient home modifications also has a good best fit line, though there are greater discrepancies between the predicted and observed probabilities. The remaining models also have some discrepancies between the predicted and observed probabilities, which are reflected in the best fit line. Overall, none of the models consistently over- or underestimate the probability of an outcome occurring.

The calibration plots also indicate that the predicted and actual probabilities of each model are concentrated in a small range of values, which suggests that the discriminating ability of the model may be limited. The predicted and observed probabilities for natural gas-free policy support and intention to adopt natural gas-free heating are distributed around the center of the probability scale (0.25-0.75), suggesting that it is difficult to distinguish whether a person receives a positive or negative outcome based on socio-demographic characteristics. Meanwhile, the predicted and observed probabilities for trust in the municipality, financial capability and social trust are distributed around the upper end of the probability scale (0.50-1.00), suggesting that the model cannot distinguish whether a respondents receives a negative outcome based on socio-demographic characteristics, considering that the majority of the population has an observed and predicted positive outcome. The opposite effect is visible for energy efficient home modifications, in which the predicted and observed probabilities are concentrated in the lower end of the scale (0.25-0.50), thus suggesting that the model cannot distinguish those respondents who have previously adopted energy efficient home modifications.

The c-statistics in Table 12 provide additional information on the discriminative ability of the model. These c-statistics were derived from ROC curves that were created for each model. These ROC curves can be found in Appendix 10.9. The c-statistics represents the probability that the model can discriminate between a positive and negative outcome. An c-statistic of 0.5 corresponds to a 50% chance that the model can accurately predict an outcome, thus suggesting that the model has no discriminative capacity.

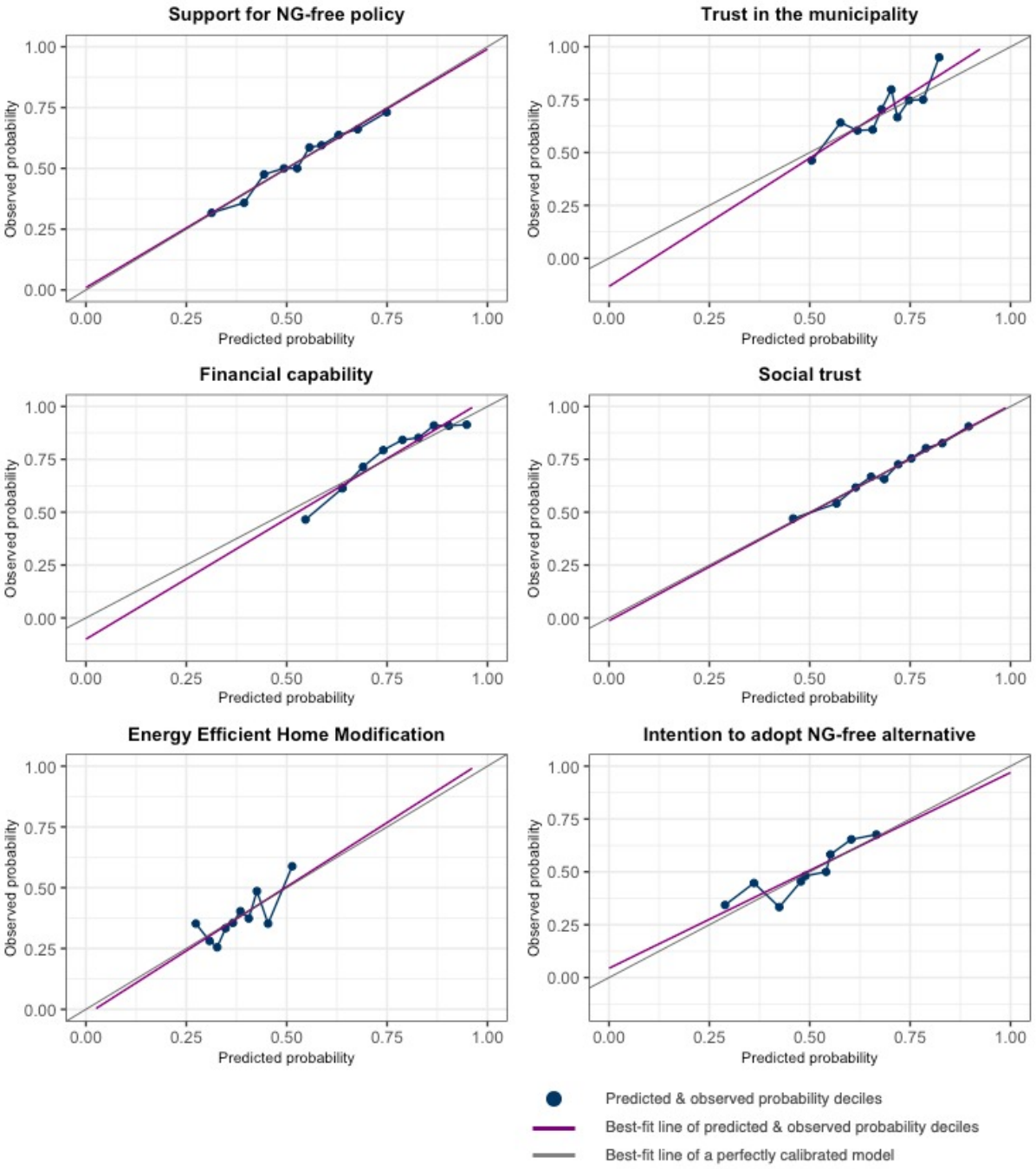

Figure 23: Calibration plots for the predictive models

There is a 64.7% chance that the model for heat transition support is able to correctly identify a person who is for or against natural gas-free policy. There is a 61% chance that the model for municipal trust can correctly determine whether a person trusts their municipality. For financial capability, there is a 74.5% chance that the model can accurately predict whether a person is able to live off of their income. There is a 67.2% chance that the model for social trust can identify whether a person trusts others. In terms of energy efficient home modifications, there is a 58.3% chance that the model can distinguish whether a person has performed energy efficient modifications to their home in the past. Lastly, there is a 62.3% chance that the model can accurately predict whether someone is considering to adopt natural gas-free heating.

Table 12: C-statistic for the predictive models

	Dependent variable:					
	NG-Free Policy Support	Trust in the Municipality	Financial Capability	Social Trust	Previous Energy Efficient Home Modifications	Intention to Adopt NG Alternative
C-statistic	0.647	0.610	0.745	0.672	0.583	0.623

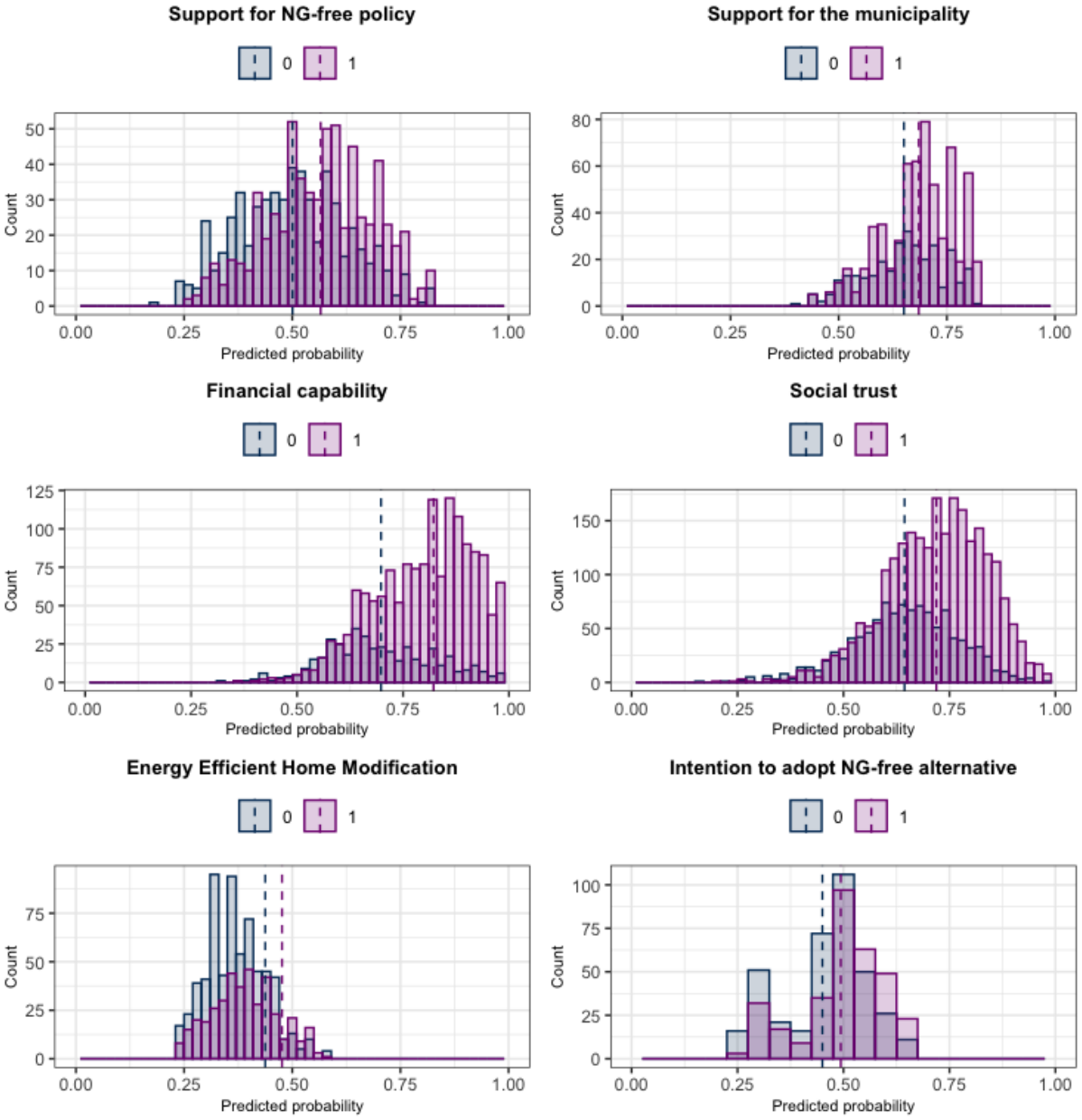

Figure 24: Discrimination histograms for the predictive models

The predictive accuracies that are summarized in Table 13 corroborate previous findings regarding the quality of the models. The predictive accuracies closely resemble the c-statistic values that were found in Table 12. This is expected, given that the c-statistics represent the probability that a model is able to distinguish between a positive or negative outcome and that the predictive accuracy indicates the percentage of correctly identified positive and negative outcomes.

The discrimination histograms in Figure 24 depict the predicted probability distributions for people with a positive and negative outcome. A model that can perfectly predict every outcome has no overlap between these probability distributions. Meanwhile, the histograms in Figure 24 corroborate the findings of the c-statistics, namely that the models are unable to distinguish between positive and negative outcomes based on socio-demographic characteristics. The differences in the mean predicted probability for positive and negative observations indicates that there are subtle differences in responses among various socio-demographics, but that the difference is insufficient for the model to discriminate between socio-demographic groups.

Table 13: Predictive accuracy of the predictive models on both the training and test dataset.

	Dependent variable:					
	NG-Free Policy Support	Trust in the Municipality	Financial Capability	Social Trust	Previous Energy Efficient Home Modifications	Intention to Adopt NG Alternative
Train Accuracy	61.4%	67.4%	80.0%	70.0%	63.4%	59.8%
Test Accuracy	59.9%	68.8%	78.8%	69.2%	61.8%	59.4%

For the purpose of this research, a good predictive model maximizes the number of true positives and true negatives. Additionally, the model must be able to distinguish minorities in the case of a skewed distribution. To determine whether the models meet the second requirement, confusion matrices were developed. These matrices are summarized in Figure 25.

When the distribution of observed outcomes favors either positive or negative responses, the model risks overestimating the number of positive or negative responses in the same direction. As was previously mentioned, the distribution of predicted probabilities for trust in the municipality, financial capability and social trust is skewed towards the upper-end of the probability scale. As a result, the model over-predicts the number of positive outcomes and is unable to distinguish the minority that has an observed negative outcome.

This effect is visible in the confusion matrices for these variables. When looking at trust in the municipality, only 30 negative outcomes were predicted, compared to 887 positive outcomes. Of these 887 positive predictions, 284 were false positives. The same is visible for financial capability, where the model predicted 38 negative outcomes compared to 2,053 positive outcomes, of which 403 were false positives. The model for social trust predicted 230 negative outcomes and 3,260 positive outcomes, of which 938 were false positives. These models overestimate the number of positive outcomes because they cannot distinguish the minority of the sample that has an observed negative outcome. While the predictive accuracy of these models is relatively higher than the other models, the number of false positives reduces the quality of these models.

The opposite effect is true for previous energy efficient home modifications, where the model predicts mostly negative outcomes (948) and very few positive outcomes (43). This results in a

large number of false negative predictions, namely 344. Overall, this model has a low predictive accuracy and is unable to identify those individuals who have made energy efficient modifications to their home.

		Predicted	
		1	**0**
Observed	**1**	466	183
	0	285	278

(a) Support for NG-free policy

		Predicted	
		1	**0**
Observed	**1**	603	15
	0	284	15

(b) Trust in the municipality

		Predicted	
		1	**0**
Observed	**1**	1650	16
	0	403	22

(c) Financial capability

		Predicted	
		1	**0**
Observed	**1**	2322	108
	0	938	122

(d) Social trust

		Predicted	
		1	**0**
Observed	**1**	24	344
	0	19	604

(e) Energy efficient home modification

		Predicted	
		1	**0**
Observed	**1**	135	193
	0	87	282

(f) Intention to adopt NG-free alternative

Figure 25: Confusion matrices for the predictive models

6 Discussion

Before discussing the results, this section addresses the methodological limitations associated with the LISS panel, the samples, the proxies and the assumptions used in this study. Keeping these limitations in mind, the results of this study are evaluated and the two research questions answered. In section 6.2, the explanatory model is evaluated and used to explain how socio-demographic characteristics influence the preferred ambition level and responsibility distribution within the heat transition. Next, section 6.3 assesses the quality of the predictive models and draws conclusions regarding their ability to predict a strategic municipal role in the heat transition based on socio-demographic characteristics. Finally, section 6.4 provides recommendations for municipalities based on both the explanatory and predictive model.

6.1 Limitations

6.1.1 LISS Panel

There are many advantages to the LISS panel as a data source. Firstly, the fact that data access if free of charge for academic purposes is a major advantage. Moreover, the archive has a wide range of cross-sectional and longitudinal data which can be combined using socio-demographic characteristics of the panel members. Additionally, the fact that a representative sample was selected from the population register ensures that all socio-demographic backgrounds are represented in the panel. It is important to note that while the panel is representative of the Dutch population, the samples used in this study may not be, due to a non-response bias and filtering of data. This will be addressed further in section 6.1.2.

A disadvantage of using a panel is that learning effects of experienced respondents may result in responses that vary significantly compared to the response of inexperienced respondents. The responses may be better, because respondents learn how to interpret questions, but they may also be worse if respondents learn how to answer questions in such a way that it reduces the time burden. Though it is not possible to determine the exact effect of these limitations on the results, potential bias in the responses ought to be kept in mind.

6.1.2 Sample

The quality of the samples used in this study is largely dependent on the extent to which different socio-demographic backgrounds are represented. Under- or over-representation of various socio-demographic groups relative to their share within the Dutch population is not necessarily problematic. While the LISS panel contains a set of respondents that is representative of the Dutch population, it is actually expected that certain groups will be under- or over represented in this study because of non-response bias and because the datasets used in this study only contain distinct subsets of the LISS panel. While under- and over-representation are not inherently problematic, under-representation can become problematic if there are too few observations to obtain any useful results. In this case, the model may not be able to find significant relationships with the under-represented socio-demographic characteristic or the model may find results that can not be externally replicated. In both instances, the reliability of the results is called into question. This section will address the limitations associated with the samples used in this study. While notable socio-demographic distributions will be addressed in this section, a full overview of the samples can be found in Appendix 10.10.

The first notable difference between the Dutch population and the samples used in this study is the age distribution. When looking at the age distribution in the Netherlands, 13% of the Dutch population is between the age of 15 and 24, and 15% is between the age of 25 and 34, these categories respectively make up 1% to 10% and 6% to 12% of the samples in this study(Central

Bureau for Statistics 2020). The reason that younger generations are under-represented is likely due to this study's focus on household heads. Given that the preferences and capabilities of household heads are likely most relevant to municipalities, the under-representation of younger generations by itself is not issue in this study. However, the extent of the under-representation calls into question whether there are sufficient observations for younger generations to find reliable results.

The second notable difference between the Dutch population and the samples used in this study is the gender distribution. Women are significantly under-represented in the used samples. The share of female residents in the Netherlands is just over 50%. Meanwhile, five samples in this study have a majority share of male respondents, ranging from 61% to 70%. Again, this distribution is likely visible because the data was filtered to contain only household heads. Only the sample for social trust has more female respondents, namely 54%. In this case, it is assumed that the under-representation of women does not significantly impact the results, because it is expected that there are sufficient female respondents to obtain externally valid results. Aside from these two demographics, no obvious differences were found between the socio-demographic distribution of the Dutch population and of the samples. Though the distribution of the remaining samples are similar to that of the Dutch population, it is still important to point out any minorities that may impact the regression results. An example in this study concerns the number of non-native Dutch respondents. In the Netherlands, approximately 17% of the population consists of ethnic minorities. While the samples used in this study have similar shares of ethnic minority representation, the number of observations for these minorities is low. Again, this may result in insignificant results or in results that are not reliable.

The impact of this limitation is magnified in the datasets that combine multiple inhabitant-specific considerations, because the sample size is significantly reduced. This effect is visible in the 'constrained' and 'mediator' models in step 6, which find fewer significant relationships than the multiple regression models that were defined in step 2. The reduced sample sizes in the combined datasets thus limit the model's ability to find significant relationships, implying that the full conceptual model is most likely incomplete.

6.1.3 Proxies

Another limitation of the research is that secondary data was used. This means that the dependent variables used in the study were chosen somewhat based on convenience and were not designed specifically for this research purpose. Ideally, six questions would have been designed and distributed to address each of the inhabitant-specific considerations by Ebskamp and Verbraak (2019). Given that this was not possible, the best possible data was selected as a proxy for each dependent variable.

The first inhabitant-specific consideration by Ebskamp and Verbraak (2019) addresses people's support for substantive goals of the energy transition. The proxy used in this study, namely support for the goal that all homes must be natural gas-free by 2050, is more specific than the proposed consideration. This means that the proxy does not reflect support for other energy transition goals, like reducing emissions from electricity production or reducing residential emissions through insulation. Given that natural gas-free policy is relatively controversial and that people are generally more supportive of less extreme measures to decarbonize the built sector, support for the heat transition may appear lower than it is in actuality. Though this is important to keep in mind, this study is largely interested in natural gas-free policy specifically, which means that the used proxy may be actually be more valuable than the one proposed by Ebskamp and Verbraak (2019).

The second inhabitant-specific consideration by Ebskamp and Verbraak (2019) addresses people's support for an active role by the municipality. In this study, it was assumed that trust in the municipality and support for the municipality could be used interchangeably. People tend to trust their municipality if it is producing results consistent with their expectations (Montalvo

2010). If people trust their municipality, they are more likely to support the municipalities initiatives because it is assumed that their expectations will be met. A limitation of this assumption is that the municipality's decision to participate in the heat transition may be an action that is not in line with the expectations of the residents, which may thus reduce support. This effect cannot be measured in this data, because it cannot distinguish between political trust inside and outside the context of the heat transition. Another limitation is that the responses for this proxy are poorly distributed. Table 11 in the section on univariate statistics, shows that the majority of the respondents trust their municipality 'fairly much', while only very few do not trust their municipality at all or very much. If the majority of the respondents provide the same response, it potentially becomes difficult for a model to distinguish the minorities.

The third inhabitant-specific consideration by Ebskamp and Verbraak (2019) determines whether people can financially contribute to the heat transition. Based on previous findings, people's ability to live off of their income was chosen as a proxy for people's ability to contribute to the heat transition (Scholte et al. 2020). The issue with this proxy, is that it is hard to determine, on a scale from one to ten, what level of financial capability is sufficient to be able to contribute to the heat transition. Respondent's who ranked their ability to live off of their income a six or higher were considered to be able to contribute, however the arbitrary nature of this scale makes it impossible to identify what level of financial capability is sufficient. Moreover, responses to this question may be biased because respondents can interpret the scale differently. Ultimately, the scale used makes it difficult to identify what level of financial capability is required to contribute to the heat transition. While it is thus not possible to distinguish absolute levels of financial capability, the study may still be able to identify relative financial capability of various socio-demographics.

The fourth inhabitant-specific consideration by Ebskamp and Verbraak (2019) considers whether people have a shared vision regarding the heat transition, because this facilitates collaboration on heat transition initiatives. Social trust was used as a proxy, because it considered a prerequisite for collaboration within the municipality. Additionally, a person's connection to their neighborhood was considered as an additional mediator variable, because it can provide more insights regarding the social dynamics within a neighborhood. Still, the presence of social trust and a neighborhood connection alone do not guarantee that heat transition initiatives will take form. According to Ebskamp and Verbraak (2019) the absence of collaborative heat transition initiatives is not a problem so long as collaboration can be promoted by the municipality. However, collaboration on heat transition initiatives may be problematic if support for the heat transition is lacking, even when social trust and neighborhood connection are present. That is why the proxies are inferior to the 'shared-vision' consideration by Ebskamp and Verbraak (2019).

Aside from the choice of proxy, there are additional limitations pertaining to the social trust and neighborhood connection variables. The arbitrary scale used to measure social trust may result in biased responses due to different interpretations by respondents. Moreover, it is not possible to identify a level of social trust that is conducive to collaboration based on this scale. Regarding a person's neighborhood connection, the distribution of responses is poor. Table 11 in the section on univariate statistics shows that the majority of the respondents feel 'connected' to their neighborhood, while only very few are 'not at all' or 'very' connected. If the majority of the respondents provide the same response, it potentially becomes difficult for a model to distinguish the minorities.

The fifth inhabitant-specific consideration by Ebskamp and Verbraak (2019) considers whether people are motivated to contribute to the heat transition, either in planning, financing or executing heat transition initiatives. The proxy used in this study, namely whether people are considering replacing their heating system with a natural gas-free alternative, is again more specific than the consideration defined by Ebskamp and Verbraak. The proxy only considers whether people are motivated to take a measure that is currently costly and controversial, but does not consider whether they are motivated to take other, less controversial heat transition measures, like improving insulation. Again, this may suggest that the results in this study

underestimate the willingness of people to contribute to planning, financing or executing heat transition initiatives.

The last inhabitant-specific consideration by Ebskamp and Verbraak (2019) asks whether people have previously contributed to the planning, financing or execution of heat transition initiatives. The proxy that is used in this study considers whether individuals have performed energy efficient modifications to their home on account of environmental considerations. There are several issues associated with this proxy. First, it only considers whether people have performed energy efficient home modifications, but does not consider whether other contributions have been made to the heat transition. Second, individuals who already live in sustainable homes may not perform energy efficient modifications because these are not necessary. Accordingly, people who already live in a sustainable home are overlooked. Lastly, the survey question does not specify what is defined as an energy efficient renovation. While some people will consider any modification that reduces energy consumption, like installing energy efficient lighting, others may only think of more costly interventions, like improving insulation, installing solar panels or upgrading the heating system.

6.1.4 Assumptions

Several assumptions were made that ought to be considered. The most important assumption that impacts the usability of the results is that the relationships between all studied variables remain constant over time and that the relevant inputs to the model remain the same. This assumption is essential given that the heat transition is a process that that takes decades to carry out. For the model to remain relevant, it must be assumed that the relationship between socio-demographic characteristics and the inhabitant-specific considerations remain constant and that the inputs remain the same, otherwise neither the explanatory or predictive model can be used for the duration of the heat transition.

This assumption is problematic, because it is not possible to conclude that the relationships and inputs remain constant. On the one hand, expert and public opinions on the heat transition are constantly evolving, meaning that people's support for natural gas-free policy and their intention to adopt natural gas-free heating is expected to change during the duration of the heat transition. On the other hand, a changing political and societal landscape may result in different levels of political and social trust among various socio-demographics. Moreover, technological advancements may reduce the financial burden associated with the heat transition, which may alter people's ability to contribute to the heat transition and thus also impact who has previously made energy efficient modifications to their home.

Though these temporal variations may impact the magnitude of the relationships, this study expects that the general trends associated with certain socio-demographics will remain relatively constant and that certain groups will always be more open to contributing in the heat transition. It is assumed that younger generations, with higher education will remain more open to novel sustainable technologies and that those who also have the financial means to contribute are more likely to do so. Similarly, it is assumed that those who are well-represented in society and have an adequate socio-economic status will continue to have more political and social trust. Accordingly, it is expected that the direction of the discovered relationships will generally remain the same, but that the magnitude may vary based on the changing heat transition context.

The assumption that the relationships and inputs remain constant also shaped some potentially problematic methodological choices. This assumption made it possible to consider data that is not up to date. Particularly the data regarding previous performance of energy efficient renovations and environmental concern, which was collected in 2009, is outdated. This choice was again made based on the assumption that the relationship between socio-demographic characteristics and these variables has not changed between then and now. However, given that climate change has received increasing attention over the past decade, it can be expected that environmental concern may have increased among certain socio-demographics since 2009. Similarly, due

to technological advancements and increased awareness, the characteristics of individuals who have adopted energy efficient modifications to their home may also have changed. Accordingly, it can be expected that the models for 2009 do not fully reflect the current relationship between socio-demographic characteristics, environmental concern and previous energy efficient home modifications.

In more recent datasets, namely those collected in 2016 and 2018, this assumption is not expected to significantly impact the validity of the regression results. It is expected that there have been few socio-political changes in the Netherlands that would result in structural changes in political trust at the municipal level or in changed neighborhood connections. Though trust in national politics may have been altered under the rule of the current cabinet or due to the Dutch childcare benefits scandal, for example, this study expects that this has little impact on trust at the municipal level. Given that it is not possible to identify incidents that may have altered trust in the municipality or neighborhood connections at a local scale, this study assumes that the use of 2016 and 2018 datasets do not significantly impact the validity of corresponding results.

An additional assumption regarding the 2016 and 2018 datasets was that socio-demographic characteristics do not change significantly within this time period. Based on this assumption, the two datasets were combined using only the 2016 socio-demographic characteristics. To test the validity of this assumption, the socio-demographic characteristics of 2016 and 2018 were compared. The majority of the socio-demographic characteristics remained constant within this time period, ranging from 93% to 100% agreement between the two datasets. Two notable differences were found. First, 20% of the respondents entered a higher age category within between 2016 and 2018. Second, only 58% of the respondents remained in the same income group within this time period. In either case, the change in age and income is generally so limited that it is not expected to impact a person's response regarding their trust in the municipality or connection to the neighborhood. Accordingly, it is expected that this assumption had little impact on the validity of the results.

6.2 Explanatory Model

This section will discuss results pertaining to the explanatory model and attempt to answer the first research question. The first research question asks how socio-demographic characteristics impact the preferred ambition level and responsibility distribution in the heat transition. According to Ebskamp and Vebraak (2019), the preferred ambition level and responsibility distribution are decided based upon a set of considerations. To answer the research question, this section will determine how socio-demographic characteristics impact the inhabitant-specific considerations by Ebskamp and Verbraak (2019).

Each inhabitant-specific consideration will be addressed separately. First, the 'step 2' results are used to verify or reject the hypotheses defined in section 3.3. Next, the 'step 6' mediation analysis and 'step 7' conceptual model will be used in combination with previous literature to explain the observed results. Finally, the first research question is answered by summarizing the relationships between socio-demographic characteristics and each inhabitants-specific consideration and explaining their impact on the heat transition ambition level and responsibility distribution.

6.2.1 Support for Natural Gas-Free Policy

Age

The data suggests that there is no statistically significant association between age and natural gas-free policy support. This result contradicts a plethora of evidence that environmental concern and climate policy support decreases with age (Buttel 1979; Hornback 1974; Mohai and

Twight 1987; Dietz, Stern, and Guagnano 1998; Hamilton 2011). While the absence of linear aging effects could shed light on the debate regarding the impact of aging and cohort effects, this study can neither prove a negative nor verify whether cohort effects are present, given that age was only considered as an ordinal variable. Scholte et al. (2020) use the same data as this study in a structural equation model and find that only people aged 45 to 54 and 65 to 74 have significantly lower natural gas-free policy support than the reference age category (18-34 years). These findings indicate why a linear aging effects are not visible in this study and may plead in favor of cohort effects. Mohai and Twight (1987) also claim that aging effects do not automatically result in conservatism and also support the theory that cohorts are responsible for variations in environmental concern. However, the absence of significant results in this study prevent it from making a useful contribution to this debate.

Gender

Being female has a significant positive effect on natural gas-free policy support. This finding is in line with the hypothesized effect. Due to the addition of the environmental concern variable, this study was able to confirm that women are significantly more concerned about the environment than men. Though the mediating effect of environmental concern on natural gas-free policy support could not be tested in this study, it can be assumed that increased natural gas-free policy support among women exists due to their generally higher environmental concern. In the theoretical background, this effect was explained based on gender socialization theory, however this cannot be verified in this study (Scholte et al. 2020; McCright 2010).

Education Level

In line with the proposed hypothesis, education level is positively associated with natural gas-free policy support. The direct effect of education level on natural gas-free policy support can potentially be explained by increased problem awareness among higher educated individuals, which had previously been found to increase the perceived political priority of the environment (Scholte et al. 2020; Dekker, Muis, et al. 2019; Dietz, Stern, and Guagnano 1998; Van Dalen and Henkens 2019; Bradley et al. 2020). Though the mediating effect of environmental concern cannot be tested, this study does find a significant positive relationship between environmental concern and education level. Additionally, the full model indicates that the effect of education level on natural gas-free policy support is partially mediated by social trust. Previous studies have indicated that social trust increases support for climate policy, because people are more supportive of stringent action when they believe others will contribute their respective share (Cologna and Siegrist 2020; Koon, Chan, and Sharma 2020).

Income Level

As was hypothesized, this study demonstrates that there is no significant relationship between income and support for natural gas-free policy. This result is reflected in the absence of a significant relationship between income and environmental concern. Scholte et al. (2020) find the same results and claimed that the impact of climate policy on your life is not dependent on your income, but on the ability to live off of your income. Like Scholte et al. (2020), this study finds a significant relationship between a person's ability to live off of their income and their support for natural gas-free policy.

Interestingly, in the full model, the effect of financial capability on natural gas-free policy support is fully mediated by social trust. Unlike the theory by Scholte et al. (2020) these findings may suggest that the ability to live off of your income does not have a direct effect on natural gas-free policy support and that people's faith in others may be paramount in determining this support. Accordingly, the concern regarding a fair distribution of responsibility and costs in the heat transition may be more important than the effect of the costs on one's lifestyle.

Ethnic Background

As was expected, ethnic background does not have a significant effect on environmental concern

or on support for natural gas-free policy.

Household Composition

In line with the hypothesis, this study did not find a significant relationship between having a partner and natural gas-free policy support. Contrary to the hypothesis, the number of children was found to be negatively associated with natural gas-free policy support. In the full conceptual model, this effect disappears due to a mediating effect by financial capability. Given that the number of children reduces financial capability, this results in lower social trust and natural gas-free policy support. If these mediating effects are valid, the study would corroborate previous findings that the number of children does not have a direct effect on natural gas-free policy support (De Witt and Schmeets 2018).

Urbanity

Contrary to the hypothesis, no significant relationship was found between urbanity and natural gas-free policy support. As Scholte et al. (2020) explain, the difference in natural gas-free policy support between urban and rural citizens may largely be explained by other socio-demographic characteristics. Given that the 'step 1' bivariate regression did yield a significant coefficient for urbanity, it can be assumed that urbanity is correlated with other socio-demographic characteristics and therefore does not have a significant independent effect. Other studies have suggested that urbanity has a direct effect due to increased exposure to environmental issues, however this theory is not confirmed by this study (Drews and Van Den Bergh 2016; Buttel 1979; Mohai and Twight 1987; Dietz, Stern, and Guagnano 1998).

Homeownership

The results indicate that homeownership is negatively associated with natural gas-free policy support. This result is in line with the hypothesis and previous findings (Programma Aardgasvrije Wijken 2020a; Programma Aardgasvrije Wijken 2020b). A likely explanation for this result is that homeowners are concerned about the financial and organizational burden associated with natural gas-free policy, which is not carried by renters. As previous studies have suggested, this result points out that support for natural gas-free policy is not only dependent on a person's environmental concern, but is also motivated or discouraged by the associated costs and effort (De Witt and Schmeets 2018; Michelsen and Madlener 2013; Arroyo and Carrete 2019; Organ, Proverbs, and Squires 2013).

Impact on Heat Transition Ambition Level and Responsibility Distribution

According to Ebskamp and Verbraak (2019), support for the heat transition among residents should be considered when deciding upon the municipality's ambition level in the heat transition. The results indicate that there is more support for natural gas-free policy among female and higher educated individuals who do not own a home, given that these variables directly impact natural gas-free policy support. Additionally, the number of children and financial capability of a household can indirectly impact natural-gas free policy support through social trust. An increase in number of children decreases financial capability, social trust and natural-gas free policy support.

When addressing the first research question, these results suggest that women, higher educated individuals and renters are more receptive to high ambition levels in the heat transition. Meanwhile, more resistance may be expected among men, lower-educated individuals and homeowners if the municipality has ambitious goals in the heat transition.

6.2.2 Trust in the Municipality

Age

In line with the proposed hypothesis, the 'step 2' results indicate that age is positively associated with trust in the municipality. Previous studies find the same results (Siebers, Gradus, and Grotens 2019; Montalvo 2010; Freitag and Ackermann 2016; Dekker and Ridder 2020). While the Government of the Netherlands (2019) explains these effects based on superior representation of older generations within the municipality, the results of this study's mediation analysis may indicate a different cause.

The findings suggest that the effect of age on trust in the municipality is fully mediated by a person's social trust and connection to the neighborhood. As was mentioned in the theoretical background, trust in the municipality is largely shaped by the capabilities of the municipality and their ability to meet the residents' expectations (Montalvo 2010; Coolen 2017). If people feel that they live in close-knit community where others can be trusted, they may associate this with proper functioning of the municipality. Meanwhile, if social trust and a community feeling is lacking, they may assign blame to the municipality.

Gender

Contrary to this study's predictions, there was no significant relationship between gender and trust in the municipality. Previous studies find that women are less trusting in the municipality because they are under-represented and their concerns are not always addressed (Ulbig 2002; Schwindt-Bayer and Mishler 2005). This study may suggest that lower physical representation of women does not significantly affect the perceived legitimacy and capability of Dutch municipalities. It is important to keep in mind, however, that the absence of significant results may also be due to the poor distribution of responses for this dependent variable. Given that the majority of the respondents trust their municipality 'fairly much', it may be hard to distinguish subtle differences in trust among men and women.

Education Level

A significant positive relationship was found between a person's education level and their trust in the municipality. This result is in line with the hypothesis and corroborates previous findings (Noordzij, Van der Waal, and De Koster 2019; Christensen, Yamamoto, and Aoyagi 2008; Government of the Netherlands 2019b; Coolen 2017; Wennekers et al. 2019). The results indicate that the effect of education level on a person's trust in the municipality is fully mediated by social trust, financial capability and their connection to their neighborhood, which may indicate why a relationship between education level and municipal trust is visible.

Again, social trust and a connection to the neighborhood may correspond to the perception that the municipality is properly functioning or is at least not severely dysfunctional. Moreover, the materialist approach that was explained in the theoretical background may explain why people who are financially capable are more trusting in their municipality (Noordzij, Van der Waal, and De Koster 2019). This theory states that people in a privileged socio-economic position are likely more satisfied with their economic resources and the system that facilitated their socio-economic status. Result in this study cannot verify whether the informational or representational approach by Noordzij et al. (2019) are also relevant towards explaining the impact of education level on municipal trust.

Income Level

No significant relationship was found between a person's income and their level of social trust. It was hypothesized that a positive relationship would be found based on the materialist approach and previous research (Scholte et al. 2020; Wennekers et al. 2019). The reason that income may not yield a significant result, is that income is not directly correlated with the ability of a

household to live off of its income. This would also explain why financial capability does have a significant effect on trust in the municipality while income does not.

Ethnic Background

Contrary to the hypothesis, ethnicity did not have a significant effect on trust in the municipality. In the bivariate regression that was performed in step 1, Western immigrants generally had lower trust than Dutch natives, while no significant difference was found with non-Western immigrants. Given that no significant results were found in the 'step 2' multiple regression, it can be assumed that ethnicity does not have an independent effect on trust in the municipality. These results contradict previous findings, which suggest that minorities tend to be less satisfied with their municipal leadership due to under-representation (Baldassare 1985; Ulbig 2007).

While the results may suggest that under-representation within municipal leadership is not a problem in the Netherlands, this claim cannot be made because representation may vary significantly between municipalities. Moreover, the limited data on ethnic minorities may imply that the results found in this study are not generalizable. Additionally, the poor distribution of responses may explain the absence of significant results.

Urbanity

No significant relationship was found between urbanity and trust in the municipality. It was hypothesized that increased urbanity would result in lower municipal trust, because it becomes harder for the municipality to cater to the needs of all its residents. It is difficult to determine why no relationship was found in this study, especially considering that the Dutch Government found a negative relationship between urbanity and trust in the municipality (Government of the Netherlands 2019b). The most likely explanation is the poor response distribution. Given that the majority of the sample trusts the municipality 'fairly much', it becomes hard to distinguish potentially subtle differences in municipal trust among urban and rural residents.

Household composition

In line with the hypotheses, no significant relationship was found between household composition and trust in the municipality.

Homeownership

In line with the hypotheses, no significant relationship was found between homeownership and trust in the municipality.

Impact on Heat Transition Ambition Level and Responsibility Distribution

According to Ebskamp and Verbraak (2019), residents' support for the municipality should be considered when deciding upon the municipality's ambition level in the heat transition. The results indicate that there are higher levels of municipal trust among older and higher educated individuals, due to the increased financial capability, social trust and neighborhood connection among these individuals.

When addressing the first research question, these results suggest that older and higher educated individuals may be more receptive of strict heat transition goals set by the municipality. Meanwhile, younger and lower-educated individuals may show more resistance if the municipality takes a steering role in the heat transition.

6.2.3 Financial Capability

Age

The data suggests that there is no statistically significant association between age and financial capability, suggesting that the null hypothesis cannot be rejected. Previous studies indicate that financial capability generally increases with age due to increased income but also due to improved spending patterns and less debt related behavior (Xiao and C. Chen 2015; Allen, Albertone, and Redpath 2018). The absence of a significant relationship may indicate that financial capability does not increase or decrease linearly with age, but instead varies depending on different phases in life. This, however, cannot be verified with the methodological approach used in this study. Another potential explanation for the absence of significant results may be that the scale on which respondents were asked to rank their ability to live off of their income is subject to bias.

Gender

While it was hypothesized that gender would not have an independent effect on financial capability, the results indicate that women generally have a lower financial capability than men. It was assumed that effects of a wage gap and part-time employment would be reflected in the income variable due to the correlation between these socio-demographic characteristics. It appears, however, that the effect of gender on financial capability extends beyond the difference in income.

Still, previous studies do not find that gender impacts financial capability (Taylor 2011; A. Atkinson et al. 2006). A potential explanation for the difference could either be that women rank their ability to live off of their income lower due to a stronger innate risk aversion, or that women have a different spending behavior than men (Roumeliotou and Rontos 2009). Another more likely explanation is that the model is unable to produce reliable coefficients for these variables due to multicollinearity. The presence of multicollinearity suggests that correlations between coefficient are so strong that the model is unable to independently test their effects on the dependent variable, because a change in one independent variable imminently results in a change in the collinear variable. If the model cannot distinguish between the effect of income and gender, it makes sense that both would yield a significant coefficient.

Education Level

It was expected that education level does not have a significant independent effect on financial capability, due to its correlation with income. The results indicate that education is positively associated with financial capability, while previous studies indicate that education level does not impact financial capability beyond its impact on income (Dekker, Muis, et al. 2019; Allen, Albertone, and Redpath 2018; Arts et al. 2019; Wennekers et al. 2019; Bahmani-Oskooee, Hegerty, and Wilmeth 2008). Again, one explanation may be that a person's education level impacts their interpretation of the ability to live off of their income, but a more likely explanation is the presence of multicollinearity between education level and income.

Income Level

In line with the hypothesis, income was found to have a positive effect on a person's ability to live of off their income. Households with a higher income generally have a higher disposable income and can save more than low income households (Arts et al. 2019). This increased ability to live off of one's income thus increases the ability to contribute financially to the heat transition.

Ethnic Background

It was hypothesized that ethnicity would not have an independent effect on ethnicity. Contrary to this hypothesis, the findings indicate that Western immigrants have a lower financial capability than Dutch natives. Previous studies do not find a significant relationship between ethnicity and financial capability (Arts et al. 2019; Ooijervaar, Bloemendal, and Boerdam 2016;

Olsthoorn, Koot, and Hoff 2020; Wennekers et al. 2019). It is thus expected that these results are not generalizable because there are insufficient observations for Western and non-Western immigrants to assume external validity of the model.

Household Composition

In line with the hypothesis, people's perceived ability to live off of their income decreases with the number of children in the household. Previous studies find the same results, which can be explained based on the higher living costs associated with a larger household (Arts et al. 2019; Allen, Albertone, and Redpath 2018; Olsthoorn, Koot, and Hoff 2020; Wennekers et al. 2019). Based on these findings, it can be assumed that families have a lower ability to financially contribute to the heat transition.

Contrary to the hypothesized effect that having a partner improves financial capability, the results indicate that financial capability decreases when living with a partner. The hypothesized effect was based on the assumption that both partners contribute to the household income, however additional data would be required to distinguish between one- and two-income households. Given that the information for this variable is incomplete, it is not possible to further discuss the impact of having a partner on financial capability.

Urbanity

In line with the hypothesis, no significant relationship was found between urbanity and financial capability. This result corroborates the findings of previous studies.

Homeownership

Lastly, a positive relationship was found between home-ownership and financial capability. This result is in line with the hypothesized effect. It is not possible to distinguish whether home-ownership improves financial capability or whether it is a result of financial capability. While most studies suggest the latter based on the premise that a significant investment is required to purchase a home, the former may also be true when considering the financial impact of low mortgage interest rates compared high rental prices in the Netherlands (Oh 2004; Haurin et al. 2002; Rohe and Lindblad 2013; Stotz 2019).

Impact on Heat Transition Ambition Level and Responsibility Distribution

According to Ebskamp and Verbraak (2019), residents' ability to financially contribute to the heat transition ought to be considered when deciding upon the responsibility distribution. The results indicate that there are higher levels of financial capability in households with a male household head and few or no children. Moreover, financial capability was found to increase with income and education level.

When addressing the first research question, these results suggest that male, higher educated individuals with a high income and small household size may have the financial means to contribute to the heat transition and can thus be given more responsibility for its execution. Meanwhile, female, lower educated individuals with a lower income or a large household may not have the financial means to contribute to the heat transition. This would suggest that the municipality must take more responsibility towards achieving the heat transition targets.

6.2.4 Social Trust

Age

Contrary to the hypothesis, age was found to have a positive effect on social trust. Meanwhile, previous studies by Dutch institutions have indicated that trust decreases with age (Schmeets 2018; Arends and Schmeets 2015). Given that these studies also use a sample of the Dutch

population and the same survey question, it seems unlikely that completely opposite effects would be found. One explanation may be that this study modelled age as a numeric variable instead of a factor, which means that any non-linear effects cannot be taken into account. Another explanation may be that younger generations are under-represented, as was suggested in the limitations section. Given the inconsistency with previous results, the positive relationship found in this study ought to be considered with caution.

As was hypothesized, a significant relationship was found between a person's age and their connection to the neighborhood. This effect corroborates previous studies which suggest that a neighborhood connection is facilitated due to residential stability of older generations (Letki 2008; Wickes et al. 2013). The 'step 6' mediation analysis indicated that the impact of a person's connection to their neighborhood on their social trust is fully mediated by trust in the municipality. Given that age has a significant effect on connection to the neighborhood, this mediation effect may explain why there is a positive relationship between age and social trust. However, based on the models defined in this study, it was not possible to verify this explanation.

Gender

The results indicate that there is no significant relationship between gender and social trust, nor between gender and a person's connection to their neighborhood. While the latter was hypothesized, the former is not in line with the hypothesized effect. A significant negative effect was expected between gender and social trust due to the generally higher risk aversion among women (Roumeliotou and Rontos 2009). This result also contradicts previous studies in the Netherlands, which find that women are less trusting than men (Schmeets 2018; Arends and Schmeets 2015). Given that this study has a substantial sample size and makes use of the same proxy for social trust as the previous studies in the Netherlands, it is unclear why different effects are found. It can only be concluded that this study is unable to disprove the null hypothesis.

Education Level

In line with the hypothesis, the results indicate that there is a positive relationship between education level and social trust. The results indicate that the effect of education on social trust is partially mediated by financial capability. This result corroborates previous findings that have suggested that social trust increases due to the economic wellness, skills and resources that are generally associated with a higher education level (Roumeliotou and Rontos 2009; Tolsma and Gesthuizen 2009).

A negative relationship was found between education level and a person's connection to the neighborhood. This is in line with the hypothesized effect and corroborates previous findings. Like previous studies, this study cannot identify why lower educated individuals have stronger neighborhood connections (Letki 2008; Wickes et al. 2013; Tolsma and Gesthuizen 2009).

Income Level

The results indicate that there is a positive relationship between income and social trust. Previous studies suggest that social trust increases in high income neighborhoods due to increased spending on public goods and community development (Roumeliotou and Rontos 2009; Tolsma and Gesthuizen 2009). While this study cannot verify this theory, it does indicate that the effect of income on social trust is fully mediated by financial capability. This may again suggest that social trust is directly affected by a person's economic wellness and resources.

No significant relationship was found between income and a person's connection to their neighborhood. It was hypothesized that income level would increase a person's neighborhood connection based on the premise that high income neighborhoods spend more on community development (Laméris, Hipp, and Tolsma 2018; Letki 2008; Wickes et al. 2013; Tolsma and Gesthuizen 2009). Given that this study does not find a significant relationship, this theory cannot be verified.

Ethnic Background

In line with the hypothesized effect, Western and non-Western immigrants were found to have lower social trust than Dutch natives. The most likely explanation for this effect is that ethnic minorities often feel segregated (Den Ridder et al. 2019) and that they have conflicting values and economic interests (Wickes et al. 2013; Phan, Blumer, and Demaiter 2009; Havekes et al. 2014; Gorbunova, Ambrasat, and Scheve 2015; Baldassare 1985; Mundaca, Busch, and Schwer 2018). Though it is not possible to conclusively state what causes this discrepancy in social trust, these explanations are most common in previous literature. In the full conceptual model, ethnicity does not have a significant effect on social trust, which suggests that ethnicity is no longer a determinant of social trust when financial capability and trust in the municipality are included as explanatory variables for social trust.

Based on the same reasoning, it was also expected that ethnic minorities are less connected to their neighborhood. The results indicate that there is no significant relationship between ethnicity and a person's neighborhood connection. While it may be expected that ethnic diversity reduces neighborhood connections according to Putnam's conflict theory, this study cannot verify or reject this theory because it contains no information regarding ethnic diversity at the neighborhood level. While on a national level, ethnic minorities are inherently minorities, at the neighborhood level, there may be limited ethnic diversity. Accordingly, it makes sense that significant results were obtained for social trust, but not for a neighborhood connection.

Household Composition

No significant relationship was expected between the number of children and a person's social trust and neighborhood connection. The results indicate that there is a negative relationship between the number of children in the household and social trust. No studies were found to indicate that the number of children in a household impacts social trust. The most likely explanation for the obtained results is that there is an undetected mediation effect of financial capability on social trust. The number of children has a significant effect on financial capability, however the constrained model for social trust did not include number of children as a significant coefficient due to the limited sample size compared to step 2 results. Accordingly, a potential full mediation effect of financial capability on social trust was ignored in the 'step 6' mediation analysis. Based on the reduced sample size and potential mediation effects of financial capability, it also becomes apparent why the number of children in a household does not impact social trust in the full conceptual model.

Again, no significant relationship was expected between living with or without a partner, and a person's social trust and neighborhood connection. The result indicate that living with a partner negatively effects a person's social trust. Though previous studies do not find consistent results regarding the impact of partnership on social trust, studies that do find significant results generally find a positive effect of partnership on social trust (Schmeets 2018; McCabe 2012; Arends and Schmeets 2015). In this case, the questionable results found in this study cannot be explained by limitations in the mediation analysis nor by limitations in the sample. In the full conceptual model, having a partner does not have a significant effect on social trust, which suggests that partnership is no longer a determinant of social trust when financial capability and trust in the municipality are included as explanatory variables for social trust. Based on the models defined in this study, it is not possible to conclude why partnership has a significant impact on social trust in the 'step 2' results, but does not have a significant effect in the final conceptual model.

Urbanity

The study predicted that urbanity would have a negative effect on social trust and connection to the neighborhood, based on the premise that residential stability in rural areas increases a connection to the community, which in turn promotes social trust (Siebers, Gradus, and Grotens 2019; Baldassare 1985; Stein 2014; Roumeliotou and Rontos 2009). As was expected, a negative relationship was found between urbanity and a person's connection to their neighborhood.

Interestingly, no significant relationship was found between urbanity and social trust in the 'step 2' results, while urbanity did have a significant negative effect on social trust in the full conceptual model. This indicates that urbanity alone cannot explain social trust, but that a person's connection to the neighborhood in combination with urbanity can explain a person's social trust.

Homeownership

Homeownership was found to have a positive effect on social trust and a person's connection to the neighborhood. Meanwhile, it was expected that homeownership would not shape social trust due to the limited availability of previous studies. Though no mediation effects were found in the 'step 6' mediation analysis, mediation by financial capability is expected to be the main explanation for the obtained results. In the 'step 2' results, homeownership has a significant effect on both financial capability and social trust, however the 'step 6' constrained model for social trust does not indicate a significant effect, probably due to the decreased sample size. Accordingly, full or partial mediation by financial capability is ignored. Moreover, a person's connection to their neighborhood may also mediate the effect of homeownership on social trust. While neither effect can be verified based on the current models, these appear to be the most likely explanations for the obtained results.

Impact on Heat Transition Ambition Level and Responsibility Distribution

According to Ebskamp and Verbraak (2019), residents' ability to collaborate on heat transition initiatives ought to be considered when deciding upon the responsibility distribution. This study assumed that the ability to collaborate was positively associated with social trust and a neighborhood connection. The results indicate that higher levels of collaboration are expected among older, higher educated individuals who own their home and live in rural municipalities. Each of these socio-demographic characteristics was found to have a positive direct effect on a person's social trust, neighborhood connection or both. Additionally, the ability to collaborate is expected to be higher among individuals who have a higher financial capability and trust in the municipality, considering that both positively impact social trust.

When addressing the first research question, these results suggest that older, higher educated individuals who own their home and live in rural areas can be assigned more responsibility in the heat transition due to their expected ability to collaborate on heat transition initiatives. Meanwhile, younger, lower educated individuals who rent their home and live in urban areas are expected to be less willing and able to collaborate on heat transition initiatives. Accordingly, the municipality ought to take more responsibility in coordinating and executing the heat transition.

6.2.5 Intention to Adopt Natural Gas-Free Heating

Age

A negative relationship was expected between age and a person's intention to adopt natural gas-free heating, however, the 'step 2' results indicate that the negative relationship between age and the intention to adopt natural gas-free heating is not statistically significant. Interestingly, the 'step 6' mediation analysis indicates that age does have a significant negative effect on the intention to adopt natural gas-free heating in the 'full' model that includes support for natural gas-free policy as a mediator. This would suggest that age cannot independently explain someone's intention to adopt natural gas-free heating, but that it does impact this intention when it is considered in combination with natural gas-free policy support. This finding is in line with previous studies that suggest a decrease in motivation to adopt energy efficient technologies as a person ages because younger generations have more positive attitudes towards these technologies and are more likely to ascribe the responsibility to combat climate change to themselves (Scholte et al. 2020; Haren, Huizen, and Schilder 2019).

Gender

The results indicate that women are more likely to consider replacing their heating system with a natural gas-free alternative. This study expected that there would be no significant relationship between gender and the motivation to adopt natural gas-free heating based on the premise that more pro-environmental attitudes among women do not always translate to more pro-environmental behavioral intentions (Scholte et al. 2020; Mortensen, Heiselberg, and Knudstrup 2014; Kollmuss and Agyeman 2002; Petrovich, Hille, and Wüstenhagen 2019; Arroyo and Carrete 2019; Li et al. 2019). This study indicates that the effect of gender on the motivation to adopt natural gas-free heating is partially mediated by a person's support for natural gas-free policy, which would suggest that the more pro-environmental attitude among women translates into a greater intention to contribute to the heat transition.

Education Level

In line with the hypothesis, this study finds a positive relationship between education level and the intention to adopt natural gas-free heating. In the full model, the effect of education level on the intention to adopt natural gas-free heating was fully mediated by a person's support for natural gas-free policy. This result is in line with previous studies that indicate an increased intention to adopt energy efficient technologies with increased education level and climate policy support (Scholte et al. 2020; Weiss, Dunkelberg, and Vogelpohl 2012; Arroyo and Carrete 2019; Prasad Koirala et al. 2018; Azizi, Nair, and Olofsson 2019; Li et al. 2019). While the models used in this study cannot test this effect, it is important to keep in mind the potential role of financial capability in this relationship. Given that natural gas-free heating is expensive, it is possible that increased financial capability among higher educated individuals increases both their support for natural gas-free policy and their intention to adopt natural gas-free heating.

Income Level

This study expected that income would have a positive effect on the intention to adopt natural gas-free heating, because low income households are less likely to have the financial means to adopt natural gas-free heating and are thus expected to be less likely to consider adopting natural gas-free heating. The result indicate that income does not have a direct effect on the intention to adopt natural gas-free heating. This result may again be explained based on the fact that financial capability, rather than income, is a more important indicator of a person's ability to contribute to the heat transition. Financial capability was found to have a significant effect on the motivation to adopt natural gas-free heating, though this effect is fully mediated by social trust and natural gas-free policy support.

Ethnic Background

In line with the hypotheses, this study indicates that ethnic background does not have a significant effect on the intention to adopt natural gas-free heating.

Household Composition

The results indicate that there is no significant relationship between the number of children in a household and the intention to adopt natural gas-free heating. This result is in line with the hypothesized effect.

It was also expected that partnership would not have a significant effect on the intention to adopt natural gas-free heating based on the limited evidence suggesting the contrary. The results indicate that living with a partner increases the intention to adopt natural gas-free heating. This finding is in line with a previous study that suggested the financial risk of adopting natural gas-free heating is perceived greater among single-adult households (Scholte et al. 2020). In the full model, partnership no longer impacts the intention to adopt natural gas-free heating. This can likely be explained by mediation effects that were not found in the mediation analysis. The 'step 2' models find a significant relationship between partnership and the intention to

adopt natural gas-free heating, social trust, and financial capability. Meanwhile, the 'step 6' constrained model for the intention to adopt natural gas-free heating does not find a significant relationship with partnership, likely due to the inclusion of financial capability. Accordingly, full or partial mediation may have been undetected.

Urbanity

In line with the hypotheses, this study indicates that urbanity does not have a significant effect on the intention to adopt natural gas-free heating.

Homeownership

While it was hypothesized that homeownership would not have a significant effect on the intention to adopt natural gas-free heating, this effect could not be tested because the entire sample consisted of homeowners. Accordingly, this study cannot discuss the impact of homeownership on the intention to adopt natural gas-free heating.

Impact on Heat Transition Ambition Level and Responsibility Distribution

According to Ebskamp and Verbraak (2019), residents' motivation to contribute to the heat transition should be considered when deciding upon the responsibility distribution in the heat transition. The results indicate that there is more motivation to adopt natural gas-free heating among younger and female individuals, given that these variables directly impact natural gas-free policy support. Additionally, higher education level and financial capability of residents can indirectly indicate a higher level of motivation, due to the increased social trust associated with these characteristics.

When addressing the first research question, these results suggest that younger, female and higher educated individuals are more willing to contribute to the heat transition, which is conducive to a less active role by the municipality. Meanwhile, older, male and lower-educated individuals may be less motivated to contribute to the heat transition, which would require the municipality to take on more responsibility.

6.2.6 Previous Energy Efficient Home Modifications

Age

In line with the hypothesis, the results indicate that there is a negative relationship between a person's age and previous performance of energy efficient home modifications. This finding is in line with previous studies on energy efficient renovations, which find that older generations are less likely to have performed energy efficient modifications to their home (Scholte et al. 2020; Curtis, McCoy, and Aravena 2018). While some studies suggest non-linear effects, these were not tested in this study given that age was a numerical variable (Das, Richman, and Brown 2018; Ebrahimigharehbaghi et al. 2019). The final model is unable to clarify why this effect is visible.

It was expected that that lower adoption rates among older generations would occur due to lower environmental concern, however age was not found to have a significant effect on environmental concern in this study. A potential explanation for the obtained result thus goes beyond the information contained in the model. Aside from socio-demographic characteristics, the theoretical framework claimed that the Theory of Planned Behavior could also potentially explain why people adopt energy efficient modifications in their home. This theory claims that intention to engage in a certain behavior is the leading predictor of actual engagement in the behavior (Ajzen 1985; Arli et al. 2019; M.-f. Chen 2016). Given that the intention to adopt natural gas-free heating was negatively associated with age in this study, this may explain why previous energy efficient modifications are also negatively associated with age according to the

TPB.

Gender

The study did not find a significant relationship between gender and previous performance of energy efficient modifications in one's home. This result is in line with the hypothesized effect.

Education Level

The results indicate that the previous adoption of energy efficient modifications in one's home is not related to the education level of respondents. It was expected, however, that higher educated individuals were more likely to have adopted energy efficient modifications in their home, due higher environmental concern and increased openness to new technologies (Jansson, Marell, and Nordlund 2011; Das, Richman, and Brown 2018). The results for environmental concern confirm the theory that a higher education level is positively associated with environmental concern. Interestingly, however, environmental concern was found to have a negative effect on the previous adoption of energy efficient renovations. Though studies generally agree that environmental concern alone is not a predictor of sustainable behavior, the two are generally found to be positively correlated with one another (Ajzen 1985; Arli et al. 2019; M.-f. Chen 2016; Kollmuss and Agyeman 2002). Given the contradictory nature of these results compared to previous studies, it is assumed that the limitations associated with using 'previous energy efficient modifications' as a proxy for previous participation in the heat transition considerably limits the validity and usability of the results.

Income Level

Again, a positive relationship was expected between income and previous performance of energy efficient modifications in one's home, however no significant relationship was found. Previous studies have indicates that a higher disposable income results in greater financial freedom to invest in sustainable purchases (Scholte et al. 2020; Galvin 2019; Das, Richman, and Brown 2018; Jansson 2011; Chattopadhyay Mukherjee and Ryan 2020; Petrovich, Hille, and Wüstenhagen 2019; Jacksohn et al. 2019; He and Veronesi 2017; Vasseur and Kemp 2015a; Vasseur and Kemp 2015b; K. Westin, Jansson, and Nordlund 2018; J. Atkinson et al. 2019). A potential explanation for the contradictory results in this study may be that financial capability, rather than income, determines whether people have previously adopted energy efficient renovations, however this could not be determined based on the data used in this study. Again, the more likely explanation is that the proxy does not measure the desired effect due to the limitations that were previously discussed.

Ethnic Background

While it was hypothesized that ethnicity would not have a significant effect on the previous adoption of energy efficient modifications in the home, this effect could not be tested because the data did not contain information on the ethnicity of respondents. Accordingly, this study cannot discuss the relationship between ethnicity and previous performance of energy efficient renovations.

Household Composition

The 'step 2' results indicate that household composition is not associated with previous performance of energy efficient renovations. This result contradicts previous studies that find a positive relationship between household size and previous adoption of energy efficient modifications in the home (Chattopadhyay Mukherjee and Ryan 2020; Petrovich, Hille, and Wüstenhagen 2019; Das, Richman, and Brown 2018; Vasseur and Kemp 2015a). This effect was expected because the financial capability of two-income households is higher, and the potential energy savings increase along with household size. However, given that household composition does not impact the intention to make energy efficient modification according to previous literature, and that intention is the primary predictor of a behavior according to the TPB, it would appear

logical that household composition is not related to previous performance of energy efficient renovations. This argument supports the results found in this study.

Interestingly, the 'step 5' results indicate that having a partner is negatively associated with previous energy efficient modifications. This result contradicts previous findings and the TPB. This result can potentially be explained based on the incorrect assumption made in previous literature, that living with a partner increases financial capability and thus the ability to adopt energy efficient modifications (Das, Richman, and Brown 2018). This study finds that financial capability is not positively associated with having a partner, because the effect on financial capability depends on whether one or both partner have an income. Given that this study finds a negative relationship between having a partner and financial capability, it seems likely that the reduced financial capability associated with partnership would result in decreased opportunities for energy efficient modifications. This potential explanation cannot be confirmed by the data however, because the impact of financial capability on previous energy efficient modifications could not be measured.

When considering these results for household composition, it is important to keep in mind that the proxy used in this study has many limitations. Accordingly, the impact of household composition on previous adoption of energy efficient modifications remains questionable.

Urbanity

The results indicate that urbanity is not associated with previous performance of energy efficient renovations. The study did not hypothesize regarding the effect of urbanity on previous energy efficient renovations due to the absence of previous literature and the contradictory arguments regarding the potential impact of urbanity. Given the questionable validity of the proxy, this study also will not draw conclusions regarding the effect of urbanity on previous adoption of energy efficient renovations.

Homeownership

The results indicate that homeownership is not significantly associated with previous adoption of energy efficient renovations. This result contradicts the hypothesis, which argued that energy efficient renovations were more likely among homeowners, because it was considered irrational for renters to invest in energy efficient modifications of their home. However, given that the survey question did not specify what is classified as an energy efficient modification, it becomes impossible to distinguish whether low-cost investments (e.g. installing energy efficient light bulbs) and high-cost investments (e.g. insulation the home) were more or less common among homeowners and renters. Again, the limitations of the proxy call into question the validity of the results.

Impact on Heat Transition Ambition Level and Responsibility Distribution

According to Ebskamp and Verbraak (2019), previous contributions to the heat transition by residents should be considered when deciding upon the responsibility distribution in the heat transition. The results indicate that previous energy efficient home modifications are more common among younger individuals and individuals who have lower environmental concern. Based on the wide range of contradictory results found for this inhabitant-specific consideration, it is concluded that this study's model on previous performance of energy efficient home modifications cannot be used by municipalities to help determine a strategic municipal role. Given that the proxy for previous participation in the heat transition is unreliable, the obtained results are questionable and using them to determine a strategic municipal role would be unwise.

6.3 Predictive Model

This section will discuss the quality and applicability of the predictive models. Again, each inhabitant-specific consideration is addressed separately. For each model, the quality will be assessed based upon their calibration, discrimination and cross-validation results. Based on these results, conclusions are drawn regarding the ability of each model to predict a municipal strategic role in the heat transition.

6.3.1 Support for Natural Gas-Free Policy

The optimal model to predict support for natural gas-free policy includes gender, education level, number of children, urbanity and homeownership as predictors. The Hosmer-Lemeshow test and corresponding calibration plot for this model indicate that the model is well-calibrated. The calibration plot indicates that the model does not consistently over- or underestimate the predicted probabilities compared to the observed probabilities. However, the model also indicates that the observed and predicted probabilities all range between 0.25 and 0.75, which suggests that the discriminative power of the model is limited.

This result is confirmed by the ROC curves and corresponding c-statistic, which together indicate that there is only a 64.7% chance that the model can correctly identify whether a person is for or against natural gas-free policy. This probability is only 14.7% higher than guessing a person's support without any additional intel. The discrimination histogram also indicates the significant overlap between the predicted probabilities for respondents who are for and against natural gas-free policy.

While the calibration results indicate that the model can accurately predict the probability that a person with certain socio-demographic characteristics supports natural gas free policy, the discrimination results indicate that this probability is not high or low enough to provide useful information for municipalities. This is confirmed by the cross-validation results, which indicate that only 59.9% of the predicted outcomes for the test dataset were accurate. Given that the predictive accuracy on the train dataset was 61.5%, the low accuracy cannot be attributed to overfitting of the data, but is purely due to the poor discriminative ability of the model.

These results indicate that the coefficients for gender, education level, number of children, urbanity and homeownership are not strong enough to predict a person's support for natural gas-free policy. Accordingly, this predictive model cannot be used by municipalities to predict the support for natural gas-free policy among its residents and the corresponding level of ambition that can be taken on in the heat transition.

6.3.2 Trust in the Municipality

The optimal model to predict trust in the municipality includes age, education level and homeownership as predictors. The Hosmer-Lemeshow test and corresponding calibration plot for this model indicate that the model is reasonably well-calibrated. The non-significant p-value for the Hosmer-Lemeshow test indicates that there is no clear absence of calibration. The calibration plot indicates that the model does not consistently over- or underestimate the predicted probabilities compared to the observed probabilities, but also indicates that there are some deciles of predicted probabilities where the model does over- or underestimate the probability of trusting the municipality. The best fit line indicates that the highest predicted probabilities tend to be underestimated, while the lowest tend to be overestimated. Accordingly, the range of predicted probabilities is smaller than the range of observed probabilities. Moreover, the calibration plot indicates that the observed and predicted probabilities all range between approximately 0.5 an 1.0, which suggests that the discriminative power of the model is limited.

This result is confirmed by the ROC curves and corresponding c-statistic, which together indicate that there is only a 61.0% chance that the model can correctly identify whether a person trusts their municipality. This probability is only 11% higher than guessing a person's trust without any additional intel. The discrimination histogram also indicates there is almost a complete overlap between the predicted probabilities for respondents who do and do not trust their municipalities and that the majority of the predicted probabilities are above 0.5. This result suggests that the model predicts that people of almost all socio-demographic backgrounds trust their municipality, and cannot readily distinguish those who do not.

While the calibration results indicate that the model can predict the probability that a person with certain socio-demographic characteristics trusts their municipality with reasonable accuracy, the discrimination results indicate that this probability is consistently too high to provide useful information for municipalities. While the cross-validation indicates that 68.8% of the results are true positives and true negatives, the model only predicted that 30 respondents out of 917 would not trust their municipality, compared to 299 observed responses. Even though the majority of the respondents do trust their municipality, the model must be able to distinguish those who do not trust their municipality in order to be useful.

These results indicate that the coefficients for age, education level and homeownership are not strong enough to predict a person's trust in the municipality. The predictive model is unable to identify individuals who do not trust their municipality based on their socio-demographic characteristics. Accordingly, the model cannot be used by municipalities to determine whether they can take an ambitious stance in the heat transition.

6.3.3 Financial Capability

The optimal model to predict financial capability includes age, gender, education level, income level, ethnicity, number of children and homeownership as predictors. The Hosmer-Lemeshow test and corresponding calibration plot for this model indicate that the model is well-calibrated. The calibration plot indicates that the model does not consistently over- or underestimate the predicted probabilities compared to the observed probabilities. The most notable difference is that the lowest predicted probability decile is overestimated, which implies that actual financial capability of these respondents is lower than that which is predicted. Moreover, the calibration plot indicates that the observed and predicted probabilities all range between approximately 0.5 an 1.0, which suggests that the discriminative power of the model is limited.

This result is confirmed by the ROC curves and corresponding c-statistic, which together indicate that there is a 74.5% chance that the model can correctly identify whether a person trusts their municipality. This probability is only 24.5% higher than guessing a person's trust without any additional intel, which is a significant improvement over the two previous models. However, the discrimination histogram again indicates there is almost a complete overlap between the predicted probabilities for respondents who do and do not believe that they can easily live off of their income and that the majority of the predicted probabilities are above 0.5. This result suggests that the model predicts that people of almost all socio-demographic backgrounds are easily able to live off of their income and cannot readily distinguish those who cannot.

While the calibration results indicate that the model can predict the probability that a person with certain socio-demographic characteristics is able to live off of their income with reasonable accuracy, the discrimination results indicate that this probability is consistently too high to provide useful information for municipalities. While the cross-validation indicates that 78.8% of the results are true positives and true negatives, the model only predicted that 38 respondents out of 2,091 are unable to live off of their income, compared to 425 observed responses. Even though the majority of the respondents are able to live off of their income, the model must be able to distinguish those who cannot in order to be useful.

These results indicate that the coefficients for age, gender, education level, income level, ethnic-

ity, number of children and homeownership are not strong enough to predict a person's ability to live off of their income. The predictive model is unable to identify individuals who cannot live off of their income based on their socio-demographic characteristics. Accordingly, the model cannot be used by municipalities to determine the extent to which residents can or cannot contribute financially.

6.3.4 Social Trust

The optimal model to predict social trust includes age, education level, income level, ethnicity, number of children, partnership and homeownership as predictors. The Hosmer-Lemeshow test and corresponding calibration plot for this model indicate that the model is well-calibrated. The calibration plot indicates that the model correctly estimates the probability that a person with certain characteristics trusts others in each decile of predicted probabilities. However, the calibration plot also indicates that the observed and predicted probabilities all range between approximately 0.5 an 1.0, which again suggests that the discriminative power of the model is limited.

This result is confirmed by the ROC curves and corresponding c-statistic, which together indicate that there is only a 67.2% chance that the model can correctly identify whether a person trusts their municipality. This probability is only 17.2% higher than guessing a person's social trust without any additional intel. However, the discrimination histogram again indicates there is almost a complete overlap between the predicted probabilities for respondents who do and do not trust others and that the majority of the predicted probabilities are above 0.5. Again, this suggests that the model predicts that people of almost all socio-demographic backgrounds are generally trust others and cannot readily distinguish those who do not.

While the calibration results indicate that the model can accurately predict the probability that a person does or does not generally trust others, the discrimination results indicate that this probability is consistently too high to provide useful information for municipalities. While the cross-validation indicates that 69.1% of the predicted outcomes are true positives and true negatives, the model only predicted that 230 respondents out of 3,490 do not generally trust others, compared to 1,060 observed responses. Even though the majority of the respondents are do generally trust others, the model must be able to distinguish those who do not in order to be useful.

These results indicate that the coefficients for age, education level, income level, ethnicity, number of children, partnership and homeownership are not strong enough to predict a person's social trust. The predictive model is unable to identify individuals who do not generally trust others based on their socio-demographic characteristics. Accordingly, the model cannot be used by municipalities to determine the extent to which collaboration can be facilitated among residents through social trust.

6.3.5 Previous Energy Efficient Home Modifications

The optimal model to predict whether people previously performed energy efficient modifications to their home includes age, gender, education level and partnership as predictors. The Hosmer-Lemeshow test and corresponding calibration plot for this model indicate that the model is somewhat calibrated. The non-significant p-value for the Hosmer-Lemeshow test indicates that there is no clear absence of calibration. The calibration plot, however, indicates certain deciles of predicted probabilities over- or underestimate probability that a person has performed energy efficient modifications to their home. Still, there is no systematic over- or underestimation present in the model. This result simply suggests that the model does not have sufficient information to accurately predict an outcome. The calibration plot also indicates that the observed and predicted probabilities all range between approximately 0.25 and 0.50, which

suggests that the discriminative power of the model is limited.

This result is confirmed by the ROC curves and corresponding c-statistic, which together indicate that there is only a 58.3% chance that the model can correctly identify whether a person has previously made energy efficient modifications to their home. This probability is only 8.3% higher than guessing whether this without any additional intel. Moreover, the discrimination histogram indicates there is almost a complete overlap between the predicted probabilities for respondents who have and who have not made energy efficient modifications to their home. Given that these predicted probabilities almost entirely lie within the 0.25 to 0.50 range, the model predicts that almost none of the respondents have made energy efficient modifications to their home.

The calibration results indicate that the model is not able to predict the probability that a person has or has not made energy efficient modifications to their home with great accuracy. Additionally, the discrimination results indicate that the probabilities are consistently too low to provide useful information for municipalities. The cross-validation indicates that only 61.8% of the predicted outcomes are true positives and true negatives. Moreover, the model only predicted that 43 respondents out of 991 have made energy efficient modifications to their home, compared to 368 observed responses. Even though the majority of the respondents have not made energy efficient modifications to their home, the model must be able to distinguish those who have in order to be useful.

These results indicate that the coefficients for age, gender, education level and partnership are not strong enough to predict whether a person has made energy efficient modifications to their home. The predictive model is unable to identify individuals who have made energy efficient modifications based on their socio-demographic characteristics. Accordingly, the model cannot be used by municipalities to determine their ambition level and role in the execution of the heat transition.

6.3.6 Intention to Adopt Natural Gas-Free Heating

The optimal model to predict a person's intention to adopt natural gas-free heating includes gender and education level as predictors. The Hosmer-Lemeshow test and corresponding calibration plot for this model indicate that the model is somewhat calibrated. The non-significant p-value for the Hosmer-Lemeshow test indicates that there is no clear absence of calibration. The calibration plot, however, indicates certain deciles of predicted probabilities over- or underestimate probability that a person has performed energy efficient modifications to their home. However, there is no systematic over- or underestimation present in the model. Accordingly, the calibration plot only suggests that the model does not have sufficient information to produce predicted probabilities with a higher level of accuracy. The calibration plot also indicates that the observed and predicted probabilities all range between approximately 0.25 and 0.75, which suggests that the discriminative power of the model is limited.

This result is confirmed by the ROC curves and corresponding c-statistic, which together indicate that there is only a 62.3% chance that the model can correctly identify whether a person intends to adopt natural gas-free heating. This probability is only 12.3% than guessing a person's intent without any additional intel. The discrimination histogram also indicates that there is a significant overlap between the predicted probabilities for respondents who do and who do not consider adopting natural gas-free heating. This suggests that the model cannot distinguish between these two groups.

The calibration results indicate that the model is not able to predict the probability that a person has or has not made energy efficient modifications to their home with great accuracy. Moreover, the discrimination results indicate that the observed and predicted probabilities are not high or low enough to provide useful information for municipalities. This is confirmed by the cross-validation results, which indicate that only 59.4% of the predicted outcomes for the

test dataset were accurate. Given that the predictive accuracy on the train dataset was 59.8%, the low accuracy cannot be attributed to overfitting of the data, but is purely due to the poor discriminative ability of the model.

These results indicate that the coefficients for gender and education level are not strong enough to predict a person's intention to adopt natural gas-free heating. Accordingly, this predictive model cannot be used by municipalities to predict the intention of their residents to contribute to the heat transition, which implies that this information cannot be used to determine a desired ambition level and responsibility division.

6.4 Recommendations for Municipalities

The first aim of this study was to determine whether socio-demographic characteristics impact the preferred ambition level and responsibility distribution in the heat transition. The second aim was to determine whether this impact is strong enough so that municipalities can predict their municipal strategic role in the heat transition based on the socio-demographic characteristics within their districts.

While the explanatory model indicates that there are significant relationships between certain socio-demographic characteristics and the inhabitant-specific considerations, the predictive model indicates that it is not possible to predict these inhabitant-specific considerations based on socio-demographic characteristics of respondents. For municipalities, this implies that the explanatory model can provide potentially useful intel when making inhabitant-specific considerations, but that socio-demographic characteristics alone do not provide a silver bullet approach to determine a municipal strategic role.

Given that the predictive model is not usable by municipalities, the value of the explanatory model will now be discussed. Specifically, this study recommends how municipalities ought to consider the socio-demographic characteristics of their residents when defining their strategic role. Given that the socio-demographic makeup of municipalities is generally very diverse, it is impossible to determine a strategic role that is suitable to the attitudes and capabilities of all residents in the municipality. Accordingly, municipalities should consider adopting a different strategy in each district.

Research has indicated that the distribution of socio-demographic characteristics can vary between districts due to spatial segregation of ethnic and socio-economic groups (Hartog and Zorlu 2009; Van Ham and Manley 2009; M. v. Ham 2016; Musterd and Kempen 2009; Johnston, Poulsen, and Forrest 2016; Ponds, M. V. Ham, and Marlet 2015; Sleutjes, Valk, and Ooijevaar 2018; Leidelmeijer, Schulenberg, and Noordhuizen 2015). These studies have shown that ethnic minorities and individuals with low income are generally more concentrated within cities and that within these cities, individuals with a high income and education level are often segregated from those with a lower income and education level (M. v. Ham 2016; Ponds, M. V. Ham, and Marlet 2015). Where segregation takes place is largely dependent on the the housing market. More socio-economic spatial segregation occurs when districts have a high concentration of either social housing or privately owned homes (Ponds, M. V. Ham, and Marlet 2015; M. v. Ham 2016). The segregation of ethnic minorities is often linked to this socio-economic segregation, but may also be due to congregation with co-ethnics (Van Ham and Manley 2009; Musterd and Kempen 2009; Johnston, Poulsen, and Forrest 2016). There are also other socio-demographic trends that can provide useful insights. In terms of age, urban populations are becoming younger, while rural populations, especially in regions where the population is shrinking, are becoming relatively older (Leidelmeijer, Schulenberg, and Noordhuizen 2015). Meanwhile, there is limited segregation of older generations within cities. In terms of household composition, there is an increased tendency for families to stay in cities (Ponds, M. V. Ham, and Marlet 2015). While families were previously more concentrated in suburban and rural areas, this finding may suggest that the spatial distribution of different household compositions is diverse. Lastly, there are limited variations in the distribution of male and female residents in municipalities, which suggests that

this characteristic provides little information for municipalities.

Based upon the spatial distribution of socio-demographic characteristics, municipalities can identify whether differences in the preferences and capabilities of residents can be expected within various districts. These differences can be identified by using the inhabitant-specific considerations by Ebskamp and Verbraak (2019) in combination with the explanatory model developed in this study. To summarize, Ebskamp and Verbraak (2019) claim that support for the heat transition and for the municipality are the main limiting factors when deciding upon the municipality's ambition level. Meanwhile, the financial and collaborative capabilities of residents are the limiting factors in the level of responsibility that can be assigned to them. On the contrary, residents' motivation to contribute, as well as their previous contributions to the heat transition increase the level of responsibility that can be assigned to them. Section 6.2 already specified how socio-demographic characteristics impact each inhabitant-specific consideration and thus the desired level of ambition and distribution of responsibilities within the heat transition. This section recommends how municipalities can define their ambition level and responsibility distribution accordingly.

6.4.1 Defining an Ambition Level

Education, financial capability, age and homeownership are significantly associated with natural gas-free policy support or trust in the municipality. If municipalities can identify districts that have distinctly skewed population distributions with respect to these characteristics, they can consider adjusting their ambition level accordingly. This section recommends how municipalities should choose an ambition level and strategic role based on the spatial distribution of socio-demographic groups within their districts. Figure 26 summarizes which ambition levels and municipal strategic roles may be most suitable depending on the socio-demographic distributions of districts.

Municipalities can expect greater acceptance of a steering role in the heat transition in districts that have a high socio-economic status. Support for natural gas-free policy and trust in the municipality is higher among individuals with higher education level. Moreover, the financial capability of these residents is associated with increased support for natural gas-free policy. Given that acceptance of a steering role is less of a limiting factor in this case, municipalities can choose any strategic role and can define their ambition level based on other considerations.

On the contrary, districts with a low socio-economic status may be less receptive if the municipality takes a steering role in the heat transition. Individuals with a lower financial capability and education level tend to be less supportive of natural gas-free policy. Moreover, individuals with a lower education level tend to be less trusting in their municipality. Combined, these findings imply that individuals with a lower socio-economic status may express more resistance to a high ambition level in the heat transition and a steering role by the municipality. In this instance, the municipality may wish to take on the role of 'awaiter' and thus postpone defining strict targets until there are more favorable political and market conditions. Alternatively, the municipality can attempt to improve support by taking on the role of 'connector' or 'facilitator'. Given that a large majority of the neighborhoods with a low socio-economic status consist of social and rental housing, it would be unwise to take on a more ambitious role, given that a 70% resident approval is required to perform renovations.

While districts with a high economic status are more conducive to high ambition levels, it is important for municipalities to keep in mind that districts with distinctly high socio-economic status generally have a high share of privately owned homes. Given that homeownership has been associated with lower levels of natural gas-free policy support, the municipality should be more cautious when defining their ambition level while also actively increasing support among homeowners by minimizing the perceived financial and organizational burden. These characteristics are associated with the strategic role of a 'connector' or a 'facilitator'. If the municipality desires a higher ambition level, it can attempt to align initiatives as a 'director'.

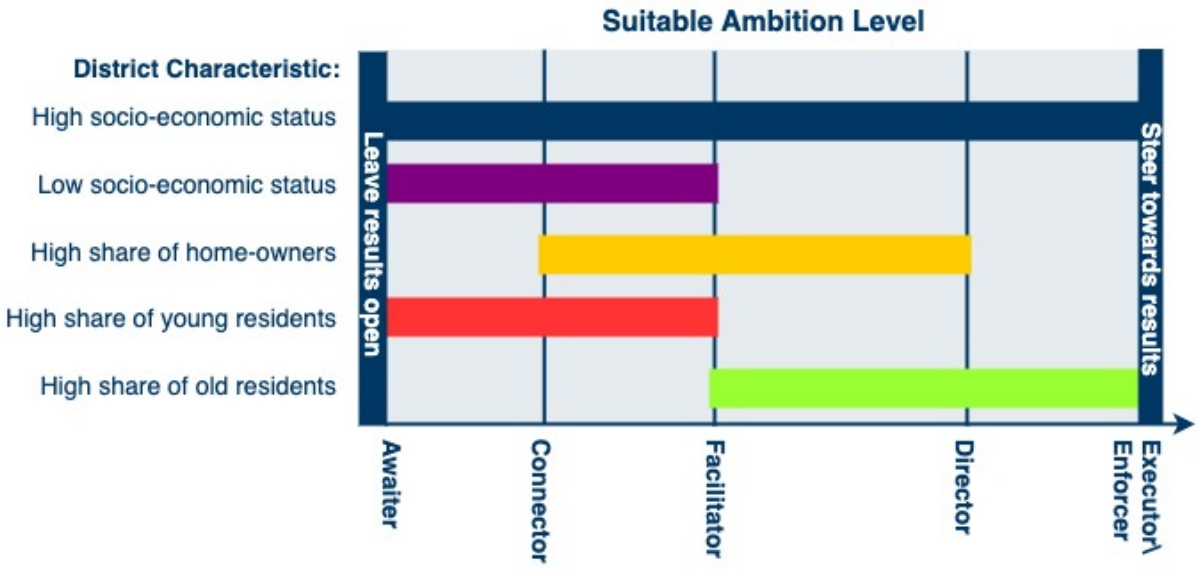

Figure 26: An overview of suitable ambition levels depending on the socio-demographic population distribution within districts

Aside from socio-economic status, the age distribution across districts may impact the extent to which the municipality can take a steering role in the heat transition. Though age was not associated with a person's support for the heat transition, the study did find that trust in the municipality is higher among older individuals. While younger individuals were found to be more motivated to contribute, they are less trusting in the municipality and thus may be less accepting of a steering role in the heat transition. Meanwhile, older individuals are less motivated to contribute, but may be more accepting of a steering role by the municipality due to higher trust. This may suggest that younger districts ought to be given more freedom in their heat transition ambitions, while older generation may be more receptive of strict guidelines.

Given that this study cannot determine whether individuals trust the actions of their municipality in the context of the heat transition, it would be interesting to determine whether older individuals are more accepting of a steering role due to lower environmental concern and expertise on innovative technologies. Additionally, this raises the question whether a lack of trust in the capability of municipalities among younger individuals may results in more resistance against a strict heat transition vision by the municipality.

6.4.2 Defining a Responsibility Distribution

Many socio-demographic characteristics are relevant to the choice of responsibility distribution. If municipalities can identify districts that have distinctly skewed population distributions with respect to these characteristics, they can consider adjusting their responsibility distribution accordingly. This section recommends how municipalities should choose a responsibility distribution and strategic role based on the spatial distribution of socio-demographic groups within their districts. Figure 27 summarizes which responsibility distributions and municipal strategic roles may be most suitable dependent on the socio-demographic distributions of districts.

Municipalities can expect that the ability of residents to contribute to the heat transition is greatest in districts with a high socio-economic status. Individuals with a high income and education level generally have greater financial means to contribute to the heat transition. Additionally, education level and financial capability are positively associated with social trust. Social trust is essential for successful collaboration on heat transition initiatives and improves people's motivation to contribute. In line with these findings, the motivation to adopt natural

gas-free heating is higher among individuals with higher levels of education, financial capability and social trust. These findings imply that people are more motivated to contribute, but also that they have the means to invest in and collaborate on heat transition initiatives. In this context, municipalities can assign more responsibility for the heat transition to residents by taking on the role of 'awaiter', 'connector', 'facilitator' or 'enforcer', depending on the desired ambition level.

On the contrary, districts with a low socio-economic status may not be able to take on as much responsibility. This conclusion is made based on the finding that individuals with a lower education and income level generally have lower levels of financial capability, social trust and motivation to contribute to the heat transition. These findings imply that districts with a low socio-economic status have less motivation and fewer means to invest in and collaborate on heat transition initiatives. In this context, municipalities should take on more responsibility for the execution of the heat transition by taking on the role of 'facilitator', 'director' or 'executor'. The higher the ambition level of the municipality, the more actively they ought the be involved in the execution of the plans within these neighborhoods. It is important to keep in mind, however, that too high ambition levels may result in resistance within these districts.

While homeownership was considered a limiting factor in the choice of ambition level, homeownership is found to be conducive to greater responsibility. Homeownership is associated with greater financial capability and a greater neighborhood connection. Accordingly, homeowners are expected to have greater financial and collaborative means to contribute to the heat transition. Though this finding may imply that renters may have fewer financial means to contribute, or that they lack the social connections required to collaborate on heat transition initiatives, this finding does not have significant implications for the choice of strategic role. This stems from the fact that renters are generally not responsible for the execution of heat transition measures on their home. This responsibility lies with the landlord. Though districts with homeowners are theoretically expected to manage higher levels of responsibility, the relevance of this finding is minimal and the choice of responsibility distribution should rather be based on other socio-demographic characteristics.

Though gender and household composition were also associated with financial capability it was concluded that this information is of limited use to municipalities, given that there generally are no distinctly skewed distributions of gender and household composition between districts. If municipalities do find that districts have significantly more families than the remainder of the municipality, they may consider assigning less responsibility to these districts based on the assumption that financial capability may be lower.

If the municipality identifies segregation of older and younger generations between districts, or if the municipality as a whole is significantly older or younger than the average Dutch population, the municipality may wish to consider the implications of these findings on their responsibility distribution. While the results indicate that a person's neighborhood connection, and perhaps even their social trust, increases with age, the results also indicate that the motivation to contribute to the heat transition decreases. This may suggest that collaboration among residents becomes more likely at a higher age, but that collaboration on heat transition initiatives is less probable. In this case, it is recommended that the municipality does not focus on promoting collaboration, but instead attempts to remove the barriers and burdens associated with heat transition tasks, for example as a 'facilitator', 'director' or 'executor'. Meanwhile, younger residents may be less likely to collaborate on heat transition initiatives, but are more motivated to act. Accordingly, in distinctly young districts, the municipality can either attempt to promote collaboration as a 'connector' or attempt to align initiatives as a 'director'. Alternatively, the municipality can let individual initiatives run their course by taking on the role of 'awaiter' or 'facilitator', depending on the municipality's ambition level.

The last socio-demographic characteristic that may be considered when deciding upon a responsibility distribution is urbanity. The results of this study indicate that residents in urban districts have significantly lower levels of social trust and have a lower perceived neighborhood connection. Accordingly, urbanity reduces the likelihood that residents will collaborate on heat

transition initiatives. In this case, the municipality can either attempt to promote collaboration as a 'connector' or it can take an active role in aligning heat transition initiatives as a 'director'. In rural areas, where collective initiatives are deemed more likely, the municipality has more freedom to choose its role based upon its ambition level.

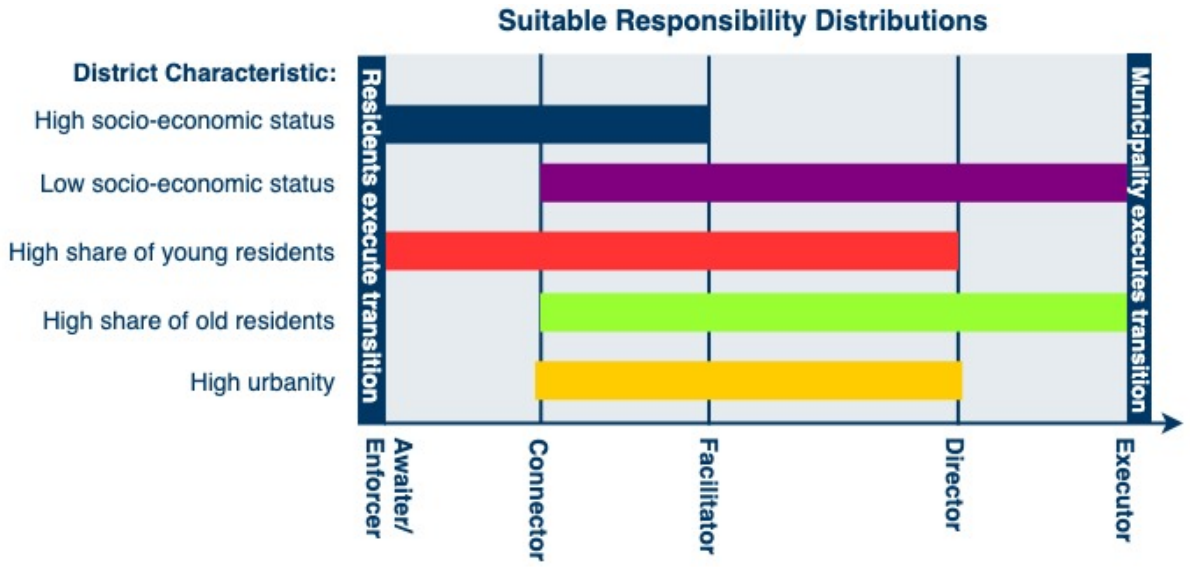

Figure 27: An overview of suitable responsibility distributions depending on the socio-demographic population distribution within districts

7 Conclusion

The aim of this research was to determine whether socio-demographic characteristics can help predict an effective role division between a municipality and its residents in the heat transition. The research extended upon a previous study by Ebskamp and Verbraak (2019), who developed a set of considerations based on which municipalities can define their ambition levels within the heat transition and assign responsibility for the execution of these ambitions. To determine if and how socio-demographic characteristics impact the choice of strategic municipal role, the first research question asked how socio-demographic characteristics of residents influence their preferred ambition level and responsibility distribution in the heat transition. By performing logistic regression analyses, the relationships between socio-demographic characteristics and the inhabitant-specific considerations by Ebskamp and Verbraak (2019) were identified.

When deciding upon an ambition level, municipalities can consider the presence of heat transition support and trust in the municipality among their residents (Ebskamp and Verbraak 2019). The results indicate that there is a direct positive association between natural gas-free policy support and social trust, education level and being female, while this support is negatively associated with homeownership. Financial capability is also positively associated with natural gas-free policy support, however this effect was fully mediated by a person's social trust. Trust in the municipality has a direct and positive association with financial capability, social trust and a person's connection to the neighborhood. Age and education level have an indirect positive effect which is mediated by the three variables that have a direct effect. Based on these results, it was concluded that support for a high ambition level and steering role by the municipality in the heat transition is favored among individuals with increased age, education level and financial capability. Additionally, women are expected to be more accepting of an ambitious steering role than men, and homeowners are likely more resistant to an ambitious steering role than renters.

When deciding on a responsibility distribution, the ability of residents to financially and collaboratively contribute to the heat transition should be considered as a limiting factor. The results indicate that there is a positive association between financial capability and a person's education level, income and homeownership. Meanwhile, financial capability was found to be negatively associated with the number of children in a household and with the female gender. The results indicate that social trust, a proxy for collaborative ability, is directly and positively associated with financial capability, trust in the municipality, education level and age, while it is negatively associated with urbanity. Income and a person's neighborhood connection were indirectly and positively associated with social trust, and were respectively mediated by financial capability and trust in the municipality. Ultimately, the study indicates that residents who are young, live in urban areas and have a low income and education level can take on less responsibility in the heat transition due to a lower financial and collaborative ability.

While the financial and collaborative ability of residents limit the responsibility they can take on, their motivation to contribute increases the responsibility they can take on (Ebskamp and Verbraak 2019). While previous contributions to the heat transition can also be considered by municipalities when deciding upon a responsibility distribution, this study did not find reliable results regarding the relationship between this inhabitant-specific consideration and socio-demographic characteristics. This study found that support for natural gas-free policy, social trust and being female are positively associated with the intention to adopt natural gas-free heating, while age is negatively associated with this intention. Additionally, education level and financial capability have a positive indirect effect on the intention to adopt natural gas-free heating, which is fully mediated by a person's social trust and natural gas-free policy support. Given that a high motivation to contribute is conducive to an increased level of responsibility, it is expected that individuals who are younger, female, higher educated and financially capable are more willing to accept a large responsibility in the execution of the heat transition.

The second research question asked whether socio-demographic characteristics can be be used to predict an effective strategic municipal role within the heat transition. Binary logistic regression analyses were performed between the socio-demographic characteristics and inhabitant-specific

considerations. The balance between goodness of fit and information loss was optimized to develop predictive models for each inhabitant-specific consideration. Based on measures of calibration, discrimination and cross-validation it was concluded that the models have insufficient predictive power to be used by municipalities.

While the explanatory model indicates that there are some significant relationships between socio-demographic characteristics and the preferred ambition level and responsibility distribution in the heat transition, the predictive model indicates that these relationships are not strong enough to predict an optimal strategic municipal role. With this knowledge, municipalities were recommended to consider the spatial distribution of socio-demographic characteristics within their municipality when deciding upon their municipal strategic role in each district. If districts have distinctly different distributions of certain socio-demographic characteristics, municipalities may consider adjusting their ambition level and responsibility distribution in these districts based on the expected differences in the preferences and capabilities of the residents. It is important to keep in mind, however, that socio-demographic characteristics are not a silver bullet approach towards defining a strategic role in the heat transition and that communication with residents is essential to identify their exact preferences and capabilities.

This study suggests that there is some added value in considering socio-demographic characteristics to determine the preferences and capabilities of residents, but that socio-demographic characteristics do not provide a complete picture. Future research should investigate which factors - aside from socio-demographic characteristics - influence the preferences and capabilities of residents. If the explanatory and predictive model in this study can be updated with additional input variables, then the explanatory and predictive power of the models may increase. Meanwhile, if no additional factors are found that structurally influence the preferences and capabilities of residents, it can be concluded that personal contact with residents is indispensable in the heat transition.

While the diverse preferences and capabilities of residents are an essential consideration when defining a municipal strategic role, it is also important to keep in mind that this is only one of many considerations. Additionally, municipalities must consider how to deal with their own knowledge and capacities, their other municipal responsibilities, and a wide range of other stakeholders who may have conflicting interests (Ebskamp and Verbraak 2019; Dignum et al. 2021). Future research should expand on the results of this study by identifying how municipalities can balance the interests of all stakeholders while maintaining support and trust among its residents.

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9 References

References

Abreu, Maria Isabel, Rui Oliveira, and Jorge Lopes (2017). "Attitudes and practices of homeowners in the decision-making process for building energy renovation". In: *Procedia Engineering* 172, pp. 52–59. ISSN: 1877-7058. DOI: 10.1016/j.proeng.2017.02.016. URL: http://dx.doi.org/10.1016/j.proeng.2017.02.016.

Ajzen, Icek (1985). "From Intentions to Actions: A Theory of Planned Behavior". In: *Action Control: From Cognition to Behavior*. Ed. by Julius Kuhl and Jürgen Beckmann. Berlin, Heidelberg: Springer Berlin Heidelberg, pp. 11–39. ISBN: 978-3-642-69746-3. DOI: 10.1007/978-3-642-69746-3_2. URL: https://doi.org/10.1007/978-3-642-69746-3_2.

Allen, Simon, Giovanni Albertone, and Andrew Redpath (2018). *Living conditions in Europe 2018 edition*. Eurostat. ISBN: 9789279864971.

Alsema, Erik, Robert Harmsen, Marc Londo, Bas van Zuijlen, and Laura van de Kar (2020). *SmartTrans: Leidraad voor gemeentes bij het vormgeven van de warmtetransitie voor particuliere woningeigenaren*. Tech. rep. Copernicus Intitute for Sustainable Development.

Arends, Judit and Hans Schmeets (2015). *Sociaal en institutioneel vertrouwen in Nederland*. Tech. rep. The Hague: CBS, pp. 1–18.

Arli, Denni, Abi Badejo, Joan Carlini, Cassandra France, Charles Jebarajakirthy, Kathy Knox, Robin Pentecost, Helen Perkins, Park Thaichon, Tapan Sarker, and Owen Wright (2019). "Predicting intention to recycle on the basis of the theory of planned behaviour". In: *International Journal of Nonprofit and Voluntary Sector Marketing* 25, pp. 1–14. DOI: 10.1002/nvsm.1653.

Arroyo, Pilar and Lorena Carrete (2019). "Motivational drivers for the adoption of green energy The case of purchasing photovoltaic systems". In: *Management Research Review* 42.5, pp. 542–567. DOI: 10.1108/MRR-02-2018-0070.

Arts, Koos, Wim Bos, Marion van den Brakel, Kai Gidding, Daniël Herbers, Reinder Lok, Jasper Menger, Jeroen Nieuweboer, Ferdy Otten, Noortje Pouwel-Urlings, and Jan Walschots (2019). *Welvaart in Nederland 2019*. Tech. rep. The Hague: CBS.

Assche, Danny Van A N, Guido Dierickx, Danny Van A N Assche, and Guido Dierickx (2007). "The decentralisation of city government and the restoration of political trust The Decentralisation of City Government and the Restoration of Political Trust". In: *Local Government Studies* 33.1, pp. 25–47. DOI: 10.1080/03003930601081069.

Atkinson, Adele, Stephen Mckay, Elaine Kempson, and Sharon Collard (2006). *Levels of Financial Capability in the UK: Results of a baseline survey*. Tech. rep. March. Personal Finance Research Centre University of Bristol.

Atkinson, J., M. Heaslip, H. Grimshaw, J. O'Brien, M. Fawcett, L. Marix Evans, and B. Taylor (2019). *People Powered Retrofit: A community led model for owner occupier retrofit*. Tech. rep. Carbon Co-op.

Azizi, Shoaib, Gireesh Nair, and Thomas Olofsson (2019). "Energy & Buildings Analysing the house-owners' perceptions on benefits and barriers of energy renovation in Swedish single-family houses". In: *Energy & Buildings* 198, pp. 187–196. DOI: 10.1016/j.enbuild.2019.05.034.

Bahmani-Oskooee, Mohsen, Scott W Hegerty, and Harvey Wilmeth (2008). "Short-run and long-run determinants of income inequality: evidence from 16 countries Short-run and long-run determinants of income inequality: evidence from 16 countries". In: *Journal of Post Keynesian Economics* 30.3, pp. 463–484. DOI: 10.2753/PKE0160-3477300308.

Baldassare, Mark (1985). "Trust in Local Government". In: *Social Science Quarterly* 66.3, pp. 704–712.

Banducci, Susan A, Todd Donovan, and Jeffrey A Karp (2004). "Minority Representation, Empowerment, and Participation". In: *The Journal of Politics* 66.2, pp. 534–556.

Bjørneboe, Matilde Grøn, Svend Svendsen, and Alfred Heller (2018). "Energy & Buildings Initiatives for the energy renovation of single-family houses in Denmark evaluated on the basis of barriers and motivators". In: *Energy & Buildings* 167, pp. 347–358. DOI: 10.1016/j.enbuild.2017.11.065.

Bradley, Graham L, Zakaria Babutsidze, Andreas Chai, and Joseph P Reser (2020). "The role of climate change risk perception, response efficacy , and psychological adaptation in pro-environmental behavior: A two nation study". In: *Journal of Environmental Psychology* 68, pp. 1–12. ISSN: 0272-4944. DOI: 10.1016/j.jenvp.2020.101410. URL: https://doi.org/10.1016/j.jenvp.2020.101410.

Brounen, Dirk, Ruben Cox, and Peter Neuteboom (2012). "Safe and Satisfied? External Effects of Homeownership in Rotterdam". In: *Urban Studies* 49.August 2011, pp. 2669–2691. DOI: 10.1177/0042098011432558.

Brouwer, Max (2019). *Het ene model is het andere niet: Zes rekenmodelen voor de energietransitie in de gebouwde omgeving onderzocht.* Tech. rep. May. Talent voor Transitie.

Buttel, F. H. (1979). "Age and Environmental Concern: A Multivariate Analysis". In: *Youth and Society* 10.3, pp. 237–256.

Castillo, E Higueras, F J Liébana Cabanillas, and F Muñoz Leiva (2019). "The role of collectivism in modeling the adoption of renewable energies: a cross-cultural approach". In: *International Journal of Environmental Science and Technology* 16, pp. 2143–2160. ISSN: 1735-2630. DOI: 10.1007/s13762-019-02235-4. URL: https://doi.org/10.1007/s13762-019-02235-4.

Castro, Paula (2006). "Applying Social Psychology to the Study of Environmental Concern and Environmental Worldviews : Contributions from the Social Representations Approach". In: *Journal of Community & Applied Social Psychology* 16, pp. 247–266.

Central Bureau for Statistics (2020). *Kerncijfers wijken en buurten 2020 [Data file].* URL: https://opendata.cbs.nl/statline/%7B%5C#%7D/CBS/nl/dataset/84799NED/table?ts=1613568123709.

Chattopadhyay Mukherjee, Sanghamitra and Lisa Ryan (2020). "Factors influencing early battery electric vehicle adoption in Ireland". In: *Renewable and Sustainable Energy Reviews* 118, pp. 1–12. ISSN: 1364-0321. DOI: 10.1016/j.rser.2019.109504. URL: https://doi.org/10.1016/j.rser.2019.109504.

Chen, Mei-fang (2016). "Extending the theory of planned behavior model to explain people ' s energy savings and carbon reduction behavioral intentions to mitigate climate change in Taiwan". In: *Journal of Cleaner Production* 112, pp. 1746–1753. ISSN: 0959-6526. DOI: 10.1016/j.jclepro.2015.07.043. URL: http://dx.doi.org/10.1016/j.jclepro.2015.07.043.

Chen, Xiangjie, Ke Qu, John Calautit, Anandasivakumar Ekambaram, Wei Lu, Caroline Fox, Guohui Gan, and Saffa Riffat (2020). "Energy & Buildings Multi-criteria assessment approach for a residential building retrofit in Norway". In: *Energy & Buildings* 215. DOI: 10.1016/j.enbuild.2019.109668.

Christensen, Tom, Kiyoshi Yamamoto, and Saizo Aoyagi (2008). *Trust in local government - service satisfaction, culture and demography.* Tech. rep. Japan Society for the Promotion of Science, pp. 1–26.

Christoforou, Asimina (2011). "Social Capital Across European Countries: Individual and Aggregate Determinants of Group Membership". In: *The American Journal of Economics and Sociology* 70.3, pp. 699–728.

Cologna, Viktoria and Michael Siegrist (2020). "The role of trust for climate change mitigation and adaptation behaviour: A meta-analysis". In: *Journal of Environmental Psychology* 69, pp. 1–13. ISSN: 0272-4944. DOI: 10.1016/j.jenvp.2020.101428. URL: https://doi.org/10.1016/j.jenvp.2020.101428.

Coolen, Lisa (2017). "Puzzelen met vertrouwen: een onderzoek naar vertrouwen van burgers in de gemeente na een herindeling". PhD thesis.

Curtis, John, Daire McCoy, and Claudia Aravena (2018). "Heating system upgrades: The role of knowledge, socio-demographics, building attributes and energy infrastructure". In: *Energy Policy* 120, pp. 183–196. ISSN: 0301-4215. DOI: 10.1016/j.enpol.2018.05.036. URL: https://doi.org/10.1016/j.enpol.2018.05.036.

Das, Runa, Russell Richman, and Craig Brown (2018). "Demographic determinants of Canada's households' adoption of energy efficiency measures : observations from the Households and Environment Survey, 2013". In: *Energy Efficiency* 11, pp. 465–482.

De Witt, Susanne and Hans Schmeets (2018). *Milieu en duurzame energie: Opvattingen en gedrag.* Tech. rep. Den Haag: CBS.

Dekker, Paul, Quita Muis, Inge Sieben, and Pepijn Van Houwelingen (2019). *Burgerperspectieven 2019—3*. Tech. rep. Den Haag: SCP.
Dekker, Paul and Josje den Ridder (2020). *Burgerperspectieven 2020—1*. Tech. rep. Den Haag: SCP.
Den Ridder, Josje, Emily Miltenburg, Willem Huijnk, and Sosha Van Rijnberk (2019). *Burgerperspectieven 2019—4*. Tech. rep. Den Haag: SCP.
Dietz, Thomas, Paul C Stern, and Gergory A Guagnano (1998). "Social structural and social psychological bases of environmental concern". In: *Environment and Behavior* 30.4.
Dignum, Marloes, Petra Van Der Kooij, Eva Kunseler, Hans Mommaas, Ton Dassen, Marc Hanou, Pieter Boot, Edwin Buitelaar, Nico Hoogervorst, and Martine Uyterlinde (2021). *Wartmetransitie in de Praktijk: Leren van Ervaringen bij het Aardgasvrij Maken van Wijken*. Tech. rep. Planbureau voor de Leefomgeving.
Dinesen, Peter Thisted and Kim Mannemar Sønderskov (2012). "Trust in a Time of Increasing Diversity : On the Relationship between Ethnic Heterogeneity and Social Trust in Denmark from 1979 until Today". In: *Scandinavian Political Studies* 35.4, pp. 273–294. DOI: 10.1111/j.1467-9477.2012.00289.x.
Drews, Stefan and Jeroen C J M Van Den Bergh (2016). "What explains public support for climate policies ? A review of empirical and experimental studies review of empirical and experimental studies". In: *Climate Policy* 16.7, pp. 855–876. DOI: 10.1080/14693062.2015.1058240.
Ebrahimigharehbaghi, Shima, Queena K Qian, Frits M Meijer, and Henk J Visscher (2019). "Unravelling Dutch homeowners' behaviour towards energy efficiency renovations: What drives and hinders their decision-making?" In: *Energy Policy* 129, pp. 546–561. ISSN: 0301-4215. DOI: 10.1016/j.enpol.2019.02.046. URL: https://doi.org/10.1016/j.enpol.2019.02.046.
Ebskamp, Bas and Majelle Verbraak (2019). *Strategische positie kiezen in de energietransitie: Wegwijzer voor gemeenten*. Tech. rep.
Ectogrid (2020). *Good neighbor energy*.
Eon, C., J. Breadsell, G. Morrison, and J. Byrne (2019). "Shifting Home Energy Consumption Through a Holistic Understanding of the Home System of Practice". In: *Decarbonising the Built Environment*. Palgrace Macmillen.
Ericsson, Kerin and Per Svenningsson (2009). *Introduction and development of the Swedish district heating systems: Critical factors and lessons learned*. Tech. rep., pp. 1–54.
Femenías, Paula and Anna-Lisa Lindén (2010). *Energy Efficiency in the Housing Sector – The Swedish Case*. Tech. rep.
Freitag, Markus and Maya Ackermann (2016). "The impact of associational life on trust in local institutions : a comparison of 57 Swiss municipalities". In: *Local Government Studies* 42.4, pp. 616–636. ISSN: 0300-3930. DOI: 10.1080/03003930.2016.1154846. URL: http://dx.doi.org/10.1080/03003930.2016.1154846.
Galvin, Ray (2019). "Energy Research & Social Science Letting the Gini out of the fuel poverty bottle? Correlating cold homes and income inequality in European Union countries". In: *Energy Research & Social Science* 58, pp. 1–14. ISSN: 2214-6296. DOI: 10.1016/j.erss.2019.101255. URL: https://doi.org/10.1016/j.erss.2019.101255.
Gorbunova, Lidia A, Jens Ambrasat, and Christian von Scheve (2015). "Neighborhood Stereotypes and Interpersonal Trust in Social Exchange: An Experimental Study". In: *City & Community* 14.2, pp. 206–225. DOI: 10.1111/cico.12112.
Government of the Netherlands (2019a). *Climate Agreement*. Tech. rep. June. The Hague, pp. 1–247.
– (2019b). *Staat van het Bestuur — 2018*. Tech. rep. The Hague: Government of the Netherlands.
Gregory-smith, Diana, Danae Manika, and Pelin Demirel (2017). "Green intentions under the blue flag: Exploring differences in EU consumers' willingness to pay more for environmentally-friendly products". In: *Business Ethics* 26, pp. 205–222. DOI: 10.1111/beer.12151.
Ham, Maarten van (2016). "Sociaal-economische segregatie in Europese steden". In: *Tijdschrift voor beleid, politiek en maatschappij* 43.1, pp. 88–92. DOI: 10.5553/BenM/138900692016043001013.
Hamilton, Lawrence C (2011). "Education , politics and opinions about climate change evidence for interaction effects". In: *Climatic Change* 104, pp. 231–242. DOI: 10.1007/s10584-010-9957-8.

Hamzah, Muhammad Iskandar and Nurul Sya (2020). "Do pro-environmental factors lead to purchase intention of hybrid vehicles ? The moderating effects of environmental knowledge". In: *Journal of Cleaner Production* 279, pp. 1–14. DOI: 10.1016/j.jclepro.2020.123643.

Haren, Grijze, Groene Huizen, and Frans Schilder (2019). *Grijze haren, groene huizen: Over waarom langer zelfstandig wonende ouderen hun woning (niet) verduurzamen*. Tech. rep. Den Haag: PBL.

Harrell, Frank E. (2015). "Multivariable Modeling Strategies". In: *Regression Modeling Strategies: With Applications to Linear Models, Logistic and Ordinal Regression, and Survival Analysis*. Cham: Springer International Publishing, pp. 63–102. ISBN: 978-3-319-19425-7. DOI: 10.1007/978-3-319-19425-7_4. URL: https://doi.org/10.1007/978-3-319-19425-7_4.

Hartog, Joop and Aslan Zorlu (Jan. 2009). "Ethnic segregation in The Netherlands: An analysis at neighbourhood level". In: *International Journal of Manpower* 30.1/2. Ed. by Amelie F Constant, Martin Kahanec, and Klaus F Zimmermann, pp. 15–25. ISSN: 0143-7720. DOI: 10.1108/01437720910948366. URL: https://doi.org/10.1108/01437720910948366.

Haurin, Donald R, Robert D Dietz, Bruce A Weinberg, Donald R Haurin, Robert D Dietz, and Bruce A Weinberg (2002). "The Impact of Neighborhood Homeownership Rates : A Review of the Theoretical and Empirical Literature". In: *Journal of Housing Research* 13.2, pp. 119–151.

Havekes, Esther, Marcel Coenders, Karien Dekker, and Tanja van der Lippe (2014). "The Impact of Ethnic Concentration on Prejudice: The Role of Cultural and Socioeconomic Differences among Ethnic Neighborhood Residents". In: *Journal of Urban Affairs* 36.5, pp. 815–832. DOI: 10.1111/juaf.12091.

He, Pan and Marcella Veronesi (2017). "Personality traits and renewable energy technology adoption: A policy case study from China". In: *Energy Policy* 107, pp. 472–479. ISSN: 0301-4215. DOI: 10.1016/j.enpol.2017.05.017. URL: http://dx.doi.org/10.1016/j.enpol.2017.05.017.

Hornback, K. E. (1974). "Orbits of opinion : the role of age in the environmental movement's attentive public, 1968-1972". PhD thesis. Michigan State University.

Inglehart, Ronald (1981). "Post-Materialism in an Environment of Insecurity". In: *The American Political Science Review* 75.4, pp. 880–900.

International Energy Agency (2017). *Deep Energy Retrofit - A Guide for Decision Makers*. October. ISBN: 9783981933031.

Jacksohn, Anke, Peter Grösche, Katrin Rehdanz, and Carsten Schröder (2019). "Drivers of renewable technology adoption in the household sector". In: *Energy Economics* 81, pp. 216–226. ISSN: 0140-9883. DOI: 10.1016/j.eneco.2019.04.001. URL: https://doi.org/10.1016/j.eneco.2019.04.001.

Jansson, Johan (2011). "Consumer Eco-Innovation Adoption: Assessing Attitudinal Factors and Perceived Product Characteristics". In: *Business Strategy and the Environment* 20, pp. 192–210.

Jansson, Johan, Agneta Marell, and Annika Nordlund (2011). "Exploring consumer adoption of a high involvement eco-innovation using value-belief-norm theory". In: *Journal of Consumer Behavior* 10, pp. 51–60. DOI: 10.1002/cb.

Johnston, Ron, Michael Poulsen, and James Forrest (Feb. 2016). "Ethnic Residential Patterns in Urban England and Wales, 2001–2011: A System-Wide Analysis". In: *Tijdschrift voor economische en sociale geografie* 107.1, pp. 1–15. ISSN: 0040-747X. DOI: https://doi.org/10.1111/tesg.12128. URL: https://doi.org/10.1111/tesg.12128.

Kollmuss, Anja and Julian Agyeman (2002). "Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior?" In: *Environmental Education Research* 8.3, pp. 239–260. DOI: 10.1080/1350462022014540.

Koon, Olivia, Ricky Chan, and Piyush Sharma (2020). "Moderating effects of socio-cultural values on pro-environmental behaviors". In: *Marketing Intellegence & Planning* 38.5, pp. 603–618. DOI: 10.1108/MIP-10-2019-0534.

Laméris, Joran, John R Hipp, and Jochem Tolsma (2018). "Perceptions as the crucial link ? The mediating role of neighborhood perceptions in the relationship between the neighborhood context and neighborhood cohesion". In: *Social Science Research* 72, pp. 53–68. ISSN: 0049-089X. DOI: 10.1016/j.ssresearch.2018.02.010. URL: https://doi.org/10.1016/j.ssresearch.2018.02.010.

Lehmann, Steffen (2008). "Sustainability on the Urban Scale : Green Urbanism – New Models for Urban Growth and Neighbourhoods". In: *Urban Energy Transition*, pp. 409–430.
Leidelmeijer, Kees, Rene Schulenberg, and Betty Noordhuizen (2015). *Ontwikkeling van ruimtelijke verschillen in Nederland*. Tech. rep.
Letki, Natalia (2008). "Does Diversity Erode Social Cohesion ? Social Capital and Race in British". In: *Political Studies* 56, pp. 99–126. DOI: 10.1111/j.1467-9248.2007.00692.x.
Lettenbichler, S. and A. Provaggi (2019). *100% Renewable Energy Districts*. Tech. rep. European Technology and Innovation PLatform for Renewable Heating & Cooling.
Li, Ding, Luman Zhao, Shuang Ma, Shuai Shao, and Lixiao Zhang (2019). "Resources, Conservation & Recycling What influences an individual's pro-environmental behavior? A literature review". In: *Resources, Conservation & Recycling* 146, pp. 28–34. ISSN: 0921-3449. DOI: 10.1016/j.resconrec.2019.03.024. URL: https://doi.org/10.1016/j.resconrec.2019.03.024.
März, Steven (2018). "Beyond economics — understanding the decision-making of German small private landlords in terms of energy efficiency investment". In: *Energy Efficiency* 11, pp. 1721–1743. DOI: 10.1007/s12053-017-9567-7.
McCabe, Brian J (2012). "Homeownership and Social Trust in Neighbors". In: *City & Community* 11.4, pp. 389–408. DOI: 10.1111/j.1540-6040.2012.01416.x.
– (2013). "Are Homeowners Better Citizens? Homeownership and Community Participation in the United States". In: *Social Forces* 91.March, pp. 929–954. DOI: 10.1093/sf/sos185.
McCright, Aaron M (2010). "The effects of gender on climate change knowledge and concern in the American public". In: *Population and Environment* 32, pp. 66–87. DOI: 10.1007/s11111-010-0113-1.
Michelsen, Carl Christian and Reinhard Madlener (2013). "Motivational factors influencing the homeowners' decisions between residential heating systems: An empirical analysis for Germany". In: *Energy Policy* 57, pp. 221–233. ISSN: 0301-4215. DOI: 10.1016/j.enpol.2013.01.045. URL: http://dx.doi.org/10.1016/j.enpol.2013.01.045.
Ministry of Economic Affairs and Climate (2020). *Klimaatplan*. Tech. rep. The Hague, pp. 1–62.
Mohai, Paul and Ben W. Twight (1987). "Age and Environmentalism: An Elaboration of the Buttel Model Using National Survey Evidence". In: *Social Science Quarterly* 68.4, pp. 798–815.
Montalvo, Daniel (2010). *Understanding Trust in Municipal Governments*. Tech. rep. Latin American Public Opinion Project, pp. 1–5.
Mortensen, A, P Heiselberg, and M Knudstrup (2014). "Economy controls energy retrofits of Danish single-family houses. Comfort, indoor environment and architecture increase the budget". In: *Energy & Buildings* 72, pp. 465–475. ISSN: 0378-7788. DOI: 10.1016/j.enbuild.2013.12.054. URL: http://dx.doi.org/10.1016/j.enbuild.2013.12.054.
Mundaca, Luis, Henner Busch, and Sophie Schwer (2018). "'Successful low-carbon energy transitions at the community level ? An energy justice perspective". In: *Applied Energy* 218.March, pp. 292–303. ISSN: 0306-2619. DOI: 10.1016/j.apenergy.2018.02.146. URL: https://doi.org/10.1016/j.apenergy.2018.02.146.
Musterd, Sako and Ronald van Kempen (2009). "Segregation and Housing of Minority Ethnic Groups in Western Eurtopean Cities". In: *Tijdschrift voor economische en sociale geografie* 100.4, pp. 559–566. DOI: https://doi.org/10.1111/j.1467-9663.2009.00558.x. eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1467-9663.2009.00558.x. URL: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1467-9663.2009.00558.x.
Noordzij, Kjell, Jeroen Van der Waal, and Willem De Koster (2019). "The Educational Gradient in Trust in Politicians in the Netherlands: A Status-Based Cultural Conflict". In: *The Sociological Quarterly* 60.3, pp. 439–456. ISSN: 0038-0253. DOI: 10.1080/00380253.2019.1580551. URL: https://doi.org/10.1080/00380253.2019.1580551.
Oh, Joong-hwan (2004). "Race/ethnicity, homeownership , and neighborhood attachment". In: *Race and Society* 7, pp. 63–77. DOI: 10.1016/j.racsoc.2005.05.002.
Olsthoorn, Martin, Patrick Koot, and Stella Hoff (2020). *Kansrijk armoedebeleid*. Tech. rep. The Hague: SCP.
Ooijervaar, Jeroen, Caroline Bloemendal, and Annelies Boerdam (2016). *Jaarrapport Integratie 2016*. Tech. rep. The Hague: CBS.

Organ, Samantha, David Proverbs, and Graham Squires (2013). "Motivations for energy efficiency refurbishment in owner-occupied housing". In: *Structural Survey* 31.2, pp. 101–130. DOI: 10.1108/02630801311317527.

Pei, Zhijun (2019). "Roles of neighborhood ties , community attachment and local identity in residents' household waste recycling intention". In: *Journal of Cleaner Production* 241, p. 118217. ISSN: 0959-6526. DOI: 10.1016/j.jclepro.2019.118217. URL: https://doi.org/10.1016/j.jclepro.2019.118217.

Petrovich, Beatrice, Stefanie Lena Hille, and Rolf Wüstenhagen (2019). "Beauty and the budget: A segmentation of residential solar adopters". In: *Ecological Economics* 164, pp. 1–11. ISSN: 0921-8009. DOI: 10.1016/j.ecolecon.2019.106353. URL: https://doi.org/10.1016/j.ecolecon.2019.106353.

Phan, Mai B, Nadine Blumer, and Erin I Demaiter (2009). "Helping hands: Neighborhood diversity, deprivation, and reciprocity of support in non-kin networks". In: *Journal of Social and Personal Relationships* 26.6-7, pp. 899–918. DOI: 10.1177/0265407509345655.

Ponds, Roderik, Maarten Van Ham, and Gerard Marlet (2015). *Verschillen, ongelijkheid en segregatie: Literatuurstudie*. Tech. rep. Atlas voor gemeenten.

Prasad Koirala, Binod, Yashar Araghi, Maarten Kroesen, Amineh Ghorbani, Rudi Hakvoort, and Paulien Herder (2018). "Trust, awareness, and independence: Insights from a socio-psychological factor analysis of citizen knowledge and participation in community energy systems". In: *Energy Research & Social Science* 38, pp. 33–40. ISSN: 2214-6296. DOI: 10.1016/j.erss.2018.01.009. URL: https://doi.org/10.1016/j.erss.2018.01.009.

Programma Aardgasvrije Wijken (2020a). *"De opgave waar we voor staan is groot en complex": Essaybundel over aardgasvrije wijken door negen professoren*, pp. 1–51.

– (2020b). *Rapportage Reflectieve Monitor 2019: Voortgang & Leerervaringen 27 proeftuinen aardgasvrije wijken*. Tech. rep., pp. 1–16.

Rezbuild (2017). *Participative Processes*.

Rohe, William M and Mark Lindblad (2013). *Reexamining the Social Benefits of Homeownership after the Housing Crisis*. Tech. rep. Harvard Business School.

Roumeliotou, Myrsine and Kostas Rontos (2009). "Social Trust in Local Communities and Its Demographic , Socio-economic Predictors : The Case of Kalloni , Lesvos , Greece". In: *International Journal of Criminology and Sociological Theory* 2.1, pp. 230–250.

Sainani, Kristin L (2014). "Explanatory Versus Predictive Modeling". In: *PM&R* 6.9, pp. 841–844. ISSN: 1934-1482. DOI: 10.1016/j.pmrj.2014.08.941. URL: http://dx.doi.org/10.1016/j.pmrj.2014.08.941.

Salvad, L Laguna, E Villeneuve, and D Masson (2019). "Decision Making Near Zero Energy Building Refurbishment : A Technology Alternatives Ranking Tool Alternatives Ranking Tool". In: *IFAC PapersOnLine* 52.13, pp. 313–318. ISSN: 2405-8963. DOI: 10.1016/j.ifacol.2019.11.196. URL: https://doi.org/10.1016/j.ifacol.2019.11.196.

Sanders, Fred (2010). *Sociaal duurzame wijken, zoektocht en uitdaging?* Tech. rep. Technische Universiteit Delft.

Scheinost, Dustin, Stephanie Noble, Corey Horien, Abigail S Greene, Evelyn Lake, Mehraveh Salehi, Siyuan Gao, Xilin Shen, David O Connor, Daniel S Barron, Sarah W Yip, Monica D Rosenberg, and R Todd Constable (2019). "Ten simple rules for predictive modeling of individual differences in neuroimaging". In: *NeuroImage* 193.February, pp. 35–45. ISSN: 1053-8119. DOI: 10.1016/j.neuroimage.2019.02.057. URL: https://doi.org/10.1016/j.neuroimage.2019.02.057.

Schmeets, Hans (2018). *Vertrouwen op de kaart*. Tech. rep. The Hague: CBS, pp. 1–23.

Scholte, Samantha, Yvonne de Kluizenaar, Tim de Wilde, Anja Steenbekkers, and Christine Carabain (2020). *Op weg naar aardgasvrij wonen: De energietransitie vanuit burgerperspectief*. Tech. rep. The Hague: The Netherlands Institute for Social Research.

Schultz, P. Wesley and Lynette Zelezny (1999). "Values as Predictors of Environmental Attitudes: Evidence for Consistency Across 14 Countries". In: *Journal of Environmental Psychology* 19, pp. 255–265.

Schwindt-Bayer, Leslie A and William Mishler (2005). "An Integrated Model of Women 's Representation". In: *The Journal of Politics* 67.2, pp. 407–428.

Shipe, Maren E, Stephen A Deppen, Farhood Farjah, and Eric L Grogan (2019). "Developing prediction models for clinical use using logistic regression: an overview". In: *Journal of Thoracic Disease* 11.4, pp. 574–584. DOI: 10.21037/jtd.2019.01.25.

Siebers, Vinitha, Raymond Gradus, and René Grotens (2019). "Citizen engagement and trust : A study among citizen panel members in three Dutch municipalities". In: *The Social Science Journal* 56.4, pp. 545–554. ISSN: 0362-3319. DOI: 10.1016/j.soscij.2018.09.010. URL: https://doi.org/10.1016/j.soscij.2018.09.010.

Sleutjes, Bart, Helga A G de Valk, and Jeroen Ooijevaar (2018). "The Measurement of Ethnic Segregation in the Netherlands: Differences Between Administrative and Individualized Neighbourhoods". In: *European Journal of Population* 34.2, pp. 195–224. ISSN: 1572-9885. DOI: 10.1007/s10680-018-9479-z. URL: https://doi.org/10.1007/s10680-018-9479-z.

Sriboonchitta, Songsak, Luc Longpré, Vladik Kreinovich, and Thongchai Dumrongpokaphan (2018). "Why the Best Predictive Models Are Often Different from the Best Explanatory Models : A Theoretical Explanation". In: *Structural Changes and their Econometric Modeling*, pp. 1–9.

Steenbekkers, Anja, Lotte Vermeij, and Pepijn Van Houwelingen (2017). *Dorpsleven tussen stad en land: Slotpublicatie Sociale Staat van het Platteland*. Tech. rep. Den Haag: SCP.

Stein, Rachel E (2014). "Neighborhood Scale and Collective Efficacy: Does Size Matter?" In: *Sociology Compass* 8.2, pp. 119–128.

Steyerberg, Ewout W, Andrew J Vickers, Nancy R Cook, Thomas Gerds, Nancy Obuchowski, Michael J Pencina, and Michael W Kattan (2010). "Assessing the performance of prediction models: a framework for some traditional and novel measures". In: *Epidemiology* 21.1, pp. 128–138. DOI: 10.1097/EDE.0b013e3181c30fb2.Assessing.

Stotz, Olaf (2019). "The perception of homeownership utility : Short-term and long-term effects". In: *Journal of Housing Economics* 44.October 2016, pp. 99–111. ISSN: 1051-1377. DOI: 10.1016/j.jhe.2018.11.003. URL: https://doi.org/10.1016/j.jhe.2018.11.003.

Taylor, Mark (2011). "Measuring Financial Capability and its Determinants Using Survey Data". In: *Social Indicators Research* 102.2, pp. 297–314. ISSN: 1573-0921. DOI: 10.1007/s11205-010-9681-9. URL: https://doi.org/10.1007/s11205-010-9681-9.

Tolsma, Jochem and Maurice Gesthuizen (2009). "The Impact of Neighbourhood and Municipality Characteristics on Social Cohesion in The Netherlands". In: *Acta Politica* 0.0, pp. 1–28. DOI: 10.1057/ap.2009.6.

Ulbig, Stacy G (2002). "Policies , Procedures , and People: Sources of Support for Government? *". In: *Social Science Quarterly* 83.3.

– (2005). "Political Realities and Political Trust: Descriptive Representtaion in Municipal Government". PhD thesis.

– (2007). "Gendering Municipal Government : Female Descriptive Representation and Feelings of Political Trust". In: *Social Science Quarterly* 88.5.

United Nations Framework Convention on Climate Change (2015). *The Paris Agreement*.

Uslaner, Eric M (2012). "Trust, Diversity, and Segregation". In: *Segregation and mistrust : diversity, isolation, and social cohesion*. Chap. 1, pp. 1–16. ISBN: 9781139026758.

Van Beuningen, Jacqueline and Hans Schmeets (2013). "Developing a Social Capital Index for the Netherlands". In: *Social Indicators Research* 113, pp. 859–886. DOI: 10.1007/s11205-012-0129-2.

Van Dalen, Harry and Kène Henkens (2019). "Het veranderde klimaat over klimaatverandering". In: *Demos: Bulletin over Bevolking en Samenleving* 35.4, pp. 1–4.

Van Der Zwan, Roos, Marcel Lubbers, and Rob Eisinga (2019). "The political representation of ethnic minorities in the Netherlands: ethnic minority candidates and the role of party characteristics". In: *Acta Politica* 54.2, pp. 245–267. ISSN: 1741-1416. DOI: 10.1057/s41269-018-0085-1. URL: https://doi.org/10.1057/s41269-018-0085-1.

Van Ham, Maarten and David Manley (2009). "Social housing allocation, choice and neighbourhood ethnic mix in England". In: *Journal of Housing and the Built Environment* 24.4, p. 407. ISSN: 1573-7772. DOI: 10.1007/s10901-009-9158-9. URL: https://doi.org/10.1007/s10901-009-9158-9.

Vasseur, Véronique and René Kemp (2015a). "A segmentation analysis: the case of photovoltaics in the Netherlands". In: *Energy Efficiency* 8, pp. 1105–1123. DOI: 10.1007/s12053-015-9340-8.

Vasseur, Véronique and René Kemp (2015b). "The adoption of PV in the Netherlands: A statistical analysis of adoption factors". In: *Renewable and Sustainable Energy Reviews* 41, pp. 483–494. ISSN: 1364-0321. DOI: 10.1016/j.rser.2014.08.020. URL: http://dx.doi.org/10.1016/j.rser.2014.08.020.

Weiss, Julika, Elisa Dunkelberg, and Thomas Vogelpohl (2012). "Improving policy instruments to better tap into homeowner refurbishment potential: Lessons learned from a case study in Germany". In: *Energy Policy* 44, pp. 406–415. ISSN: 0301-4215. DOI: 10.1016/j.enpol.2012.02.006. URL: http://dx.doi.org/10.1016/j.enpol.2012.02.006.

Welch, Michael R., Roberto E. N. Rivera, Brian P. Conway, Jennifer Yonkoski, Paul M. Lupton, and Russell Giancola (2005). "Determinants and Consequences of Social Trust*". In: *Sociological Inquiry* 75.4, pp. 453–473. DOI: https://doi.org/10.1111/j.1475-682X.2005.00132.x. eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1475-682X.2005.00132.x. URL: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1475-682X.2005.00132.x.

Wennekers, Annemarie, Jeroen Boelhouwer, Crétien van Campen, and Jeanet Kullberg (2019). *De sociale staat van Nederland*. Tech. rep. The Hague: SCP.

Wentink, Carlijn, Lenneke Vaandrager, Rosalie Van Dam, Jan Hassink, and Irini Salverda (2018). "Exploring the role of social capital in urban citizens' initiatives in the Netherlands". In: *Gaceta Sanitaria* 32.6, pp. 539–546. ISSN: 0213-9111. DOI: 10.1016/j.gaceta.2017.05.011. URL: http://dx.doi.org/10.1016/j.gaceta.2017.05.011.

Westin, Kerstin, Johan Jansson, and Annika Nordlund (2018). "The importance of socio-demographic characteristics, geographic setting, and attitudes for adoption of electric vehicles in Sweden". In: *Travel Behaviour and Society* 13, pp. 118–127. ISSN: 2214-367X. DOI: 10.1016/j.tbs.2018.07.004. URL: https://doi.org/10.1016/j.tbs.2018.07.004.

Westin, Paul and Fredrik Lagergren (2002). "Re-regulating district heating in Sweden". In: *Energy Policy* 30, pp. 583–596.

Wickes, Rebecca, Renee Zahnow, Gentry White, and Lorraine Mazerolle (2013). "Ethnic Diversity and its Impact on Community Social Cohesion and Neighborly Exchange". In: *Journal of Urban Affairs* 36.1, pp. 51–78. DOI: 10.1111/juaf.12015.

Woestenburg, Alexander, Hanneke Puts, Devin Diran, Nienke Maas, Saskia Buitelaar, Anne Heeger, and Donald van den Akker (2020). *Innovatie in Besluitvorming Richting Aardgasvrije Wijken*. Tech. rep. G4, TNO, Platform 31.

Xiao, Jing Jian and Cheng Chen (2015). "Age Differences in Consumer Financial Capability". In: *International Journal of Consumer Studies* 39, pp. 387–395. DOI: 10.1111/ijcs.12205.

Yamamura, Eiji (2011). "Comparison of the effects of homeownership by individuals and their neighbors on social capital formation : Evidence from Japanese General Social Surveys". In: *Journal of Socio-Economics* 40.5, pp. 637–644. ISSN: 1053-5357. DOI: 10.1016/j.socec.2011.05.002. URL: http://dx.doi.org/10.1016/j.socec.2011.05.002.

10 Appendices

10.1 Summary of Considerations by Ebskamp and Verbraak (2019)

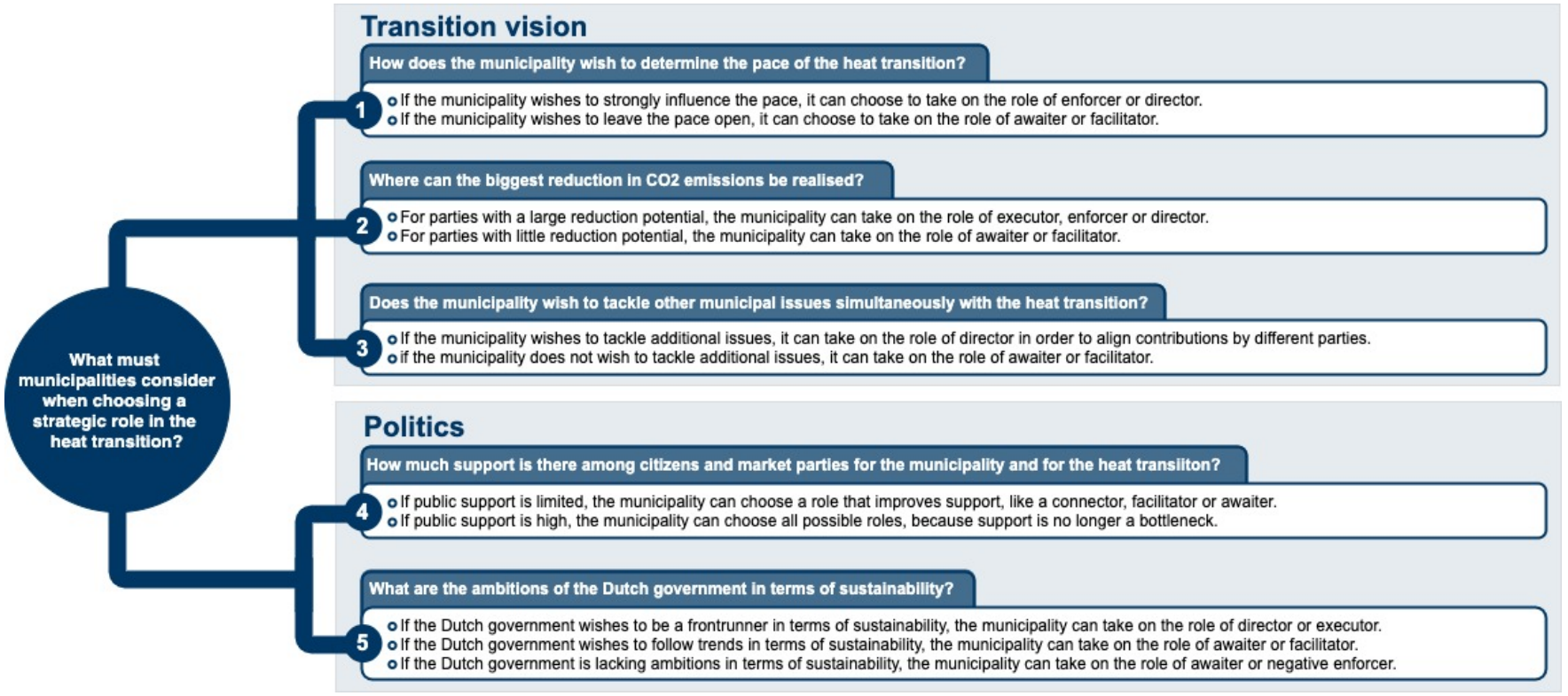

Figure 28: Summary of considerations used to choose a municipal strategic role (Ebskamp and Verbraak 2019)

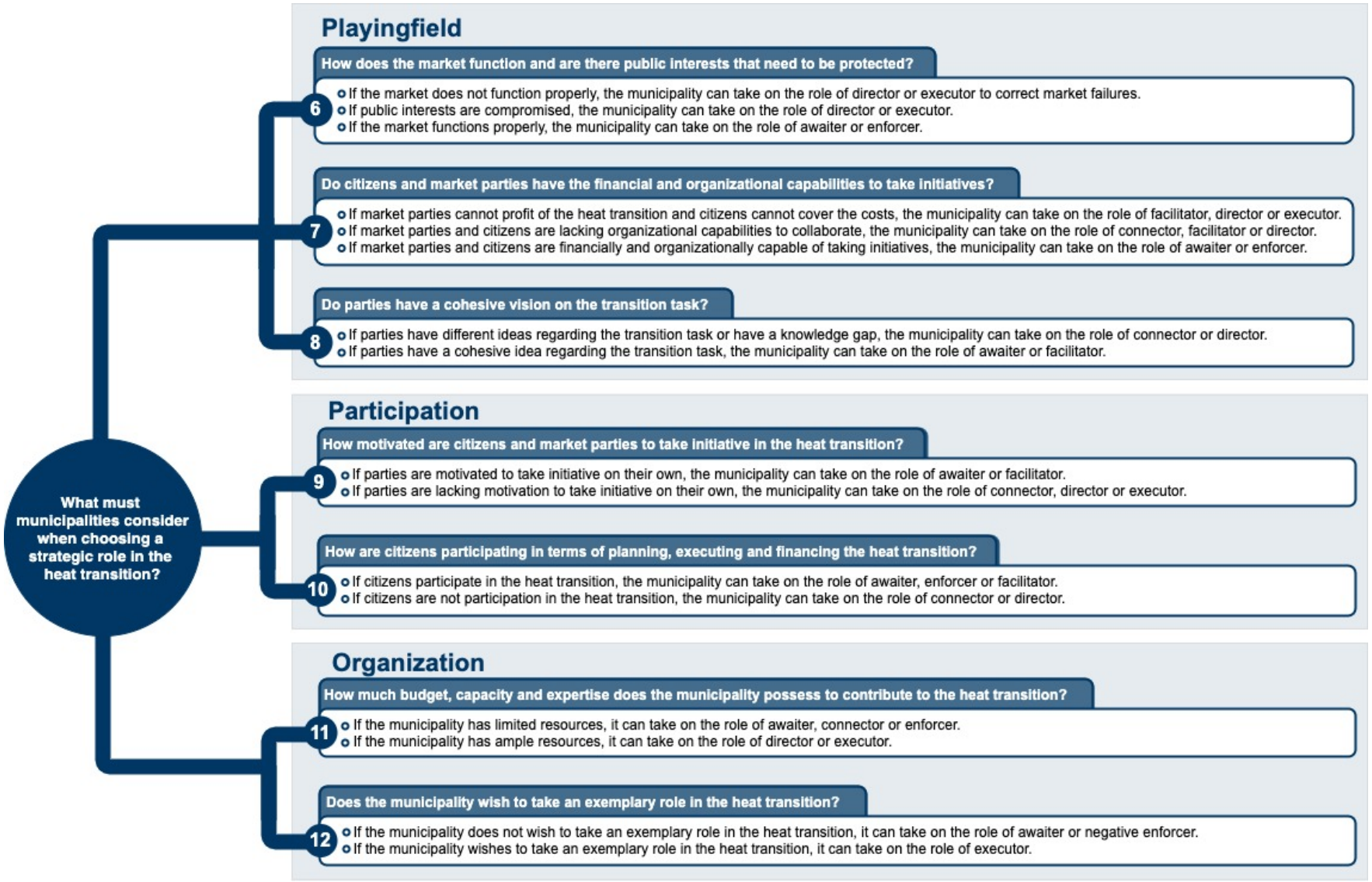

Figure 2 continued: Summary of considerations used to choose a municipal strategic role (Ebskamp and Verbraak 2019)

10.2 Datasets

Table 14: Background variable datasets

Dataset	Year	Variables
avars_201905_EN_1.0p.zip	05/2019	nomem_encr, positie, woning,
avars_201810_EN_1.0p.zip	10/2018	geslacht, lftdcat, oplcat, nettohh_f,
avars_201603_EN_1.0p.zip	03/2016	herkomstgroep, woonvorm, aantalki,
avars_200910_EN_2.0p.zip	10/2009	partner, sted, wave

Table 15: Datasets used in this study

Dataset	Study	Year	Variables
N/S*	Support for the transition to a natural gas-free building stock in 2050	05/2019	nomem_encr, AV_Steun, AV_Intentie
ci19l_EN_2.0p.sav	Economic situation: Income – Wave 12	06/2019	nomem_encr, ci19l378
ci16i_EN_2.0p.sav	Economic situation: Income – Wave 9	06/2016	nomem_encr, ci16i244
cp19k_EN_1.0p.sav	Personality – Wave 11	05/2019	nomem_encr, cp19k019
cp15h_EN_1.0p.sav	Personality – Wave 8	11/2015	nomem_encr, cp15h019
os18a_EN_1.0p.sav	Social and cultural report	10/2018	nomem_encr, os18a197
nl16a_EN_1.0p.sav	Local voters survey	03/2016	nomem_encr, nl16a082, nl16a083, nl16a084, nl16a085
bh09a_EN_1.0p.sav	Unaffiliated spirituality and social engagement	10/2009	nomem_encr, bh09a021, bh09a193

* *Dataset is not yet released. Data obtained on request from the SCP.*

10.3 Summary of Proxy Variables

Table 16: Summary of dependent variables used in this study after data processing

Variable	Question	Response
AV_Steun	To what extent are you for or against the plan that all homes must be natural gas-free by 2050?	1) Completely against 2) Against 3) Somewhat against 4) Not for/not against 5) Somewhat for 6) For 7) Completely for
AV_Intentie	Can you indicate the extent to which you agree or disagree with the following statement? As soon as my boiler of gas heater is broken, I will consider replacing it with a natural gas-free alternative.	1) Completely disagree 2) Disagree 3) Somewhat disagree 4) Don't agree/don't disagree 5) Somewhat agree 6) Agree 7) Completely agree
ci19l378 & ci16i244	Can you indicate, on a scale from 0 to 10, how hard or how easy it is for you to live off your income?	{0,1,2,3,4,5,6,7,8,9,10} 0 = very hard 10 = very easy
cp19k019 & cp15h019	Generally speaking, would you say that most people can be trusted, or that you can't be too careful in dealing with people? Please indicate a score of 0 to 10.	{0,1,2,3,4,5,6,7,8,9,10} 0 = you can't be too careful 10 = most people can be trusted
os18a197	To what extent do you feel connected to your neighborhood (or village)?	1) Not at all connected 2) Not very connected 3) Connected 4) Very connected
nl16a082	Please indicate for each of the institutions below, how much trust you have in them: the municipal council	1) None at all 2) Not very much 3) Fairly much 4) Very much
nl16a083	Please indicate for each of the institutions below, how much trust you have in them: the municipal executive	1) None at all 2) Not very much 3) Fairly much 4) Very much

Table 16 continued: Summary of dependent variables used in this study after data processing

Variable	Question	Response
nl16a084	Please indicate for each of the institutions below, how much trust you have in them: the mayor	1) None at all 2) Not very much 3) Fairly much 4) Very much
nl16a085	Please indicate for each of the institutions below, how much trust you have in them: municipal civil servants	1) None at all 2) Not very much 3) Fairly much 4) Very much
bh09a021	The earth's climate problem is grossly exaggerated.	1) Disagree completely 2) Disagree 3) Neither agree nor disagree 4) Agree 5) Agree completely
bh09a193	I have introduced energy-efficient modifications in my home on account of environmental considerations.	0) No 1) Yes

10.4 R Code for Data Processing

Required libraries:

```
library(MASS)
library(stargazer)
library(ggplot2)
library(haven)
library(dplyr)
library(gmodels)
library(naniar)
library(lmtest)
library(DescTools)
library(caret)
library(rpart)
library(rattle)
library(rpart.plot)
library(mediation)
library(gridExtra)
library(lattice)
library(ResourceSelection)
library(pROC)
library(plyr)
library(car)
```

(1)

Round2 function:

$$
\begin{aligned}
&round2 = function(x, n)\{ \\
&\quad posneg = sign(x) \\
&\quad z = abs(x) * 10^n \\
&\quad z = z + 0.5 \\
&\quad z = trunc(as.numeric(as.character(z))) \\
&\quad z = z/10^n \\
&\quad (z) * posneg \\
&\quad \}
\end{aligned}
\tag{2}
$$

Loading data:

$$data <- read_sav("filename.sav") \tag{3}$$

10.4.1 Socio-Demographic Data

Filter household head:

$$data_{iv} <- filter(data_{iv}, positie == 1) \tag{4}$$

Selecting relevant columns:

$$
\begin{aligned}
data_{iv} <- data_{iv}[c(&"nomem_encr", "woning", "geslacht", \\
&"gebjaar", "leeftijd", "lftdcat", \\
&"oplcat", "nettohh_f", "herkomstgroep", \\
&"woonvorm", "aantalki", "partner", \\
&"sted", "wave")]
\end{aligned}
\tag{5}
$$

Mutate income variable:

$$
\begin{aligned}
&data_{iv}\$nettohh\_f <- as.numeric(data_{iv}\$nettohh\_f) \\
&data_{iv}\$nettohh\_f[is.na(data_{iv}\$nettohh\_f)] <- -2 \\
&data_{iv} <- mutate(data_{iv}, "nettocat" = nettohh\_f) \\
&data_{iv}\$nettocat <- cut(data_{iv}\$nettocat, c(-3, -1, 1, 500, 1000, \\
&\qquad\qquad 1500, 2000, 2500, 3000, \\
&\qquad\qquad 3500, 4000, 4500, 5000, \\
&\qquad\qquad 7500, 50000), \\
&\qquad\qquad labels = FALSE)) \\
&data_{iv}\$nettocat <- recode(data_{iv}\$nettocat, "13", "0", "1", "2", \\
&\qquad\qquad "3", "4", "5", "6", "7", \\
&\qquad\qquad "8", "9", "10", "11", "12") \\
&data_{iv}\$nettocat <- na\_if(data_{iv}\$nettocat, 13) \\
&data_{iv}\$nettohh\_f <- na\_if(data_{iv}\$nettohh\_f, -2)
\end{aligned}
\tag{6}
$$

Recode homeownership variable:

$$data_{iv}\$woning <- recode(data_{iv}\$woning, "1", "0", "0", "0") \tag{7}$$

Recode urbanity variable:

$$\begin{aligned} data_{iv}\$sted &<- recode(data_{iv}\$sted, "5", "4", "3", "2", "1") \\ data_{iv}\$sted &<- as.numeric(data_{iv}\$sted) \end{aligned} \tag{8}$$

Recode urbanity variable:

$$\begin{aligned} data_{iv}\$herkomstgroep <- recode(&data_{iv}\$herkomstgroep, \\ &"0" = "0", "101" = "1", \\ &"102" = "1", "201" = "2", \\ &"202" = "2") \end{aligned} \tag{9}$$

Defining factor variables:

$$\begin{aligned} data_{iv}\$geslacht &<- as.factor(data_{iv}\$geslacht) \\ data_{iv}\$herkomstgroep &<- as.factor(data_{iv}\$herkomstgroep) \\ data_{iv}\$partner &<- as.factor(data_{iv}\$partner) \\ data_{iv}\$woonvorm &<- as.factor(data_{iv}\$woonvorm) \end{aligned} \tag{10}$$

10.4.2 Dependent & Mediating Variable Data

Selecting relevant columns:

$$data_{dv} <- data_{dv}[c("nomem\_encr", "DV_1", ..., "DV_n")] \tag{11}$$

Removing "don't know" and "no opinion" responses:

$$\begin{aligned} &data_{dv} <- filter(data_{dv}, DV != x) \\ &Where\ x\ =\ the\ factor\ value\ assigned\ to\ "don't\ know/no\ opinion" \end{aligned} \tag{12}$$

Proxy for municipal trust:

$$\begin{aligned} muntrust <- &(data_{muntrust}\$nl16a082\ +\ data_{muntrust}\$nl16a083\ + \\ &data_{muntrust}\$nl16a084\ +\ data_{muntrust}\$nl16a085)/4 \\ muntrust <- &round2(muntrust,\ 0) \\ data_{muntrust} <- &cbind(data_{muntrust}, muntrust) \end{aligned} \tag{13}$$

Recode connection to neighborhood variable:

$$\begin{aligned} data_{connection}\$os18a197 <- recode(&data_{connection}\$os18a197, "1" = "4", "2" = "3", \\ &"3" = "2", "4" = "1") \\ data_{connection}\$os18a197 <- &as.numeric(data_{connection}\$os18a197) \end{aligned} \tag{14}$$

Recode environmental concern variable variable:

$$\begin{aligned} data_{concern}\$bh09a021 <- recode(&data_{concern}\$bh09a021, "1" = "4", "2" = "3", \\ &"3" = "2", "4" = "1") \\ data_{concern}\$bh09a021 <- &as.numeric(data_{concern}\$bh09a021) \end{aligned} \tag{15}$$

Merging datasets:

$$data <- merge(data_{iv} + data_{dv}, by = "nomem\_encr") \tag{16}$$

10.5 R Code for Data Analysis

10.5.1 Explanatory Model

Bivariate ordinal logistic regression:

$$\begin{aligned} &polr(as.factor(DV) \sim IV, \\ &data = data, Hess = T, na.action = na.exclude) \end{aligned} \tag{17}$$

Bivariate binary logistic regression:

$$\begin{aligned} &glm(as.factor(binaryDV) \sim IV, \\ &data = data, Hess = T, na.action = na.exclude, family = "binomial") \end{aligned} \tag{18}$$

Multiple ordinal logistic regression:

$$\begin{aligned} &polr(as.factor(DV) \sim IV_1 + IV_2 + ... + IV_n, \\ &data = data, Hess = T, na.action = na.exclude) \end{aligned} \tag{19}$$

Multiple binary logistic regression:

$$\begin{aligned} &glm(as.factor(binaryDV) \sim IV_1 + IV_2 + ... + IV_n, \\ &data = data, Hess = T, na.action = na.exclude, family = "binomial") \end{aligned} \tag{20}$$

Models to test for mediation:

$$\begin{aligned} "full\ model" <- &polr(as.factor(DV) \sim MED + IV_1 + IV_2 + ... + IV_n, \\ &data = data, Hess = T, na.action = na.exclude) \\ "constrained\ model" <- &polr(as.factor(DV) \sim IV_1 + IV_2 + ... + IV_n, \\ &data = data, Hess = T, na.action = na.exclude) \\ "mediator\ model" <- &polr(as.factor(MED) \sim IV_1 + IV_2 + ... + IV_n, \\ &data = data, Hess = T, na.action = na.exclude) \end{aligned} \tag{21}$$

10.5.2 Predictive Model

Creating binary dependent variables:

```
neg <- filter(data, DV < "negative cut-off")
pos <- filter(data, DV > "positive cut-off")

neg <- mutate(neg, binaryDV = 0)
pos <- mutate(pos, binaryDV = 0)

binary <- rbind(neg, pos)
binary <- binary[c("nomem_encr", "binaryDV"]

data <- merge(data, binary, by = "nomem_encr")
```
(22)

Create data partition:

```
set.seed(3456)
Index <- createDataPartition(data$DV, p = 0.8, list = FALSE, times = 1)
Train <- data[Index, ]
Test <- data[-Index, ]
```
(23)

Model predictions:

```
Train$pp <- predict(binarymodel, data = Train, type = "response")

Test$pp <- predict(binarymodel, data = Test, type = "response")
```
(24)

Model accuracy:

```
Train$outcome <- round2(Train$pp, n = 0)
Train <- mutate(Train, accurate = (binaryDV == outcome))
sum(Train$accurate)/nrow(Train)

Test$outcome <- round2(Test$pp, n = 0)
Test <- mutate(Test, accurate = (binaryDV == outcome))
sum(Test$accurate)/nrow(Test)
```
(25)

10.6 Step 2 Multiple Regression Output

Table 17: 'Step 2' multiple regression results

	Dependent variable:					
	NG-Free Policy Support	Trust in the Municipality	Financial Capability	Social Trust	Previous Energy Efficient Home Modifications	Intention to Adopt NG Alternative
Age Category	−0.026	0.124***	−0.037	0.144***	−0.040***	−0.088
	(0.035)	(0.047)	(0.026)	(0.019)	(0.011)	(0.053)
Female	0.461***	−0.066	−0.238***	0.049	−0.025	0.750***
	(0.105)	(0.149)	(0.081)	(0.054)	(0.033)	(0.149)
Education Level	0.206***	0.103**	0.144***	0.239***	−0.019	0.157***
	(0.034)	(0.045)	(0.026)	(0.019)	(0.010)	(0.045)
Income Level	0.008	0.028	0.319***	0.068***	0.005	−0.004
	(0.024)	(0.030)	(0.019)	(0.013)	(0.007)	(0.030)
Western	−0.036	−0.418	−0.400***	−0.561***		0.134
	(0.177)	(0.224)	(0.126)	(0.100)		(0.230)
Non−Western	0.089	0.113	−0.139	−0.263***		0.110
	(0.166)	(0.231)	(0.126)	(0.100)		(0.249)
No. Children	−0.144**	−0.050	−0.353***	−0.082***	0.005	−0.074
	(0.070)	(0.072)	(0.044)	(0.031)	(0.015)	(0.084)
Partner	0.110	0.104	−0.462***	−0.151**	−0.058	0.313**
	(0.119)	(0.158)	(0.094)	(0.070)	(0.035)	(0.154)
Urbanity	0.061	−0.023	0.029	0.014	0.014	−0.045
	(0.034)	(0.049)	(0.026)	(0.020)	(0.011)	(0.044)
Homeowner	−0.472***	0.225	0.709***	0.325***	−0.015	−0.394
	(0.110)	(0.150)	(0.086)	(0.068)	(0.032)	(0.695)
Constant					0.630***	
					(0.087)	
Observations	1,519	1,138	2,609	4,366	1,307	872
Log Likelihood	−2,792.7	−1,109.0	−4,890.7	−8,715.7	−891.5	−1574.5
L−ratio test Chi^2	102.61***	36.76***	758.68***	424.17***	24.08**	49.28***
AIC	5,617.3	2,244.0	9,821.3	17,471.5	1,801.0	3,180.9

Note: **p<0.05; ***p<0.01

Table 18: 'Step 2' multiple regression results for the mediator variables

	Mediator variable:	
	Environmental Concern	Connection to the Neighborhood
Age Category	−0.073	0.097***
	(0.041)	(0.028)
Female	0.421***	0.149
	(0.126)	(0.085)
Education Level	0.200***	−0.080***
	(0.037)	(0.028)
Income Level	0.012	0.004
	(0.028)	(0.019)
Western		−0.152
		(0.131)
Non-Western		−0.128
		(0.136)
No. Children	−0.017	0.089
	(0.060)	(0.046)
Partner	−0.058	0.058
	(0.138)	(0.098)
Urbanity	0.074	−0.177***
	(0.041)	(0.031)
Homeownership	−0.106	0.241***
	(0.124)	(0.090)
Observations	1,289	2,747
Log Likelihood	−1,786.6	−2,987.1
L−ratio test Chi^2	72.27***	111.12***
AIC	3,597.2	6,000.2
Note:		**p<0.05; ***p<0.01

10.7 Step 3 Bivariate Regression Output

Table 19: Bivariate regression results for the extended models

	Dependent variable:				
	Intention to Adopt NG Alternative	NG-Free Policy Support	Social Trust	Trust in the Municipality	Previous Energy Efficient Home Modifications
NG-Free Policy Support	0.732***				
	(0.041)				
	n = 839				
Social Trust	0.154***	0.130***		0.282***	
	(0.031)	(0.022)		(0.034)	
	n = 839	n = 1,545		n = 839	
Financial Capability	0.093***	0.057**	0.278***	0.203***	
	(0.035)	(0.023)	(0.033)	(0.036)	
	n = 830	n = 1,523	n = 818	n = 835	
Trust in Municipality			0.855***		
			(0.098)		
			n = 839		
Connection to Neighborhood			0.353***	0.527***	
			(0.088)	(0. 098)	
			n = 839	n = 856	
Environmental Concern					−0.416***
					(0.057)
					n = 1,342

Note: **p<0.05; ***p<0.01

10.8 Step 6 Mediation Analysis Output

10.8.1 Model 1: Mediating Effects on the Intention to Adopt Natural Gas-Free Heating

Table 20: Effect of socio-demographic characteristics on a person's intention to adopt a natural gas-free heat source with and without controlling for a person's support for natural gas-free policy

	Full Model	*Constrained Model*	*Mediator Model*
	Intention to Adopt NG alternative	Intention to Adopt NG alternative	NG-Free Policy Support
Heat Transition Support	0.701***		
	(0.043)		
Financial Capability	0.049	0.101**	0.092**
	(0.042)	(0.041)	(0.040)
Age Category	−0.130**	−0.109	0.026
	(0.056)	(0.056)	(0.055)
Female	0.413**	0.724***	0.719***
	(0.165)	(0.159)	(0.158)
Education Level	0.044	0.145***	0.192***
	(0.050)	(0.049)	(0.050)
Income Level	−0.030	−0.032	−0.019
	(0.034)	(0.033)	(0.033)
Western	0.236	0.296	0.309
	(0.268)	(0.253)	(0.261)
Non−Western	−0.070	−0.001	0.235
	(0.278)	(0.274)	(0.274)
Partner	0.136	0.245	0.323**
	(0.168)	(0.164)	(0.164)
No. Children	−0.011	−0.014	0.008
	(0.092)	(0.091)	(0.092)
Urbanity	−0.076	−0.035	0.041
	(0.049)	(0.047)	(0.047)
Homeowner			0.207
			(0.732)
Observations	766	766	766

Note: **p<0.05; ***p<0.01

Table 21: Effect of socio-demographic characteristics on a person's intention to adopt a natural gas-free heat source with and without controlling for social trust

	Full Model	*Constrained Model*	*Mediator Model*
	Intention to Adopt NG alternative	Intention to Adopt NG alternative	Social Trust
Social Trust	0.148***		
	(0.035)		
Financial Capability	0.073	0.101**	0.219***
	(0.042)	(0.041)	(0.042)
Age Category	−0.148***	−0.109	0.268***
	(0.056)	(0.056)	(0.057)
Female	0.700***	0.724***	0.123
	(0.159)	(0.159)	(0.157)
Education Level	0.117**	0.145***	0.186***
	(0.049)	(0.049)	(0.051)
Income Level	−0.033	−0.032	−0.007
	(0.033)	(0.033)	(0.034)
Western	0.340	0.296	−0.280
	(0.255)	(0.253)	(0.257)
Non−Western	−0.006	−0.001	−0.081
	(0.276)	(0.274)	(0.281)
Partner	0.203	0.245	0.274
	(0.165)	(0.164)	(0.165)
No. Children	−0.002	−0.014	−0.116
	(0.091)	(0.091)	(0.094)
Urbanity	−0.031	−0.035	−0.021
	(0.047)	(0.047)	(0.048)
Homeowner			−0.628
			(0.725)
Observations	766	766	766

Note: **p<0.05; ***p<0.01

10.8.2 Model 2: Mediating Effect on Natural Gas-Free Policy Support

Table 22: Effect of socio-demographic characteristics on a person's support for natural gas-free policy with and without controlling for social trust

	Full Model	*Constrained Model*	*Mediator Model*
	NG-Free Policy Support	NG-Free Policy Support	Social Trust
Social Trust	0.128***		
	(0.025)		
Financial Capability	0.050	0.076***	0.236***
	(0.028)	(0.027)	(0.028)
Age Category	−0.048	−0.021	0.189***
	(0.037)	(0.037)	(0.037)
Female	0.433***	0.455***	0.140
	(0.110)	(0.110)	(0.109)
Education Level	0.158***	0.180***	0.182***
	(0.036)	(0.036)	(0.036)
Income Level	−0.013	−0.010	0.018
	(0.026)	(0.026)	(0.026)
Western	0.145	0.063	−0.528***
	(0.186)	(0.184)	(0.183)
Non−Western	0.155	0.112	−0.272
	(0.175)	(0.174)	(0.173)
Partner	0.096	0.112	0.108
	(0.125)	(0.125)	(0.125)
No. Children	−0.050	−0.069	−0.159**
	(0.075)	(0.075)	(0.075)
Urbanity	0.040	0.046	0.018
	(0.036)	(0.036)	(0.036)
Homeowner	−0.545***	−0.514***	0.160
	(0.116)	(0.116)	(0.116)
Observations	1,388	1,388	1,388

Note: **p<0.05; ***p<0.01

10.8.3 Model 3: Mediating Effects on Social Trust

Table 23: Effect of socio-demographic characteristics on social trust with and without controlling for a person's financial capability

	Full Model	*Constrained Model*	*Mediator Model*
	Social Trust	Social Trust	Financial Capability
Financial Capability	0.223***		
	(0.040)		
Connection to Neighborhood	0.263***	0.291***	0.058
	(0.096)	(0.096)	(0.095)
Age Category	0.179***	0.177***	−0.021
	(0.055)	(0.055)	(0.054)
Female	0.305	0.283	−0.256
	(0.168)	(0.168)	(0.168)
Education Level	0.184***	0.207***	0.171***
	(0.049)	(0.049)	(0.049)
Income Level	0.046	0.105***	0.323***
	(0.034)	(0.033)	(0.035)
Western	−0.331	−0.395	−0.216
	(0.237)	(0.238)	(0.231)
Non-Western	0.049	0.011	−0.042
	(0.292)	(0.288)	(0.271)
Partner	−0.081	−0.126	−0.232
	(0.171)	(0.171)	(0.175)
No. Children	−0.001	−0.055	−0.348***
	(0.081)	(0.080)	(0.079)
Urbanity	−0.117**	−0.110**	0.012
	(0.054)	(0.054)	(0.054)
Homeowner	−0.021	0.121	0.637***
	(0.167)	(0.165)	(0.169)
Observations	771	771	771

Note: **p<0.05; ***p<0.01

Table 24: Effect of socio-demographic characteristics on social trust with and without controlling for trust in the municipality

	Full Model	*Constrained Model*	*Mediator Model*
	Social Trust	Social Trust	Trust in the Municipality
Trust in Municipality	0.724***		
	(0.103)		
Connection to Neighborhood	0.181	0.291***	0.496***
	(0.098)	(0.096)	(0.107)
Age Category	0.158***	0.177***	0.088
	(0.055)	(0.055)	(0.061)
Female	0.260	0.283	−0.045
	(0.169)	(0.168)	(0.191)
Education Level	0.198***	0.207***	0.085
	(0.049)	(0.049)	(0.055)
Income Level	0.099***	0.105***	0.027
	(0.033)	(0.033)	(0.036)
Western	−0.298	−0.395	−0.364
	(0.238)	(0.238)	(0.260)
Non-Western	0.023	0.011	0.189
	(0.286)	(0.288)	(0.313)
Partner	−0.116	−0.126	0.038
	(0.171)	(0.171)	(0.196)
No. Children	−0.058	−0.055	−0.047
	(0.081)	(0.080)	(0.091)
Urbanity	−0.109**	−0.110**	−0.049
	(0.054)	(0.054)	(0.061)
Homeowner	0.072	0.121	0.132
	(0.165)	(0.165)	(0.188)
Observations	771	771	771

Note: **p<0.05; ***p<0.01

10.8.4 Model 4: Mediating Effects on Trust in the Municipality

Table 25: Effect of socio-demographic characteristics on trust in the municipality with and without controlling for social trust

	Full Model	*Constrained Model*	*Mediator Model*
	Trust in the Municipality	Trust in the Municipality	Social Trust
Social Trust	0.265***		
	(0.036)		
Age Category	0.068	0.124***	0.144***
	(0.062)	(0.047)	(0.019)
Female	−0.061	−0.066	0.049
	(0.193)	(0.149)	(0.054)
Education Level	0.016	0.103**	0.239***
	(0.056)	(0.045)	(0.019)
Income Level	−0.003	0.028	0.068***
	(0.037)	(0.030)	(0.013)
Western	−0.265	−0.418	−0.561***
	(0.263)	(0.224)	(0.100)
Non-Western	0.232	0.113	−0.263***
	(0.315)	(0.231)	(0.100)
Partner	0.132	0.104	−0.151**
	(0.197)	(0.158)	(0.070)
No. Children	−0.003	−0.050	−0.082***
	(0.092)	(0.072)	(0.031)
Urbanity	−0.041	−0.023	0.014
	(0.061)	(0.049)	(0.010)
Homeowner	0.142	0.225	0.325***
	(0.190)	(0.150)	(0.068)
Observations	771	1,138	4,366

Note: **p<0.05; ***p<0.01

Table 26: Effect of socio-demographic characteristics on trust in the municipality with and without controlling for a person's financial capability

	Full Model	*Constrained Model*	*Mediator Model*
	Trust in the Municipality	Trust in the Municipality	Financial Capability
Financial Capability	0.212***		
	(0.044)		
Age Category	0.125**	0.124***	−0.037
	(0.061)	(0.047)	(0.026)
Female	0.103	−0.066	−0.238***
	(0.191)	(0.149)	(0.081)
Education Level	0.051	0.103**	0.144***
	(0.055)	(0.045)	(0.026)
Income Level	−0.039	0.028	0.319***
	(0.039)	(0.030)	(0.019)
Western	−0.382	−0.400***	−0.217
	(0.260)	(0.224)	(0.126)
Non-Western	0.215	0.113	−0.139
	(0.314)	(0.231)	(0.126)
Partner	0.170	0.104	−0.462***
	(0.196)	(0.158)	(0.094)
No. Children	0.037	−0.050	−0.353***
	(0.092)	(0.072)	(0.044)
Urbanity	−0.072	−0.023	0.029
	(0.061)	(0.049)	(0.026)
Homeowner	0.080	0.225	0.709***
	(0.190)	(0.150)	(0.086)
Observations	771	1,138	2,609

Note: **p<0.05; ***p<0.01

Table 27: Effect of socio-demographic characteristics on trust in the municipality with and without controlling for a person's connection to their neighborhood

	Full Model	*Constrained Model*	*Mediator Model*
	Trust in the Municipality	Trust in the Municipality	Connection to the Neighborhood
Connection to Neighborhood	0.496***		
	(0.107)		
Age Category	0.088	0.124***	0.097***
	(0.061)	(0.047)	(0.028)
Female	−0.045	−0.066	0.149
	(0.191)	(0.149)	(0.085)
Education Level	0.085	0.103**	−0.080***
	(0.055)	(0.045)	(0.053)
Income Level	0.027	0.028	0.004
	(0.036)	(0.030)	(0.019)
Western	−0.364	−0.418	−0.152
	(0.260)	(0.224)	(0.131)
Non-Western	0.189	0.113	−0.128
	(0.313)	(0.231)	(0.136)
Partner	0.038	0.104	0.058
	(0.196)	(0.158)	(0.098)
No. Children	−0.047	−0.050	0.089
	(0.091)	(0.072)	(0.046)
Urbanity	−0.049	−0.023	−0.177***
	(0.061)	(0.049)	(0.031)
Homeowner	0.132	0.225	0.241***
	(0.188)	(0.150)	(0.090)
Observations	771	1,138	2,747

Note: **p<0.05; ***p<0.01

10.8.5 Model 5: Mediating Effect on Previous Energy Efficient Home Modifications

Table 28: Effect of socio-demographic characteristics on sustainable behavior with and without controlling for environmental concern

	Full Model	*Constrained Model*	*Mediator Model*
	Sustainable Behavior	Previous Energy Efficient Home Modifications	Environmental Concern
Environmental Concern	−0.442***		
	(0.061)		
Age Category	−0.200***	−0.040***	−0.073
	(0.048)	(0.011)	(0.041)
Female	−0.035	−0.025	0.421***
	(0.150)	(0.0.033)	(0.126)
Education Level	−0.024	−0.019	0.200***
	(0.044)	(0.010)	(0.037)
Income Level	0.033	0.005	0.012
	(0.033)	(0.007)	(0.028)
Partner	−0.318**	−0.058	−0.058
	(0.162)	(0.035)	(0.138)
No. Children	0.015	0.005	−0.017
	(0.070)	(0.015)	(0.060)
Urbanity	0.071	0.014	0.074
	(0.049)	(0.011)	(0.041)
Homeowner	−0.098	−0.015	−0.106
	(0.148)	(0.032)	(0.124)
Constant	1.842***	0.630***	
	(0.433)	(0.087)	
Observations	1,252	1,307	1,289

Note: **p<0.05; ***p<0.01

10.9 ROC Curves for the Predictive Models

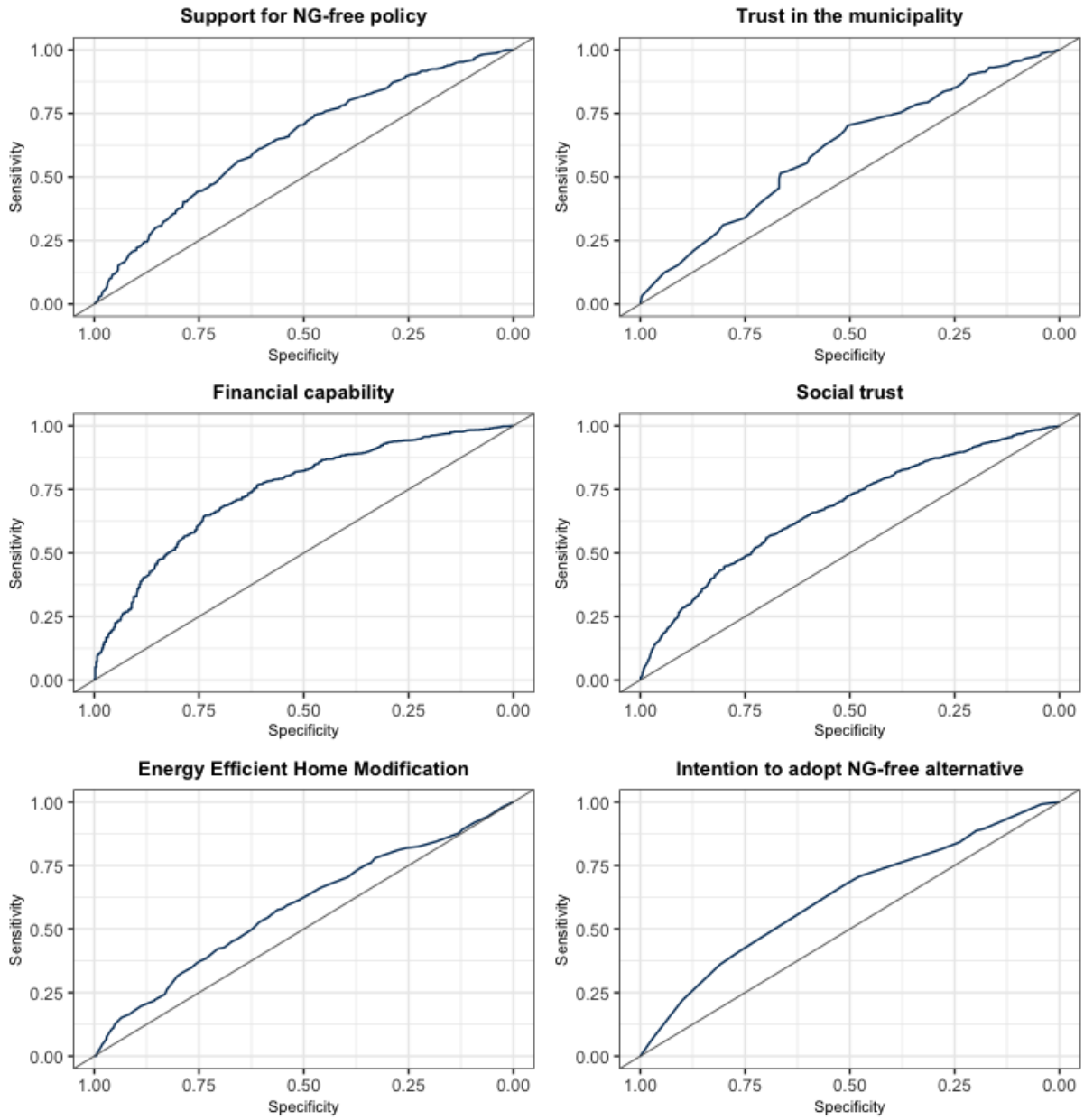

Figure 29: ROC curves for the predictive models

10.10 Socio-Semographic Distributions within the Samples

10.10.1 Natural Gas-Free Policy Support

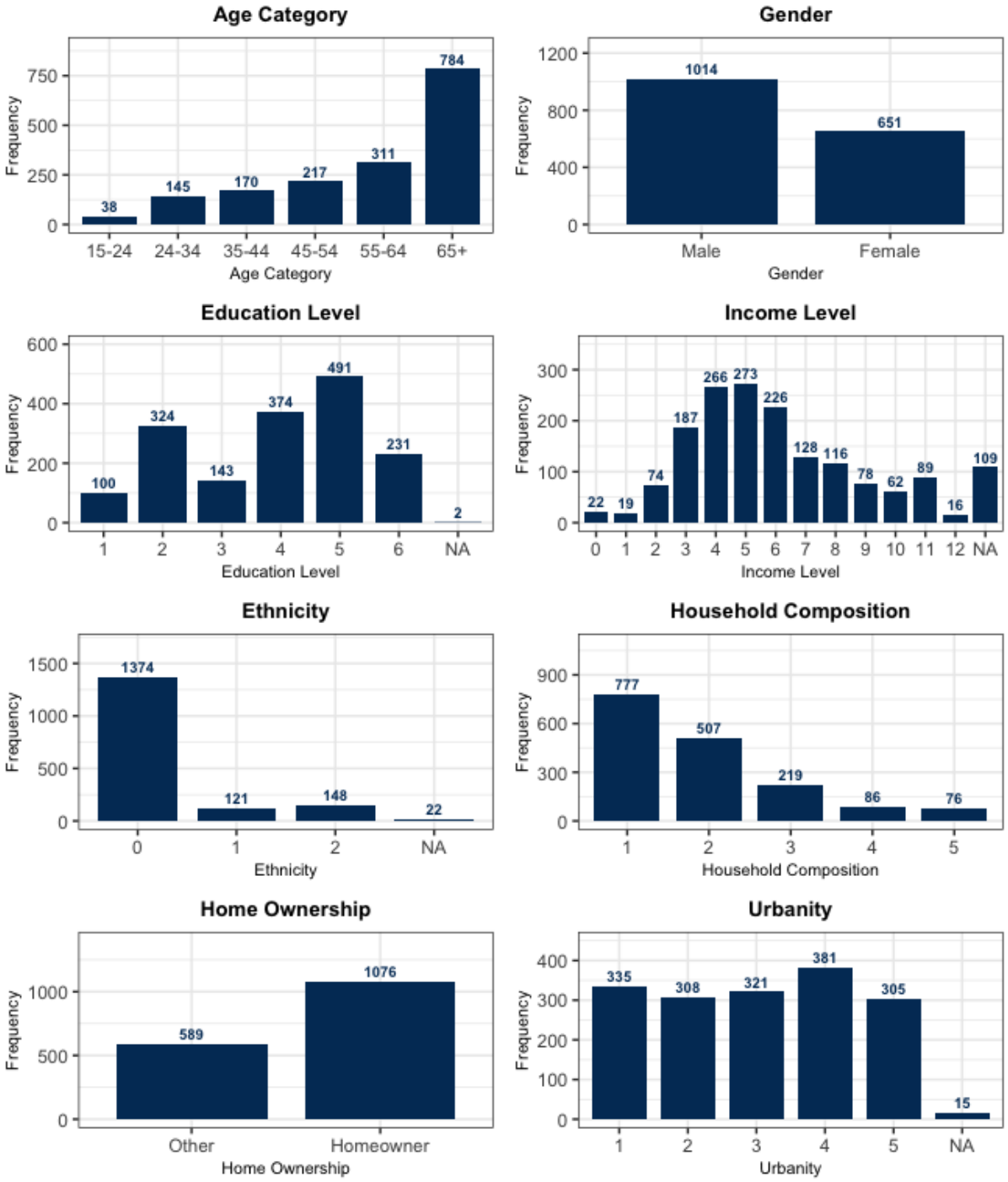

Figure 30: Distribution of socio-demographic characteristics in the dataset for natural gas-free policy support

10.10.2 Trust in the Municipality

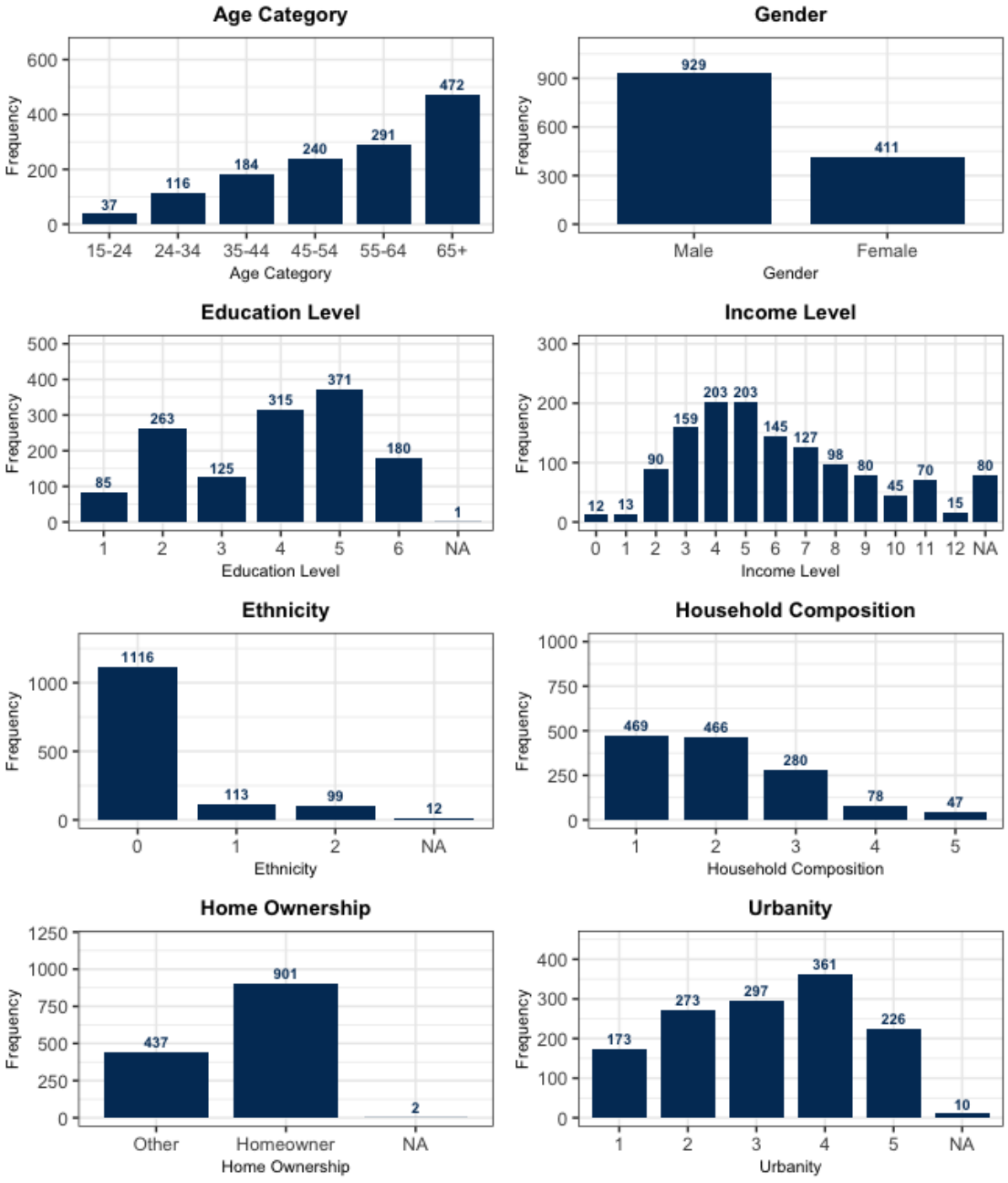

Figure 31: Distribution of socio-demographic characteristics in the dataset for trust in the municipality

10.10.3 Financial Capability

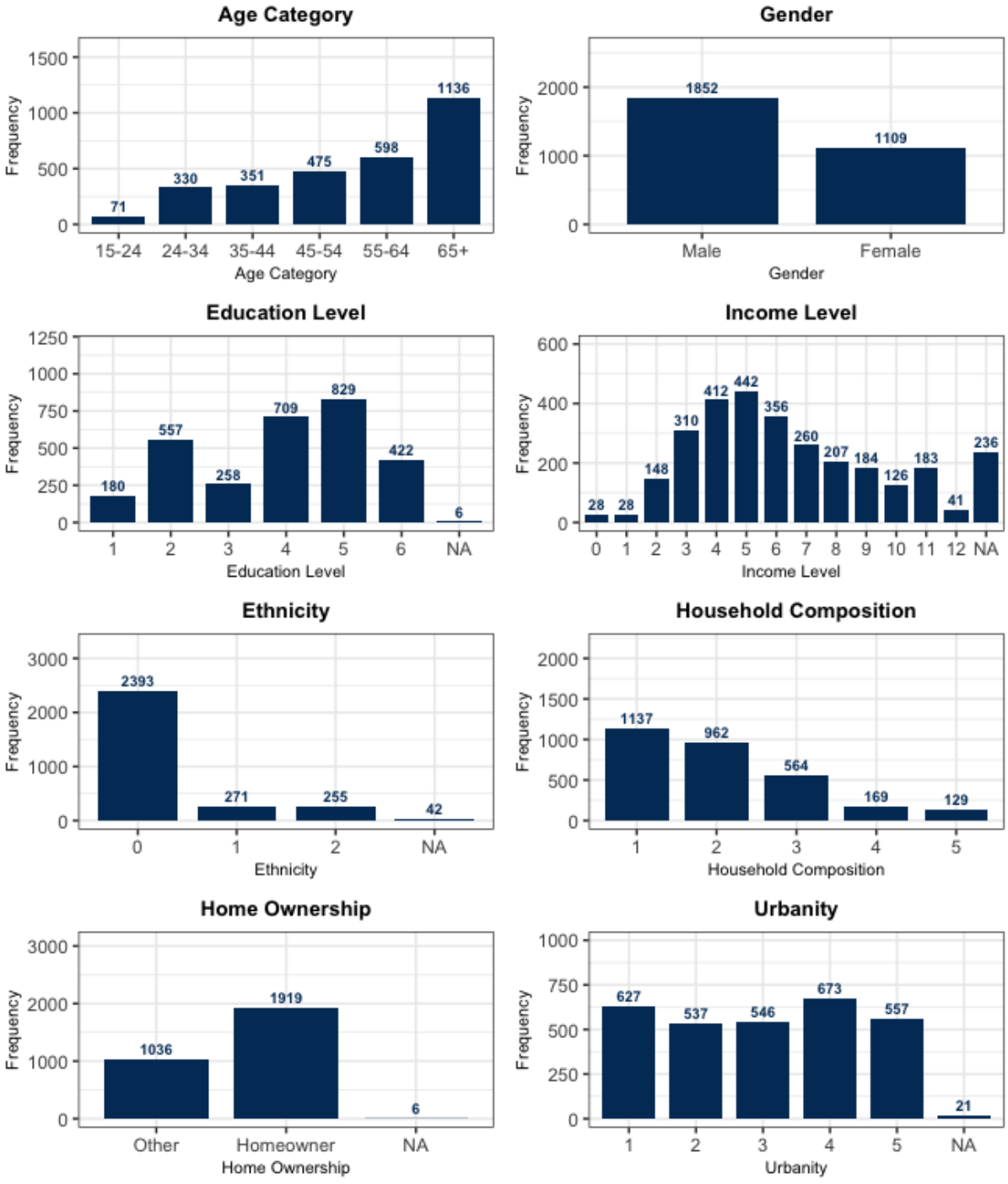

Figure 32: Distribution of socio-demographic characteristics in the dataset for financial capability

10.10.4 Social Trust

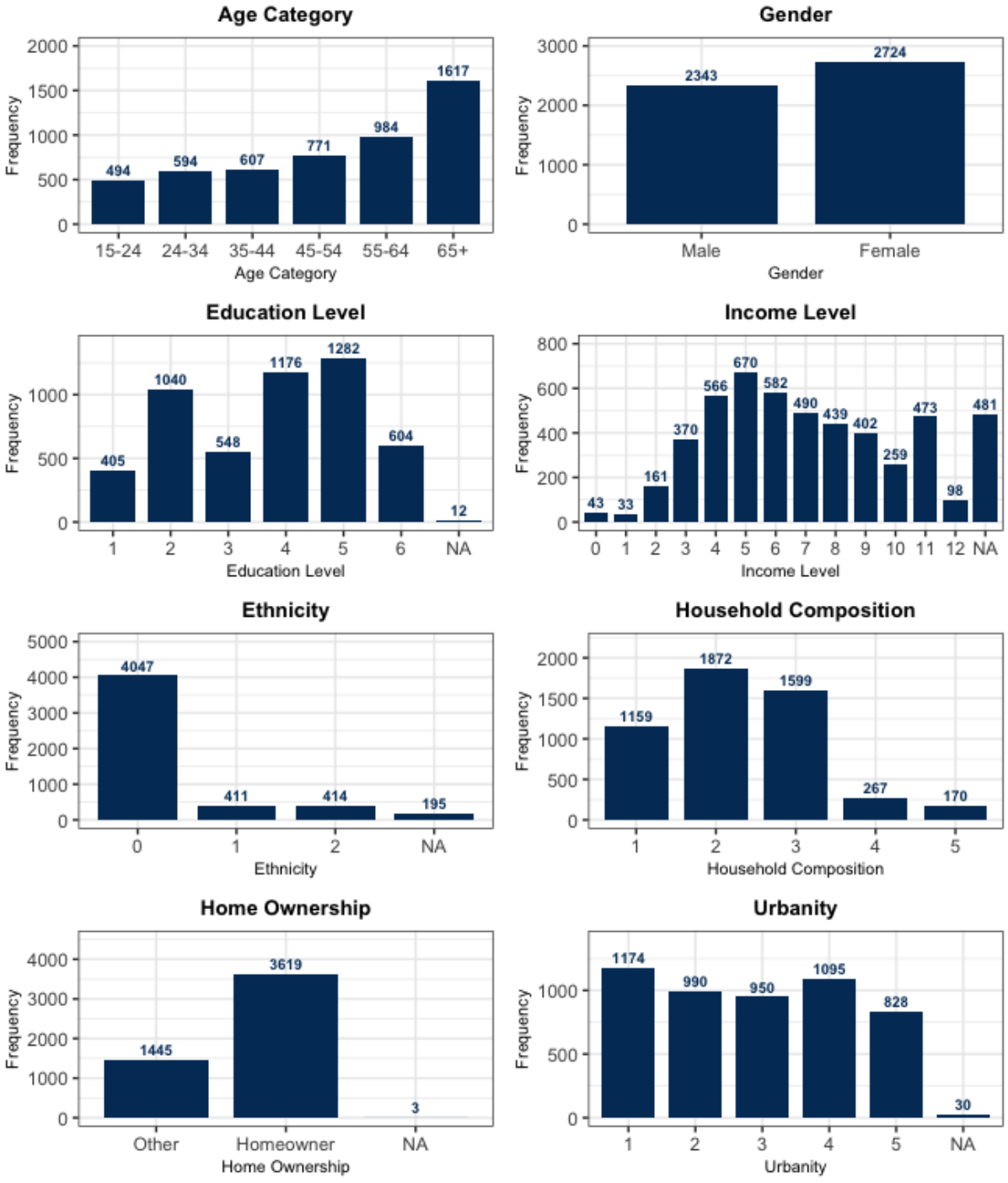

Figure 33: Distribution of socio-demographic characteristics in the dataset for social trust

10.10.5 Previous Energy Efficient Home Modifications

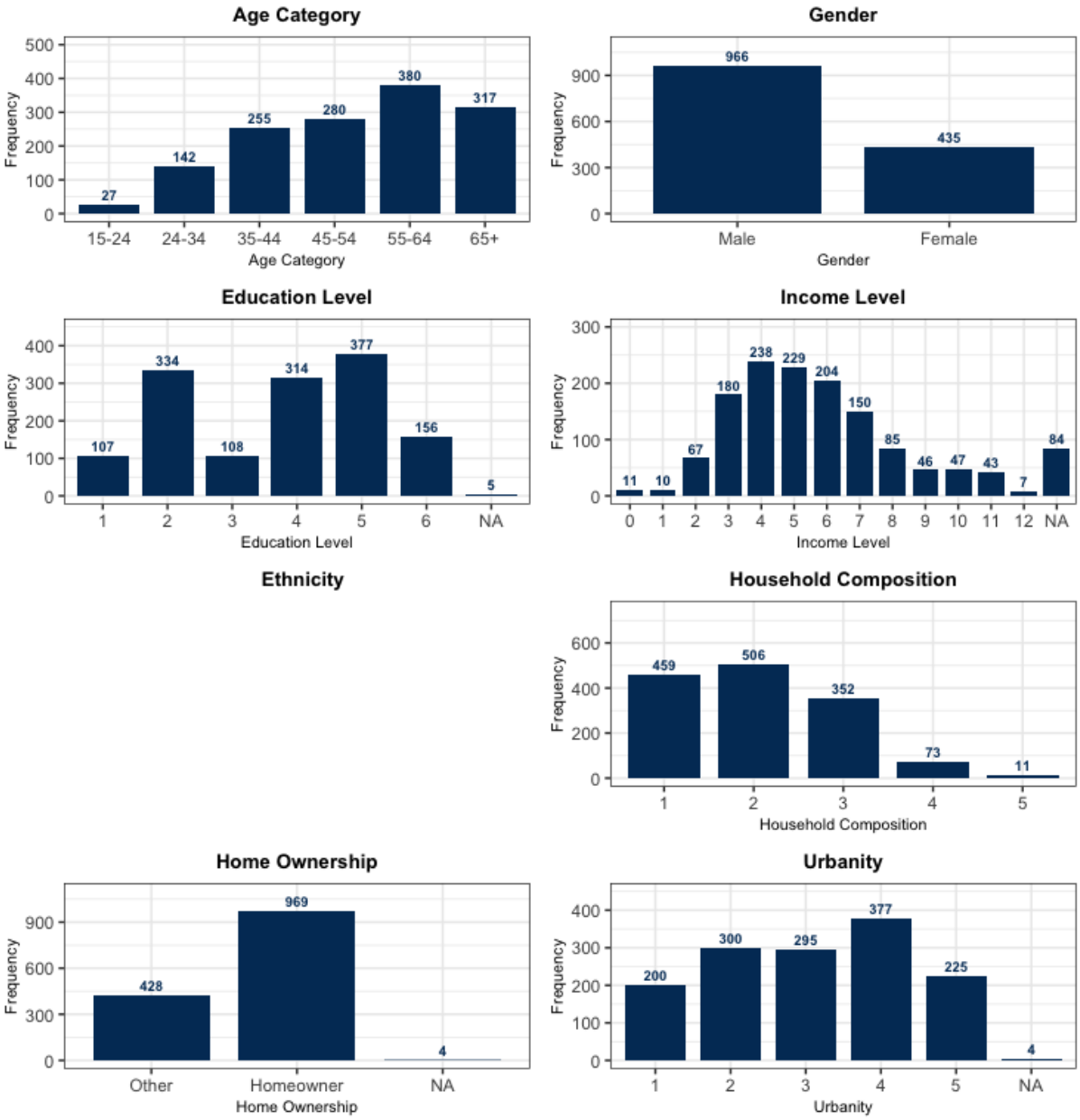

Figure 34: Distribution of socio-demographic characteristics in the dataset for the adoption of energy efficient home modifications

10.10.6 Intention to Adopt Natural Gas-Free Heating

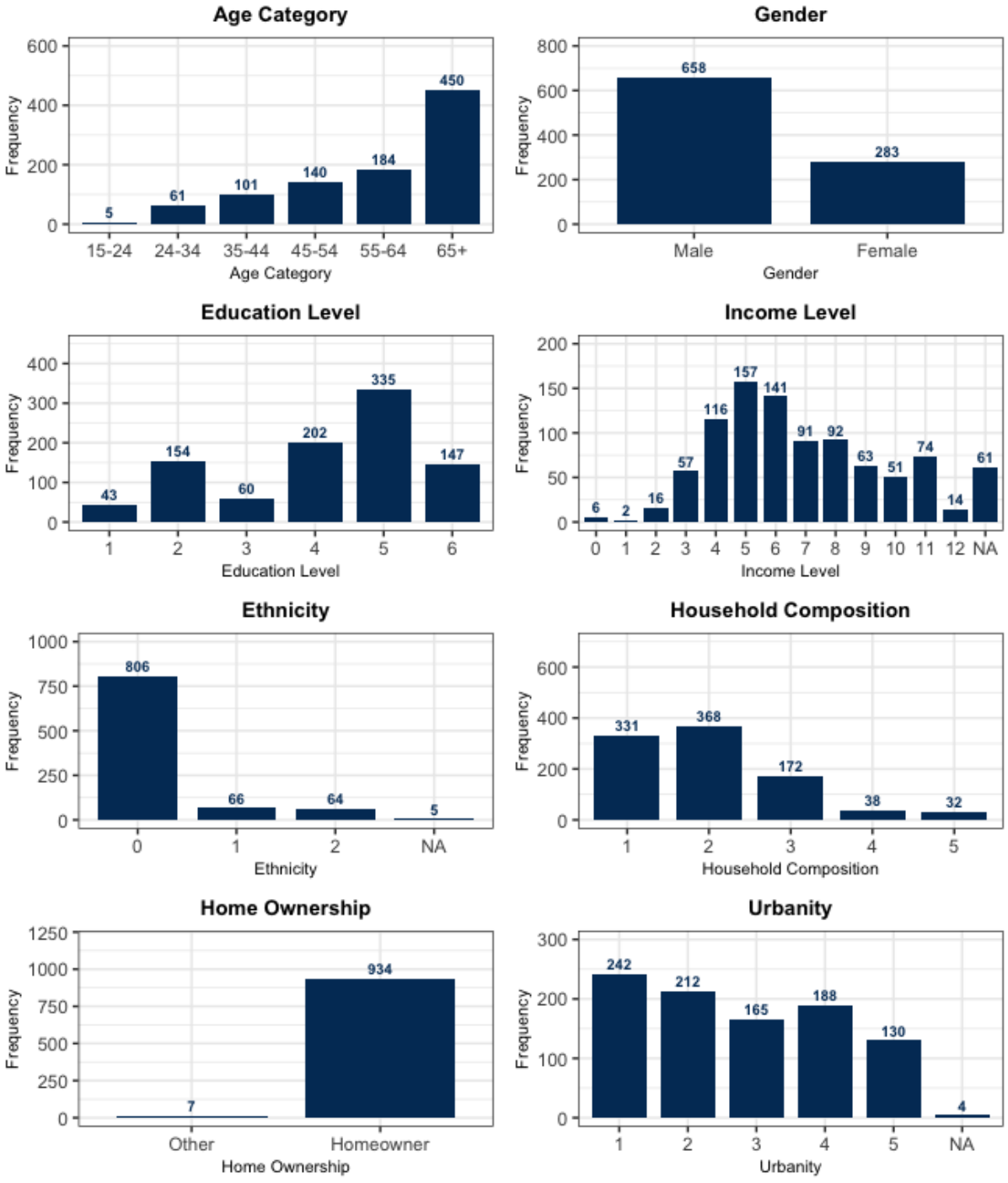

Figure 35: Distribution of socio-demographic characteristics in the dataset for the intention to adopt natural gas-free heating

10.10.7 Environmental Concern

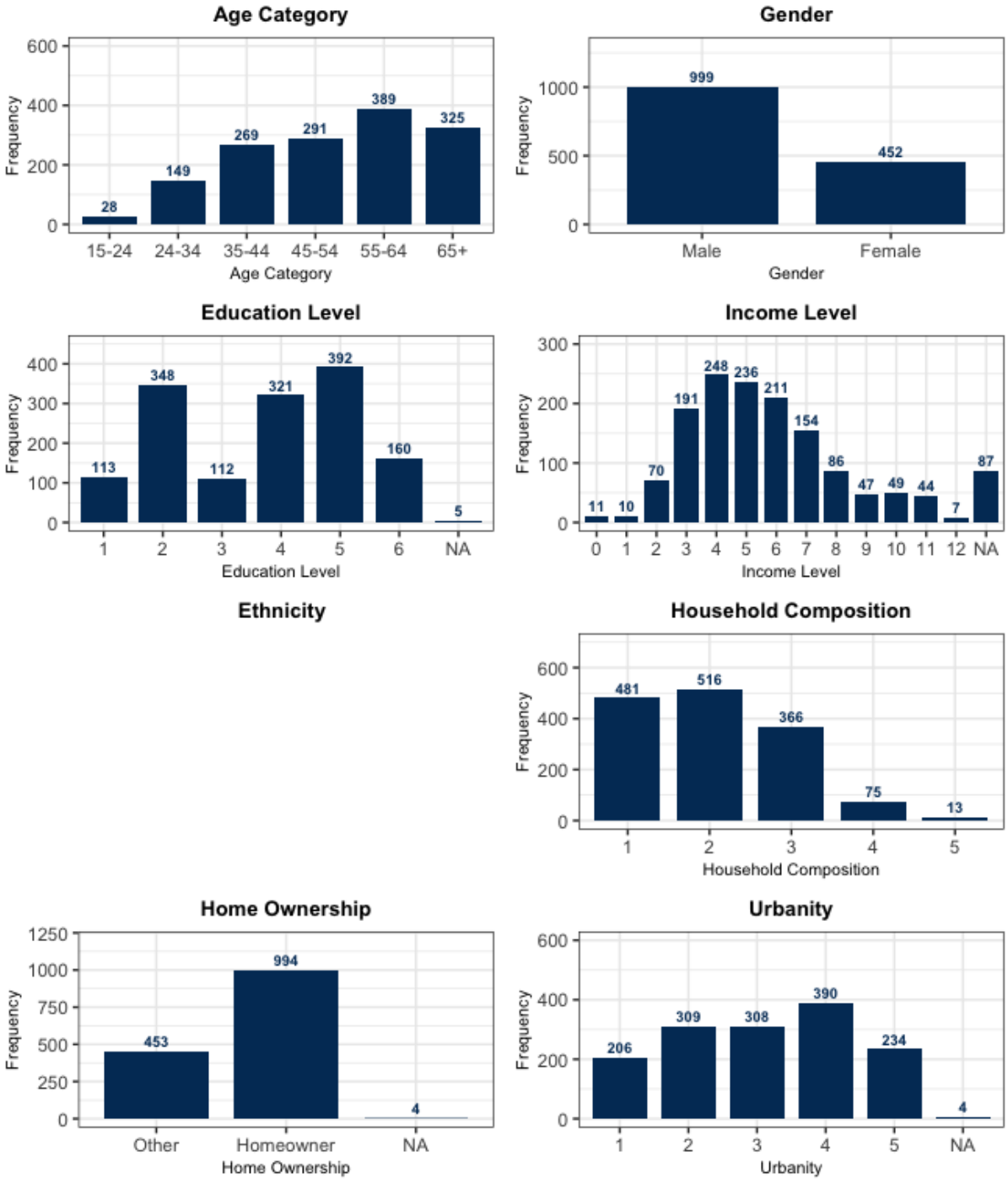

Figure 36: Distribution of socio-demographic characteristics in the dataset for environmental concern

10.10.8 Connection to the Neighborhood

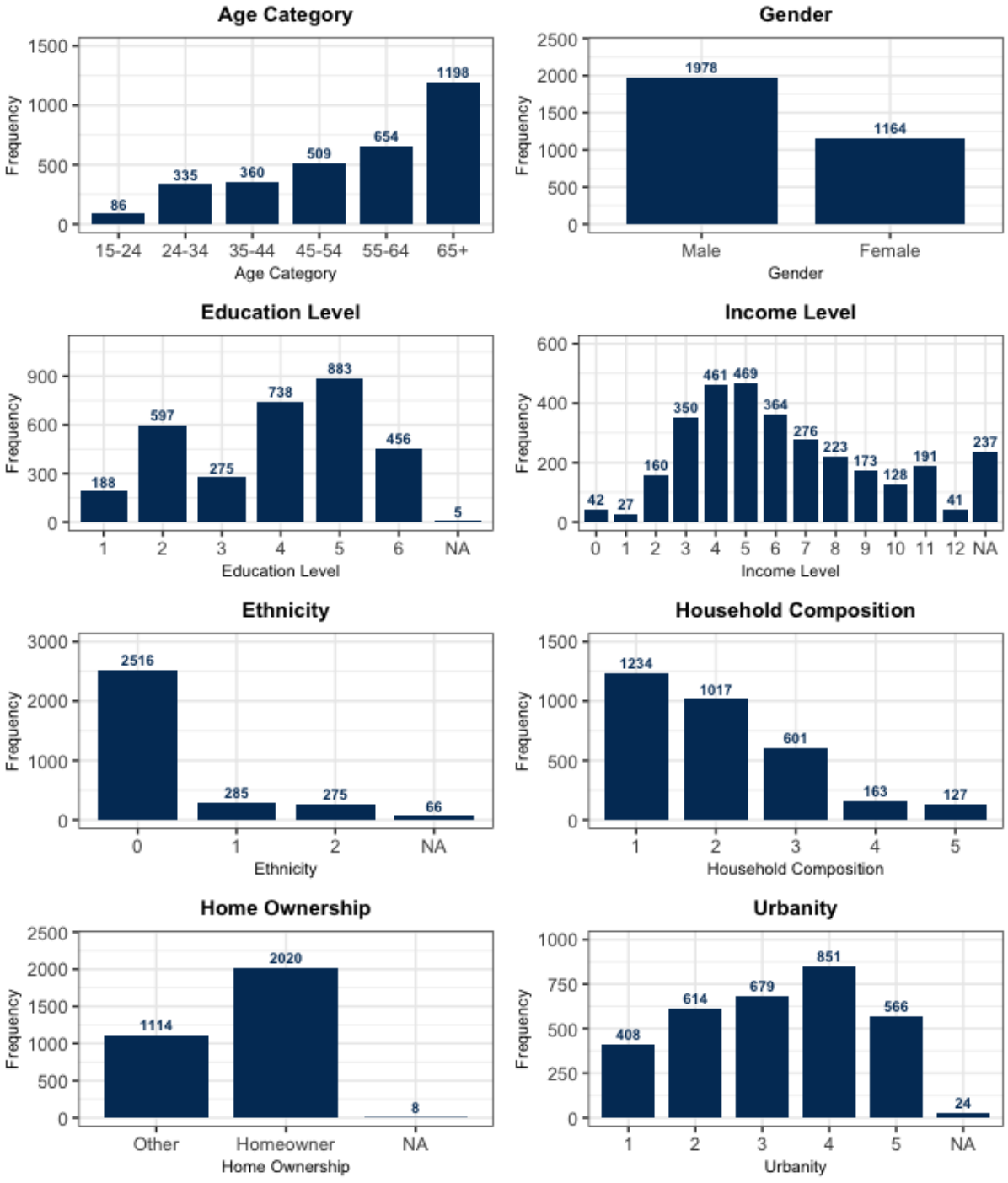

Figure 37: Distribution of socio-demographic characteristics in the dataset for respondents' connection to their neighborhood