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Full title:

Re-visiting residential self-selection and dissonance: Does intra-household decision-making change the results?

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Re-visiting residential self-selection and dissonance: Does intra-household decision-making change the results?

Abstract

A considerable amount of literature has discussed the relevance of travel attitudes for location choices and travel behavior. Numerous studies have reported evidence that individuals choose neighborhoods that allow them to travel with their preferred transport mode, a process referred to as residential self-selection. Most studies, however, assume homogeneous attitudes and preferences among household members and ignore negotiation processes between partners that influence travel and location choices. The goal of this study is to investigate the extent to which heterogeneity in attitudes between partners affect residential self-selection and residential dissonance. This study uses data from a travel survey conducted in the agglomeration area of Vienna (Austria), factor analyses and multinomial logit models to explore residential location and mode choices.

Descriptive analysis reveals that depending on the neighborhood type travel attitudes have different effects on mode choice. Heterogeneity in travel attitudes between partners partly explains limited evidence of residential self-selection and dissonance. In general, effects of residential dissonance on location choice are most relevant if both partners are dissonant. Surprisingly, only women's travel attitudes substantially influence neighborhood selection which may be explained by the fact that female partners are also more affected by neighborhood characteristics in their travel behavior than their male partners. One third of respondents does not live in neighborhoods that match their travel attitudes. More dissonant households live in suburban areas than in the urban core indicating potential pressures on the housing market. Policy implications of these results emphasize the relevance of gender and highlight the challenge of providing affordable housing with good mobility services.

Keywords: residential self-selection; residential dissonance; intra-household interaction; mode choice

1. Introduction

Travel behavior research has emphasized the impact of built environment¹ on travel behavior as summarized in several meta-studies (Ewing and Cervero, 2001, 2010). Recently, researchers have shown increased interest in residential self-selection (RSS) defined as the process of persons choosing residential locations that match their travel attitudes and satisfy their travel preferences (Cao et al., 2009). Accordingly, the effect of built environment on travel behavior is in part attributed to travel attitudes leading to a selection of specific residential locations (Mokhtarian and van Herick, 2016). For instance, persons who like car-driving may favor neighborhoods with good parking and comfortable driving conditions. A large body of literature has reported evidence supporting the RSS hypothesis (e.g. Cao et al., 2009; van Wee, 2009) though some researchers have only found moderate or no effects (e.g. Ettema and Nieuwenhuis, 2017). Others discussed the magnitude of RSS (Mokhtarian and van Herick, 2016) or argued that travel-related residential location criteria may have minor relevance for residential location choices (Ettema and Nieuwenhuis, 2017).

Other researchers addressed the phenomenon of residential dissonance which refers to residents who live in neighborhoods which do not match their travel attitudes and preferences (Schwanen and Mokhtarian, 2005). Residential dissonance can be described as a “dissonance between the actual and preferred residential neighborhood” (De Vos et al., 2012). Different factors can explain such residential dissonance, such as a constrained housing market, high real-estate prices in preferred locations, financial constraints, or priority of other location criteria (e.g. distance to workplace) (De Vos et al., 2012). Some studies found that residential dissonance partially explains the limited relevance of RSS (De Vos et al. 2012; Schwanen and Mokhtarian, 2005).

The RSS literature, however, mostly neglects that location choices may be outcomes of negotiation processes between household members who value location criteria differently (Guan and Wang, 2019; Oostendorp, 2014; Zhang and Fujiwara, 2009). Commute distance between residential locations and workplaces can be considered as an outcome of negotiation processes between partners in which gender may also play a role (Chidambaram and Scheiner, 2020, Plaut, 2006). For instance, work locations may differently influence residential location choices depending on the situation of the partner as Oostendorp (2014) pointed out in her qualitative study on couple households. Gender differences in economic prospects may increase the potential of different commute distances between female and male partners (Chidambaram and Scheiner, 2020). The literature review on household interaction by Mulley and XX provides evidence that household members influence each other in their travel behavior, for instance with respect to the sharing of mobility resources, childcaring and household duties. Several studies have found evidence for gender differences in travel patterns. For instance, women tend to use more public transport, drive less by car and have more complicated trip chains than men (VCÖ, 2010). These differences may affect their travel attitudes and hence influences residential location processes. Differences in travel behavior and attitudes and power relations between partners may influence negotiation processes while deciding on residential location. Few studies in the RSS literature acknowledge the relevance of negotiation processes and intra-household heterogeneity (De Vos et al., 2012; Næss, 2014; Scheiner, 2010). So far, however, there have been few empirical investigations into the heterogeneity of travel attitudes in couple households in the context of RSS.

¹ In this study, built environment is used as a general term to describe spatial structures in urban environments, land-use, street design and accessibility.

Addressing this research gap, this study examines the extent to which heterogeneity in travel attitudes between partners affects RSS and explains residential dissonance. To the author's knowledge, only Guan and Wang (2019) investigated this problem quantitatively though they did not discuss the relevance of heterogeneous travel attitudes between partners for residential dissonance. However, residential dissonance may be explained by heterogeneous travel attitudes and bargaining processes between partners. Partners may live at residential locations that are particularly convenient for one household member and correspond to this person's travel attitudes. This article generates insights in addition to those provided by Guan and Wang (2019) with respect to a better understanding of residential dissonance in the context of RSS. This article contributes more generally to the literature by providing an analysis at the household level that helps better understanding of RSS processes and illustrates the influence of male and female partners on residential location and travel choices.

Using 2019 survey data from the larger agglomeration of Vienna (Austria), this paper jointly investigates location and transport mode choices of couples living in the same household. The results reveal that heterogeneity in travel attitudes between partners influence residential location choices, in turn leading to residential dissonance. The findings show the additional gain of separately examining mode choices of women and men of a common household that would not have been revealed by including a gender variable only. Women seem to be more influential on location choices and more affected by the built environment in their transport mode choice than their male partners. More concretely, this study addresses the interconnectedness of location choices and daily travel behavior by including not only residents of Vienna, who, in general, have access to high-level public transport services, but also residents of Vienna's larger agglomeration where most of the persons live who commute to Vienna by car. The results indicate that more mismatched couples lived in suburban areas and may reflect pressures in the housing market driving households to the urban fringe or out of town. Policy implications of the findings in this study clarify challenges in providing adequate housing and good public transport provision particularly in the prospect of population growth in Vienna's agglomeration.

2. Literature review

2.1. The concept and relevance of residential self-selection

A great body of literature has examined the relationship between the built environment and travel behavior. In two meta-studies, Ewing and Cervero (2010, 2001) provided an overview over the effect of built environment characteristics on travel variables. They found a rather inelastic relationship (for example with a largest absolute elasticity of 0.39 for the weighted average elasticity of walking with respect to street density), though the cumulative effect of several variables on travel variables (distance, mode choice) was significant in size (Ewing and Cervero, 2010). The influence that built environment exerts on travel may vary between countries and mobility cultures. As Buehler (2011) shows, population density and public transport access have larger effects on the likelihood of choosing public transport in Germany compared to the US. Many recent studies have discussed whether the influence of built environment on travel behavior is in part indirect since "a household with a predisposition towards a certain type of travel 'self-selects' a residential location enabling the pursuit of that preferred type of travel" (Schwanen and Mokhtarian, 2005: 84). The research interest in this process, labelled as residential self-selection (RSS), led to a number of special issues in *Transport Reviews* ("Self-Selection", 2009, 29(3)), in the *Journal of Transport and Land Use* ("Viewpoints on self-selection", 2014, 7(3)) as well as in *Travel Behavior and Society* ("Travel and residential change", 2019-2020). Most studies have found evidence for RSS and reported an

autonomous significant effect of the built environment using different modeling approaches (see Mokhtarian and Cao, 2008, Cao et al., 2009 reviewing empirical findings; Khattak and Rodriguez, 2005 for sample selection modeling; Bhat and Guo, 2007 for joint discrete modeling; Scheiner, 2010 for structural equation modeling). The magnitude of this effect is still discussed. Mokhtarian and van Herick (2016) compared the quantified proportion of the built environment effect that is due to the built environment itself (after controlling for residential self-selection) for seven studies with an effect varying largely between 34 and 98 percent.

2.2. Considering residential dissonance

A number of studies raised concerns about the limitation of RSS because some residents do not live in their preferred neighborhood (Chatman, 2009; De Vos et al., 2012; Guan and Wang, 2019). Several factors might explain such residential dissonance between attitudes and built environment characteristics at the residence such as constrained housing markets, prioritizing of other location criteria (e.g. distance to family) or fundamental changes in living circumstances (such as the life event of childbirth) that change household needs and attitudes (De Vos et al., 2012; Ettema and Nieuwenhuis, 2017). Real estate prices and rents may limit the set of alternatives for residential location (Thierstein et al., 2016). For instance, public transport access can be positively correlated to real estate prices as several studies point out for German cities (Cologne, Karlsruhe, Munich, Stuttgart) (BPD Immobilienentwicklung GmbH, 2019; Thierstein et al., 2016).

Most studies investigating residential dissonance adopted the approach proposed by Schwanen and Mokhtarian (2005) to classify residents into different travel attitude and built environment types to assess their level of residential dissonance (Cao, 2015). Explicitly considering residential dissonance, Schwanen and Mokhtarian (2005) sorted their respondents based on their residential and travel attitudes into four groups (consonant urbanites, dissonant urbanites, consonant suburbanites, dissonant suburbanites), and examined their transport mode choice. Their results confirmed the RSS hypothesis and highlighted that built environment had a stronger influence on transport mode choice than travel attitudes. Though the effect of both factors (built environment, travel attitudes) was more balanced for urban residents than for suburban residents. Their results suggest a continuum with an increasing share of private vehicle use from matched urban residents, over mismatched urban residents to mismatched suburban residents, and matched suburban residents. Based on a literature review of nine studies, Cao (2015) found that most studies provided evidence that consonant residents were placed at the extremes of travel behavior and dissonant residents in between. For instance, transit use is the highest for consonant urban residents and the lowest for consonant suburban residents. The ranking of dissonant residents then depended on the relative strength of built environment and attitudinal impact on travel behavior (Cao, 2015). Results reported by Frank et al. (2007) for residents in Atlanta (US) suggest that the relative importance of built environment and travel attitudes for the share of walking trips may depend on the type of trip (i.e. discretionary or non-discretionary). Several studies have found that the impact of built environment on travel behavior is not moderated by travel attitudes (Naess, 2009, 2010). O'Fallon and Wallis (2012) reported for Auckland and Wellington (New Zealand) that dissonant residents in suburban neighborhoods showed similar travel behavior to residents living in inner urban areas. Cho and Rodriguez (2014) found for two US cities that neighborhood characteristics dominate travel preferences in highly dense neighborhoods. Comparing travel behavior of residents living in transit-orientated development (TOD) neighborhoods or not in Brisbane (Australia), Kamruzzaman et al. (2015) reported that TOD dissonant and non-TOD consonant residents showed similar travel behavior indicating a relative dominance of travel attitudes over the effect of built environment on travel behavior for these residents. Following the approach of Schwanen and Mokhtarian (2005), De Vos et al. (2012) classified residents into urban and rural neighborhoods and found that half of

students and staff members of the University of Antwerp were mismatched. Dissonant rural residents were more capable of realizing their transport mode preferences compared to urban dissonant residents. The authors explained this result by the strong urbanization in Flanders, good public transport access and a widespread wish for quiet and green neighborhoods. In their data, attitudes and land use preferences influenced walking, bicycling and transit use more than the built environment in contrast to car use. Most of these studies confirmed the RSS hypothesis though the relative impact of travel attitudes and built environment varied across different neighborhoods and countries.

2.3. Household members influence each other's travel behavior

There is a considerable body of literature examining activity patterns and time sharing between household members (cf. the comprehensive review of Ho and Mulley, 2015). A lot of research concentrates on car travel and ownership (Ibid.). Household members coordinate household tasks and travel decisions. Partners share mobility resources whose use has to be negotiated if they do not travel jointly (Scheiner, 2020). Extensive research has examined household interaction by exploring activities such as household keeping tasks or chauffeuring of other persons (e.g. Schwanen et al., 2007). For example, parents rarely jointly escort their children to school (Scheiner, 2016). Couple households have been given particular attention in the literature. Using the German Mobility Panel, Kroesen (2015) found that partners of couple households influenced each other's travel behavior over time. The analysis showed for instance that men were more likely to switch to a specific travel pattern if women showed this travel pattern in the first period (Kroesen, 2015). In a qualitative study, Gil Solá (2016) interviewed 20 high-skilled persons (10 men, 10 women) living in couple households with children in Gothenburg (Sweden). In the interviews, women and men valued women's work equally or less than men's work. Women let her male partner commute by car which restrained their access to the labor market. The interdependence between constrained car access and access to labor markets has also been found in other studies (e.g. Chidambaram and Scheiner, 2020). Gil Solá (2016) suggested that respondents used economic reasons to explain unequally shared tasks. Interestingly, car access provided women better access to labor markets but sometimes supported unbalanced sharing of tasks. More generally, theories in sociology and the economics of gender literature provide various insights and explication for unequally shared household tasks, labor time and childcare between genders (e.g. Auspurg et al., 2017; Bettio and Verashchagina, 2008; Jacobsen, 2007). To sum up, household members, particularly couples, affect each other's travel behavior via their distance and access to workplaces, shared mobility tools, household tasks and childcare.

2.4. Intra-household interaction of travel behavior and location choices

Discussing intra-household interaction with respect to residential location choices, Ho and Mulley (2015) point to the open question of whether households should be understood as one decision-making unit or as separate decision makers. Some studies compared individual to joint valuation of location criteria between household members (Borgers and Timmermans, 1993; Timmermans et al., 1992; Zhang and Fujiwara, 2009). Dutch studies found that travel time to workplace was less important than characteristics of the dwelling and environment at an individual decision level but household members jointly weighted the travel time to workplace higher (Borgers and Timmermans, 1993; Timmermans et al., 1992). Similarly, Zhang and Fukijwara (2009) reported that individuals chose different options when deciding individually, or jointly in a stated preference experiment on residential location.

Relating to intra-household interaction of location and travel choices, studies have mainly discussed commute time and distance between partners as an outcome of negotiation for residential location choices. Thus far, most data have suggested that women have shorter commute trips than men (Sicks, 2011; VCÖ, 2010), though diverging evidence has been found on whether residential locations are adapted to women's (Chapple and Weinberger, 2000; Manaugh et al., 2010) or men's workplace (Oostendorp, 2014). Some researchers found support for a "substitutability" between commute distances of two working household members (Davis, 1993). Others point out that commute distance is rather complementary between couples (Plaut, 2006, Guan and Wang, 2019). For the US, Plaut (2006) analyzed dual-worker households based on the 2001 American Housing survey and found that commute distance and time were complementary between household spouses, meaning that commute trips are jointly chosen to be longer. Among homeowners, an increase in the size of the household decreases women's commute distance and time while it has no effect on men's travel. In contrast, female and male renters have both longer trips if household size increases. In general, women and men commute longer (in distance) for higher salaries. Abraham and Hunt (1997) modeled home location as joint choice, workplace location and commute mode as individual choices using a nested logit model for households in Calgary, Canada. Travel attributes of women had larger positive effects on household utility than those of men. Thus, travel conditions of female partners were relatively more important than those of men. For Germany, Chidambaram and Scheiner (2020) found that men commuted longer, earned more and spent less time on unpaid work than their female partners. The presence of children in the household increased commute distance and gender gaps. The commute gap, the difference between male and female commute distance to workplace, increases with female "household obligations" and family duties (Chidambaram and Scheiner, 2020). Similar to other studies (e.g. Scheiner and Holz-Rau, 2012), they found that car access and use reduces the commute gap between women and men. They found evidence to support the economic power hypothesis suggesting that social status is positively associated with commute distance. Hence these studies point out that negotiation processes between partners play a significant role for residential location and commute distance though other factors, such as car access and social status, moderate commute distance.

Few studies qualitatively explored intra-household negotiation processes for residential location choice and travel behavior (e.g. Gil Solá, 2016; Oostendorp, 2014). Oostendorp (2014) surveyed 1884 households and conducted 18 interviews with two-worker households in the greater agglomeration area of Cologne and Bonn (Germany). Distance to the workplace was more relevant for residential location choice if both partners worked full-time. The workplace of the male partner was more often reason for relocation than those of the female partner and this phenomenon occurred more often if men worked full-time and women part-time. In households with children, women worked more often in the "home-office" than men and the opposite was true if the couple did not live with children. In general, full-time working women tend to make less compromises with respect to the professional life of their male partner.

Quantitative research on household interactions is rather limited with respect to discussing RSS. Susilo and Liu (2016) examined RSS and parents' influence on children's travel in the UK though they only captured residential preferences for the household in total and do not distinguish between household members. They reported that residential location motives were differently associated to mode choice between household members. Women reduced their car use more than men after relocating closer to work or school. Looking for a better neighborhood or larger flat/house were associated with a higher car use by men and children but with decreased car use by women. They found a significant effect of RSS on mode choice only for women and not for men. Built environment was more relevant for mode choice than attitudes. To the best of the author's knowledge, Guan and

Wang (2019) is the only study which quantitatively assessed intra-household interaction with respect to RSS. Based on a survey with 557 dual-earner couples living in Beijing, Guan and Wang (2019) found that husbands' travel attitudes were more important for RSS though women's travel attitudes had a greater influence on commute distance of both partners. Women's preference for car driving significantly increases commute distance of both partners and reduced husbands travel time by car on weekdays. In general, partners influenced each other in their travel behavior through their travel attitudes. Built environment had an autonomous effect after controlling for RSS. Residential dissonance also prevailed since some residences preferred proximity to non-work destination but lived in low-accessible areas for non-work destinations. Guan and Wang (2019) point to cultural differences in intra-household negotiation processes that potentially explain different results in the literature. According to the aforementioned Canadian study, the travel demand of female decision-makers in the household had a more important effect on location choice of residence and workplace (Abraham and Hunt, 1997). On the contrary, a Japanese study found that husbands were more influential on residential location choices than their female spouses (Zhang and Fujiwara, 2009).

2.5. Research questions

Household members may have diverging travel attitudes and preferences that require negotiations and compromises to find a residential location. Although many studies acknowledge the potential explanatory power of intra-household heterogeneity in the context of residential self-selection (De Vos et al., 2012; Næss, 2014; Scheiner, 2010), to the best of the author's knowledge, only Guan and Wang (2019) examined the effect of intra-household differences on residential self-selection quantitatively (Scheiner, 2020). Though they did not discuss residential dissonance and the role of heterogeneous attitudes between partners in this context. This paper aims to address this concern with the following research questions:

- To what extent does heterogeneity in travel attitudes between partners influence residential location choices and the relevance of travel attitudes for residential location choices?
- To what extent does heterogeneity in travel attitudes between partners lead to residential dissonance?

Several hypotheses motivated these research questions. Residential dissonance of one person may be explained by partners whose diverging travel attitudes match with the neighborhood type. Residential self-selection may be more important if both partners are matched. Additionally, built environment may affect partners differently. Informed by previous evidence, employment may increase the influence of women on residential location choices.

3. Methodological approach

3.1. Data

3.1.1. Study area

This paper draws data from Vienna (Austria) and its agglomeration area (Figure 1). Vienna is characterized by a well-serviced public transport system and a high share of public transport in the modal split with 38% of all weekday trips that are done by public transport (Bundesministerium für Verkehr, Innovation und Technologie, 2016). Notwithstanding, some areas in the suburban districts do not have access to high-level public transport (metro, suburban train) or secondary public transport (tramway, rapid bus lines) (Fersterer et al., 2019). In addition, Vienna attracts a considerable number of daily inbound commuters (193,973 employees from other Austrian federal

states or foreign countries) who mostly travel by motorized individual transport (MIT) (Seisser, 2016; Stadt Wien, 2014b). Based on a cordon survey in 2014, 74% of persons traveled by car or motorcycle and 26% by public transport into Vienna, non-motorized modes were not included in this survey (Technisches Büro für Verkehrswesen und Verkehrswirtschaft, 2014). Most of the inbound commuters (55%) live in the agglomeration area of Vienna with a varying level of public transport service (Niederösterreichische Landesregierung, 2015; Riesenfelder, 2011; Stadt Wien, 2014b). To address this issue of different public transport service levels and housing market pressures, this study does not only include residents of Vienna but also of its agglomeration area. More specifically, the sampling frame included six Lower Austrian districts (Mödling, Gänserndorf, Baden, Korneuburg, Tulln, Mistelbach and municipalities of the former district Wien-Umgebung). These districts cover 72% of all Lower Austrians commuting to Vienna and 52% of all Austrians commuting to Vienna in 2016 (Statistik Austria, 2019b). Commuters who live in these sampling districts hence encompass a large part of total inbound commuters traveling to Vienna. Including them into the analysis is important to assess and understand the interdependence between residential location and daily mobility.

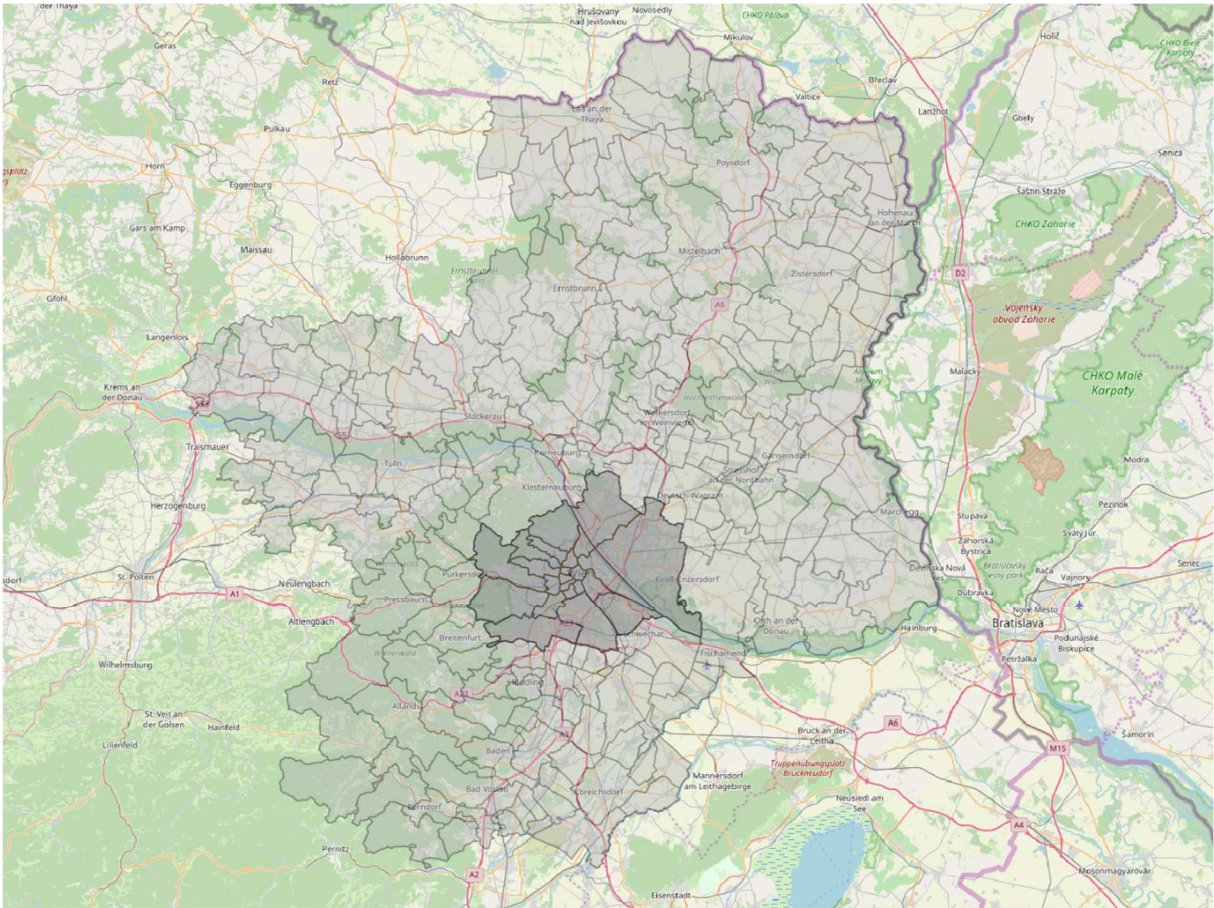


Figure 1 Sampling region: Vienna's agglomeration area (grey shaded municipalities, darker shaded municipalities for the city of Vienna) (ESRI, Transportation 2020; Statistik Austria, 2020)

3.1.2. Focus group and survey

A web-based survey was conducted in June 2019 in the Vienna agglomeration (Figure 1) and assessed daily travel behavior, residential location preferences, and travel attitudes of respondents. The questionnaire has been first tested in a focus group with five recently moved residents of a new

developed residential area (Aspern) at the urban fringe in Vienna. Four women and one man discussed their residential location choices, the influence of partners and their daily mobility. The feedback improved the comprehensiveness of the questionnaire and added important group-specific aspects (e.g. access for persons with disabilities). The web-based survey was conducted by an Austrian market research institute (market Marktforschungs GmbH & CoKG).

320 households from Vienna and 180 households from the six Lower Austrian districts have been selected out of the sampling frame. The survey was sent to one person in the household who was invited to send an additional survey link to his or her partner or another adult family member in the household. The aim was to sample household members who participate in residential location choices (e.g. partner, spouses or older family members). 2,800 households have been contacted by the market research institute and 518 households completed the survey leading to a response rate of 19%. The sample is representative for Vienna and Lower Austria (on a district level) with respect to household head's age, gender, highest educational degree in the household and household size. Table 7 in the Appendix compares sample statistics for these indicators with the actual population for Vienna and Lower Austria. Though the sample only includes some districts of Lower Austria this comparison is based on the assumption that the sample approximates the population distribution of Lower Austria. In general, the sample matches the distribution of household size, age and gender, however, has a higher share of households with higher educational degree than in the actual population. This bias is considered when interpreting the results. In the following, this study only considers heterosexual couple households whose partners responded to the survey (798 out of 1,036 persons, and 399 out of 518 households). Both partners negotiate their residential preferences and finally decide on a location. They split household chores and childcare tasks and influence each other's travel behavior. Couple households may provide more insights into travel outcomes of these negotiating processes than interaction between other household members. In addition, heterosexual couples allow analyzing the role of gender in these processes since the literature points to relevant differences between genders (see literature section and literature on economics of gender, e.g. Bettio and Verashchagina, 2008; Jacobsen, 2007).

3.2. Variables of interest

This study investigates residential self-selection (RSS) and interaction between partners in couple households. Hence, data from a survey and other sources provide information on travel attitudes, residential location criteria and built environment and have been aggregated using factor analyses. The resulting residential, travel attitude and neighborhood types provide a convenient way to test the hypotheses on RSS and household interaction in regression models.

3.2.1. Attitudes

Previous research has confirmed the relevance of travel-related attitudes for transport mode choice (Bamberg et al., 2006; Busch-Geertsema and Lanzendorf, 2017; Gärling et al., 1998; Molin et al., 2014). Particularly, attitudes relating to bicycling seem to be an important determinant to predict the level of bicycling (Handy et al., 2014; Heinen et al., 2011). Analyses of attitudinal influence on travel behavior have often been embedded in the Theory of Planned Behavior (Ajzen, 1991) and extended versions (Bamberg, 2006; Busch-Geertsema and Lanzendorf, 2017). The Theory of Planned Behavior emphasizes the sociological and psychological perspective of travel behavior explaining that attitudes towards transport modes, perceived behavioral control and subjective norm influence the intention to perform a specific behavior which at last influences the actual behavior (Ajzen, 1991; Busch-Geertsema and Lanzendorf, 2017). Travel attitudes, more specifically attitudes toward transport modes, may be discussed along three dimensions: instrumental, affective and symbolic (Busch-

Geertsema, 2018). The instrumental dimension addresses flexibility provided by using a transport mode, its costs, user friendliness, time or weather when using a transport mode. The affective dimension refers to feelings such as autonomy or relaxation while using the transport mode, while the symbolic dimension conveys, for instance, status seeking behavior (Busch-Geertsema, 2018). In this study, travel attitudes are considered to be latent constructs that are not directly observable but approximated by attitudinal statements. Respondents were asked to agree or disagree on a five-point Likert scale to travel-related attitudinal statements (Table 1). These statements aimed to address all three mentioned dimensions of attitudes towards car driving, bicycling, public transport and walking. Another part of the survey assessed the importance of residential location criteria (Table 1). These opinion statements cover different residential attributes, neighborhood and accessibility characteristics and have been informed by inputs provided by the focus group and literature (e.g. Thierstein et al., 2016). Since respondents weighted the importance of these criteria these valuations are further referred to as residential preferences.

3.2.2. Built environment

Built environment is of special interest in this study that investigates RSS and hence the relationship between built environment, attitudes and travel behavior. This study uses two types of data to assess built environment, one relates to statistical data provided by Austrian municipalities, the second type relates to accessibility characteristics self-evaluated by the respondents. Respondents provided the postcode or municipality of their residence since it is legally challenging to directly ask survey participants for their residential addresses (Bundesministerium für Verkehr, Innovation und Technologie, 2011). The survey did not include questions to geo-localize the residence of respondents in a map since it tends to significantly increase the dropout rate. However, respondents self-evaluated their access to public transport and shopping facilities and characterized their settlement type providing information on the neighborhood level. Built environment variables were selected based on the literature, the geographical context and available data. Population density is one of the most often included built environment variable in transport mode choice models (Ewing and Cervero, 2010). Several studies showed that population density is negatively correlated to vehicle miles traveled, and positively associated with walkability, land-use mix and accessibility of shops and other facilities (Ewing and Cervero, 2010; Pfaffenbichler et al., 2016). This analysis also includes a land-use variable since it indicates the diversity in built environment and is often correlated to a higher share of walking and public transport use (Ewing and Cervero, 2010). The land-use mix (LUM) indicator in this analysis is based on the entropy formula developed by Shannon and Weaver (1949) and used by Frank et al. (2005) (Mavoa et al., 2018: 686) and is defined as follows

$$LUM = -1 * (\sum_{i=1}^n p_i * \ln(p_i)) / \ln(n) .$$

The land-use mix score is a measure of land-use concentration considering the proportion (p) of each land-use category (i). n indicates the number of land-use categories that are three in this case and include residential, office and commercial buildings at a municipality level. A LUM score of one indicates the maximum of building mix between the three categories and zero the concentration in one of the three land-use categories. To address local accessibility, this study includes the settlement area type at the residence since for instance dispersed settlement necessitates more car driving than densely populated areas (Table 1). Walkability is approximated by access to shopping facilities since it has been shown to be associated with higher elasticities for walking (Ewing and Cervero, 2010). Another feature of the built environment relates to public transport access. Respondents self-evaluated their access to public transport (PT) and reported walking distance in minutes to the next bus, tramway, metro and train station (Table 1). The variable commuters per inhabitant on a municipality level may correlate with the traffic volume and a higher use of motorized individual

transport (MIT). The indicator parking area per inhabitant highlights the automobile friendliness of the neighborhood since parking at residential location has been shown to be associated with increased car use (Knoflacher, 2006). Acknowledging the positive effect of green areas on walking and bicycling that has been found in previous studies (Pfaffenbichler et al., 2016; Sugiyama et al., 2013), I calculated the share of green area (bushes, gardens and woods) relative to the total area of the municipality.

3.2.3. Residential, travel and built environment types

Three factor analyses allowed aggregating information on travel attitudes, residential preferences and built environment to create discrete types for each topic which are then included in the econometric models. Attitudes are considered to be latent constructs. Factor analysis helps identifying the latent constructs associated with different attitudinal statements by explaining variation in these variables. Statements related to residential location criteria are as well aggregated to find the underlying construct related to a residential type. Built environment variables are aggregated to form neighborhood types that characterize residential locations of respondents. Several built environment variables, items related to travel attitudes and residential location criteria are measured on an ordinal scale. Therefore, all three factor analyses used a polychoric correlation matrix assuming variables to be bivariate normally distributed and an ordinal measurement of an underlying continuum (Kolenikov and Angeles, 2004). The polychoric correlation matrix takes into account the ordinal nature of the Likert variables and provides a better correlation estimation for the underlying data than the Pearson-correlation matrix that assumes continuous data (Kolenikov and Angeles, 2004). Screen plots, eigenvalues (>1) and meaningful interpretation of the factors informed the number of types selected for each factor analysis. Respondents were assigned to the factor type yielding the highest factor score using the OLS regression method.

The residential dissonance indicator is defined in the results section since it is based on the results of the factor analyses of travel attitudes and built environment variables.

Table 1 Descriptive statistics of 798 persons living in 399 households

Variable	Definition	Percentage/mean (standard deviation)	
Socio-demographics	Age		
		20 to 24	1%
		25 to 29	7%
		30 to 34	12%
		35 to 39	11%
		40 to 44	11%
		45 to 49	11%
		50 to 54	10%
		55 to 59	11%
		60 to 64	11%
		65 to 69	7%
		70 and older	9%
	Gender	Women	50%
Employment status	Employed or attending an educational institution or training	70%	
	Unemployed or without own income	30%	
Household size	Two persons	62%	
	More than two persons	38%	
Children (below 15 years)	No	74%	
	Yes	26%	
Income	Less than 850 Euro	1%	
	851-1000 Euro	1%	
	1001-1250 Euro	1%	

		1251-1650 Euro	3%
		1651-2000 Euro	5%
		2001-2500 Euro	9%
		2501-3200 Euro	16%
		3201-4000 Euro	20%
		4001-4650 Euro	12%
		More than 4650 Euro	16%
		No information	17%
Trip information	Trip purpose	Trip to work or educational facility	56%
		Other purposes (e.g. shopping, leisure activities, chauffeuring persons)	44%
	Trip distance	In kilometers	13.35(17.29)
Attitudinal statements	Residential preferences: How important are the following criteria for your residential location choices in general? (4-point Likert scale: very important, important, less important, not important at all)	Size of apartment/house	3.44(0.59)
		Equipment of apartment/house (balcony, garden)	3.55(0.61)
		Home ownership (apartment/house)	2.91(1.04)
		Distance to family and friends	3.14(0.78)
		Living costs	3.6(0.55)
		Mobility costs	3.15(0.75)
		Access to public transport	3.39(0.78)
		Walkable and bicycling-friendly environment	3.04(0.89)
		Access to transport modes for persons with disabilities	2.5(0.96)
		Good car parking	2.94(0.93)
		Secured and sheltered bicycling parking	2.53(1.02)
		Calm neighborhood (e.g. noise, security)	3.61(0.55)
		Access to shopping and service facilities	3.41(0.63)
		Proximity to leisure and cultural activities (sport, cinema, restaurants)	2.8(0.79)
	Child-friendly environment	2.65(1.04)	
	Proximity to parks and green areas	3.15(0.81)	
	Travel attitudes: To what extent do you agree or disagree with the following statements? Please think of daily trips. There are no right or wrong answers. (5-point Likert scale: I strongly agree, I agree, undecided, I disagree, I strongly disagree)	I travel quickly by car.	3.85(1.23)
		There is not enough car parking.	3.69(1.24)
		I like car driving.	3.66(1.26)
		Car driving means freedom.	3.47(1.3)
		I can relax while driving (as a driver or passenger).	2.99(1.27)
		I travel quickly by public transport.	3.51(1.2)
I can relax in public transport.		3.19(1.21)	
My privacy is uncomfortably limited in public transport.		3.42(1.09)	
I reliably plan my way with public transport modes.		3.59(1.1)	
I like bicycling.		3.19(1.53)	
Built environment	Dwelling type	Bicycling means freedom.	3(1.47)
		I bicycle because I enjoy the exercise.	3.15(1.5)
	Settlement area type	I like walking.	4.11(0.99)
		I feel responsible to use environmentally friendly transport modes in daily life because of environmental and climate change reasons.	3.4(1.24)
	Access to bus services	Apartment house with more than 3 apartments	62%
		Single family (detached) and duplex (semi-detached) house	38%
		Densely developed area - urban core	47%
		Less densely developed and populated area - suburban area or the city fringe	40%
	Sparely developed and populated area - dispersed, isolated settlement or rural area	14%	
	Less than 5 minutes	63%	

	5 to 10 minutes	31%
	11 to 15 minutes	0%
	more than 15 minutes	2%
	not available / do not know	4%
Access to tram services	Less than 5 minutes	32%
	5 to 10 minutes	21%
	11 to 15 minutes	0%
	more than 15 minutes	8%
	not available / do not know	40%
Access to metro services	Less than 5 minutes	14%
	5 to 10 minutes	26%
	11 to 15 minutes	0%
	more than 15 minutes	19%
	not available / do not know	40%
Access to train services	Less than 5 minutes	7%
	5 to 10 minutes	29%
	11 to 15 minutes	0%
	more than 15 minutes	46%
	not available / do not know	18%
Land-use mix (a)	0 concentrated (1 land use only), 1 maximally mixed	0.07(0.04)
Access to shopping facilities	Less than 5 minutes	44%
	5 to 10 minutes	39%
	11 to 15 minutes	0%
	more than 15 minutes	14%
	not available / do not know	4%
Share of green area (b)	Area dedicated to bushes, gardens, forests out of total municipality area	0.34(0.21)
Commuters per inhabitant (c)	Ratio of commuters (employees, students) per inhabitant in municipality	0.45(0.03)
Parking area (b)	Parking area per inhabitant in m ² in municipality	3.06(3.57)
Population density (d)	Inhabitants per km ² in municipality	5152(6059)

Source: survey statistics, a Statistik Austria (2019e), b Bundesamt für Eich- und Vermessungswesen (2012), c Statistik Austria (2019a), d Bundesamt für Eich- und Vermessungswesen (2012), Statistik Austria (2019c), e Statistik Austria (2019c)

3.3. Modeling approach

To address the first research question, this paper uses a statistical control approach suggested by several studies (e.g. Ettema and Nieuwenhuis, 2017; Moktharian and Cao, 2008). Although more complex approaches do exist to model RSS and intra-household interaction, several reasons favor the use of statistical control and multinomial logit models. Cao et al. (2009) reviewed different approaches to estimate RSS effects and concluded that longitudinal data and structural equation models are the most suited to respond to these questions. Due to the cross-sectional nature of the data, the longitudinal approach is not possible in this study, a limitation further discussed in the following section. Structural equation models provide the advantage to consider endogenous variables and indirect effects though they require variables to be multivariate normally distributed. They are also more restrictive towards categorical variables since this modeling approach requires linear equations. Generalized structural equation models allow categorical dependent variables but when tested with the data used in this study the generalized structural equation model led to the same results as the multinomial logit models. Hence the simpler multinomial logit approach was preferred in this analysis. Another aspect relates to the approach of modeling intra-household interaction. Ho and Mulley (2015) provide a comprehensive overview over modeling approaches for household interaction. Several studies modeled household interaction based on group utility functions (cf. review of Ho and Mulley, 2015; Zhang et al., 2009). However, these studies concentrate

on activity pattern, time sharing or car ownership. They do not seem adequate to model transport mode choices because partners may have different commute trips and destinations. Thus, multinomial logit models seem to be an adequate approach to directly answer the proposed research questions.

The modeling approach foresees three separate multinomial logit models: one for neighborhood selection, one for women's mode, one for man's mode choice (cf. Figure 2). Dotted lines in Figure 2 show the relationships of interest in this study. The process of residential self-selection is operationalized by examining first the influence of female and male travel attitudes on location choice (neighborhood type selection). This approach compares model results without and including a residential dissonance indicator. Second, I assess the impact of built environment (neighborhood type) on mode choice and test the effect of including travel attitudes. Intra-household interaction is captured by distinguishing the effect of female and male travel attitudes and residential preferences on location and mode choices.

Addressing the second research questions, the neighborhood selection model includes residential and travel attitude types and tests the relevance of residential dissonance by comparing coefficients between two models (with and without including residential dissonance). As previous literature in this context (e.g. Pinjari et al., 2007), this article uses transport mode choice as outcome variable to assess residential self-selection. Persons consider travel distance and time to workplaces in their residential location choices (De Vos et al., 2012, Chidambaram and Scheiner, 2020, Plaut, 2006). Mode choice relates to the primary transport mode selected for commuting (to an educational site or workplace) or, in case this does not apply (e.g. for unemployed persons), the primary mode used on the most often traveled trip. The mode choice mirrors daily travel decisions in this article. Mode choice models distinguish three modes: non-motorized transport (NMT), public transport (PT) and motorized individual transport (MIT). NMT includes walking, bicycling and kick scooters (non-electric and electric). PT includes the use of bus, tram, metro and train and MIT the use of car, motorcycle, and scooter (electric or combustion engine). Mode choice models of both partners show two effects. First, this model approach allows examining the moderating role of travel attitude type on the effect of neighborhood type on mode choice to test the RSS hypothesis. According to this statistical control approach, travel behavior is determined by built environment and other control variables (Ettema and Nieuwenhuis, 2017; Moktharian and Cao, 2008). Following the RSS hypothesis, persons with specific travel attitudes select themselves in neighborhood types allowing them to travel with their preferred modes. Built environment is hence correlated to the error terms via omitted attitudinal variables² (Ettema and Nieuwenhuis, 2017; Moktharian and Cao, 2008). The model partially corrects this bias by explicitly including travel attitudes³. The second purpose of the mode choice models is to reveal potential interaction between partners by including travel attitudes of the partner.

² $TB = f_1(BE(AT), X) + \varepsilon(AT)$ with travel behavior (TB), built environment (BE), attitudes (AT), other control variables (X) and errors (epsilon)

³ The new function controls for this bias by expliciting considering attitudes with xi as standard errors
 $TB = f_2(BE, AT, X) + \xi$

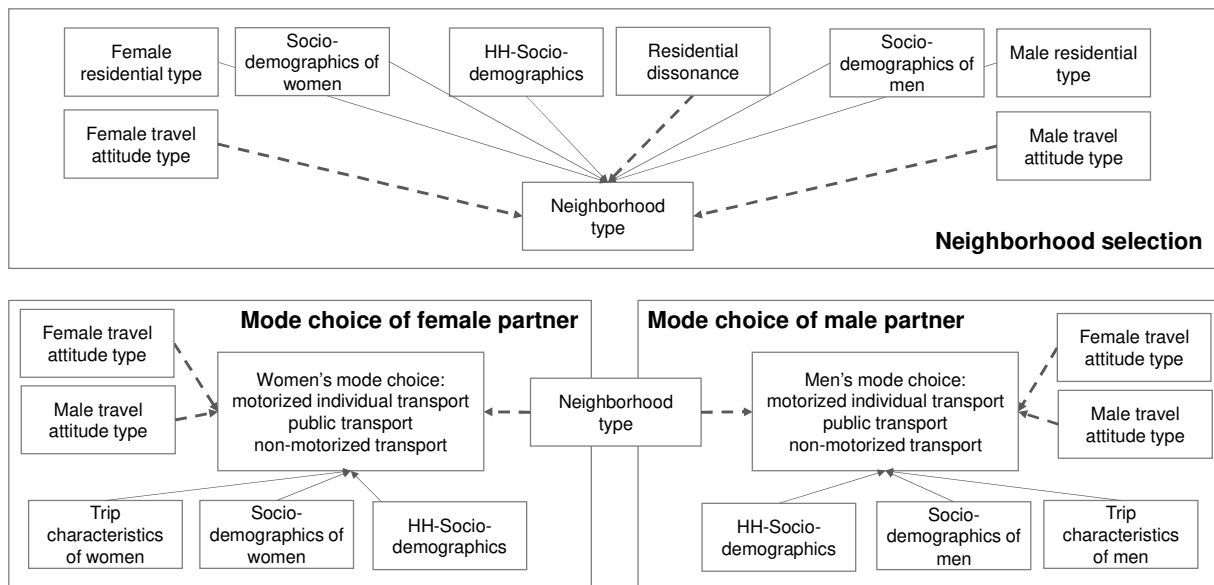


Figure 2 Model structure (dotted lines highlight the impact of residential self-selection and dissonance)

3.4. Model specification

Next to travel attitude, residential and neighborhood types, socio-demographic and trip-specific variables are included in the models. Several studies demonstrated the relevance of trip purpose for trip distance and mode choice (Ho and Mulley, 2015). The models also include trip distance since particularly, non-motorized modes (NMT) are distance sensitive. Respondents used the Austrian journey planner VOR AnachB to calculate travel time and distance of their commutes or most often traveled trips and entered the numbers in the survey. Socio-demographic information covers age, household size, income, educational attainment, employment status, and age group of children in the household (below 15 years old and above 15 years old). Children's impact on parental traveling may vary with their age (Janke and Handy, 2019). Another variable included in the analysis refers to the dwelling type. Neighborhoods with single family or semi-detached houses tend to be less densely populated and more concentrated in residential land-use. Their residents are often more car-dependent and likely to own a car compared to residents of buildings with multiple apartments (VCÖ, 2010). Car ownership is not considered since all households in the sample own at least one car. 36% of Viennese households do not own any car and 15% of Lower Austrian households (Bundesministerium für Verkehr, Innovation und Technologie, 2016). Though the share of households without car ownership decreases for households with two or more persons (19% for Vienna, 4% for Lower Austria). The overrepresentation of car owners in the sample is potentially linked to fact that we oversampled households of higher educational degree and income classes. Respondents may be more likely to choose car over other modes compared to the average population. Attention is paid to this potential bias while discussing the results. Although income and educational attainment are correlated in this sample both variables are included in the models. All persons with college degree do not have a high income and the influence of both variables on neighborhood selection is relevant for this analysis.

3.5. Limitations

Cao et al. (2009) enumerated several conditions necessary to establish the causal relationship between attitudes and built environment suggested by the RSS hypothesis. One of these conditions relates to time precedence and the authors suggest the use of longitudinal data. However, as numerous studies before (De Vos et al., 2012; Ettema and Nieuwenhuis, 2017; Schwanen and

Mokhtarian, 2005), this study tries to contribute to the RSS literature by using cross-sectional data. The causal relationship between travel attitudes and built environment is questioned by several studies that have found reverse effects (e.g. Kroesen, 2019; Naess, 2009; Van Acker et al. 2014). Naess (2009) suggested that the fact of spending time in a specific neighborhood may influence travel attitudes and car ownership indicating a reverse causality between built environment and attitudes. More recently, Kroesen (2019) confirmed this relationship and reported that built environment and travel behavior influenced travel-related residential preferences over time. This paper still tests the RSS in its classical understanding of the relationship between built environment and travel attitudes though discussing possible reverse effects in the conclusion section. Another limitation relates to the fact that the survey does not provide any information about how long respondents have lived at their current residential location. Hence, it is not possible to account for the time passed since relocating. Travel attitudes may change over time and do not reflect attitudes at the point of relocation. Unfortunately, it is not possible to control for this potential bias. One shortcoming of this study is that the survey does not provide information whether partners had joint trips and potentially misses synergy effects (e.g. partners sharing a car). The share of joint trips may be lower for weekday compared to weekend and lower for mandatory compared to discretionary trips (Ho and Mulley, 2013; Scheiner, 2010). For instance, couples living with children often divide childcare tasks and rarely bring their children together to school (Scheiner, 2016). In our data, 56% of all trips headed to work, school or other educational institutions. Therefore, the share of joint trips may be small in this data. Since the survey did not provide information who used the car in the household the interaction of car use between partners is not included in the mode choice model.

4. Results

First, this study explores heterogeneity in attitudes and mode choices between partners. Second, residential self-selection and dissonance are tested in several multinomial logit models.

4.1. Differences in travel attitudes and residential preferences between partners

Respondents were classified into three travel attitude types using factor analysis. Table 2 highlights factor loadings and statistically significant differences in the evaluation of attitudinal statements between partners. Cronbach's alpha of 0.81 indicates a good internal reliability implying that the covariance between the items significantly explains their variance and items are related to an underlying latent construct. The first type "Anti-car-pro-PT-bike type" (factor1) includes respondents who like public transport (PT) and bicycling, dislike car driving and consider themselves environmentally conscious (258 respondents). The second type "Anti-PT-pro-bike-car type" (factor2) includes persons who like driving and bicycling but dislike traveling by public transport (275 respondents). The third type "Anti-bike-pro-PT-car type" (factor3) appreciates using PT, likes car driving, but dislike bicycling and wishes for more car parking (264 respondents). The last column of Table 2 shows the mean difference in the evaluation between partners for each travel attitude item and the significance level based on the t-test. Partners seem to differently evaluate car- and bicycling-related attitudinal statements and have rather similar opinions on public transport. This may be linked to the fact that partners face the same quality level of public transport service at their residence that may affect their overall evaluation of using public transport services. This interpretation would support the argument for a reverse causality between built environment and attitudes as pointed out in the previous section (cf. Kroesen, 2019).

Table 2 Factor loadings for travel-related attitudinal statements and significant mean differences between partners

Items	factor1	factor2	factor3	uniqueness	mean
I travel quickly by car.	-0.61	0.28	0.06	0.55	-0.05
There is not enough car parking.	-0.25	0.12	0.32	0.82	0.03
I like car driving.	-0.68	0.39	0.37	0.24	-0.29 ***
Car driving means freedom.	-0.72	0.46	0.32	0.17	-0.2 ***
I can relax while driving (as a driver or passenger).	-0.58	0.40	0.33	0.39	-0.24 ***
I travel quickly by public transport.	0.57	-0.14	0.59	0.32	0.07
I can relax in public transport.	0.53	-0.08	0.40	0.55	0
My privacy is uncomfortably limited in public transport.	-0.44	0.15	0.09	0.78	-0.01
I reliably plan my way with public transport modes.	0.62	-0.11	0.52	0.33	0.05
I like bicycling.	0.49	0.80	-0.19	0.08	-0.28 ***
Bicycling means freedom.	0.47	0.84	-0.08	0.07	-0.22 ***
I bicycle because I enjoy the exercise.	0.47	0.83	-0.16	0.06	-0.22 ***
I like walking.	0.47	0.17	0.16	0.73	0.19 ***
I feel responsible to use environmentally friendly transport modes in daily life because of environmental and climate change reasons.	0.61	0.04	0.16	0.60	0.22 ***
Persons ⁺	258	276	264		

Absolut values greater than 0.3 are bold. *Number of respondents classified into this type based on the highest factor score, Cronbach's alpha: 0.81, *** pvalue <0.01, ** pvalue <0.05 based on t-test, Bartlett test of sphericity (chi-square statistic= 6,135, p-value=0) indicates that the variables in the matrix are correlated. Uniqueness shows the percentage of variance for the variable that is not explained by the common factors.

Based on another factor analysis, respondents were classified into four residential types: the neighborhood-orientated type who gives equal weight to several criteria with a moderate focus on neighborhood characteristics (factor1), the car- and property-orientated type (factor2), the cost-minimizing type (factor3), and the pro-walking-bicycling type (factor4) (Table 3). The last column of Table 3 shows the mean difference in the evaluation of residential criteria between partners and significance level based on the t-test. It seems that partners attributed significantly different importance to residential location criteria though with modest mean differences. Particularly, partners attached different levels of importance to distance to family members and friends when choosing their residence. It stands out that partners tend to differ more in their evaluation of travel-related attitudinal statements compared to residential location criteria (with respect to the size of mean difference). This result seems intuitive since mode choices are individual decisions that indirectly depend on other household member's choices (e.g. availability of car) while residential location choices are more often jointly made by partners.

Table 3 Factor loadings for residential location criteria and significant mean differences between partners

Items	factor1	factor2	factor3	factor4	uniqueness	mean
Size of apartment/house	0.35	0.26	0.13	0.21	0.66	-0.03
Equipment of apartment/house (balcony, garden)	0.42	0.38	0.13	0.19	0.57	0.13 ***
Home ownership (apartment/house)	0.29	0.48	-0.06	0.09	0.60	-0.07
Distance to family and friends	0.45	0.17	0.05	-0.18	0.67	0.22 ***

Living costs	0.40	-0.12	0.26	0.10	0.65	0.1 ***
Mobility costs	0.55	-0.31	0.29	0.16	0.44	0.1 **
Access to public transport	0.51	-0.58	0.15	0.06	0.35	0.13 ***
Walkable and bicycling-friendly environment	0.61	-0.31	-0.28	0.20	0.37	0.13 ***
Access to transport modes for persons with disabilities	0.59	-0.13	-0.04	-0.24	0.51	0.1 **
Good car parking	0.28	0.49	0.13	-0.17	0.57	-0.02
Secured and sheltered bicycling parking	0.47	-0.06	-0.26	0.25	0.59	0.04
Calm neighborhood (e.g. noise, security)	0.50	0.38	0.17	0.18	0.51	0.05
Access to shopping and service facilities	0.56	-0.12	0.22	-0.24	0.49	0.16 ***
Proximity to leisure and cultural activities (sport, cinema, restaurants)	0.66	-0.01	-0.01	-0.31	0.44	0.12 ***
Child-friendly environment	0.49	0.17	-0.38	-0.08	0.50	0.09 **
Proximity to parks and green areas	0.62	0.00	-0.29	-0.03	0.47	0.14 ***
Persons ⁺	229	209	184	176		

Absolut values greater than 0.3 are bold. ⁺ Number of respondents classified into this type based on the highest factor score, Cronbach's alpha: 0.77, ***pvalue <0.01, ** pvalue <0.05 based on t-test, Bartlett test of sphericity (chi-square statistic= 2,467, pvalue=0) indicates that the variables in the matrix are correlated. Uniqueness shows the percentage of variance for the variable that is not explained by the common factors.

4.2. Residential dissonance and the relative importance of neighborhood types

To analyze travel behavior in different built environments, residences of respondents are classified into neighborhood types based on factor analysis. Three factors are retained (cf. Table 4). The first neighborhood type is characterized by a densely populated environment, very good public transport access, mixed land-use, less green areas, less commuters and parking area. It is named urban core environment and mainly includes Viennese postcodes. The second neighborhood type is moderately populated, rather concentrated in land-use, has poor public transport access (relative to other service quality levels in the sample area), less green area and parking per inhabitant but a high number of commuters. It is further referred to as suburban environment. The third neighborhood type includes dispersed settlement among others, is less densely populated, has modest public transport access though with access to bus and train services. It is characterized by significant parking area and further referred to as urban-rural environment.

Table 4 Factor loadings for built environment variables

	factor1	factor2	factor3	uniqueness
Settlement area type	-0.81	0.01	-0.14	0.21
Access to bus	0.37	-0.13	0.19	0.73
Access to tram	0.81	-0.25	-0.19	0.23
Access to metro	0.85	-0.12	-0.01	0.24
Access to train	0.41	-0.07	0.09	0.76
Land-use mix	0.63	0.41	0.08	0.40
Access to shopping facilities	0.68	-0.07	0.15	0.48
Share of green area	-0.31	-0.49	-0.14	0.60
Commuters per inhabitant	-0.43	0.50	-0.10	0.53
Parking area per inhabitant	-0.28	-0.02	0.56	0.61
Population density	0.76	0.30	-0.18	0.28
Persons ⁺	336	225	237	

Absolut values greater than 0.3 are bold. ⁺ Number of respondents classified into this type based on the highest factor score, Cronbach's alpha(of standardized items): 0.81, Bartlett test of sphericity (chi-square statistic= 2,824,

pvalue=0) indicates that the variables in the matrix are correlated. Uniqueness shows the percentage of variance for the variable that is not explained by the common factors.

One of the research questions of this paper asks about the influence of residential dissonance. To set up a residential dissonance indicator, mode-specific attitude types have been manually matched with neighborhood types based on the interpretation of the factors (cf. Table 5). Neighborhood types differ in their built environment characteristics that incentivize or privilege the travel with specific transport modes. Residential dissonance is thus not based on residential preferences but on a matching between travel attitude and neighborhood types since this paper aims to test the residential self-selection (RSS) hypothesis. This manual matching seemed to be more appropriate than setting an arbitrary threshold for each built environment variable to be matched or mismatched and to define rules to aggregate matches or mismatches for different variables into one residential dissonance indicator. The anti-car-pro-PT-bike type is matched in the urban core because it provides less comfort for car drivers, has excellent PT access and is densely populated, often correlated with shorter trip distances and hence more attractive for NMT. Poor PT access in suburban areas and auto-orientated urban-rural areas (e.g. with respect to the parking situation) suggest that anti-car-pro-PT-bike types may be mismatched in these areas. Anti-PT-pro-bike-car type is matched in suburban neighborhoods since this type tends to dislike using PT and PT access is relatively poor in suburban neighborhoods. Suburban and urban-rural areas may provide favorable conditions for car use and bicycling. Anti-bike-pro-PT-car types are mismatched in suburban neighborhoods because of the relatively poor PT access but are matched in the other neighborhood types either because of good PT access or the comfort of car driving. Based on this manual matching, 283 out of the 798 respondents are considered to be mismatched or dissonant and the majority matched or consonant.

Table 5 Matching between travel attitude and neighborhood types

		Neighborhood type		
		Urban core	Suburban	Urban-rural
Travel attitude type	Anti-car-pro-PT-bike type	matched	mismatched	mismatched
	Anti-PT-pro-bike-car type	mismatched	matched	matched
	Anti-bike-pro-PT-car type	matched	mismatched	matched

Following the approach of Schwanen and Mokhtarian (2005) and De Vos et al. (2012), Figure 3 lines up the modal split of consonant and dissonant residents by neighborhood type. Figure 3 lists the neighborhood types with respect to their public transport service level: Neighborhoods in the urban core provide most public transport service, followed by urban-rural and suburban neighborhoods. Consonant and dissonant residents are listed with respect to a hypothesized decreasing share of public transport (PT) in the modal split based on their travel attitude types. Figure 3 shows a continuum of increasing of motorized individual transport (MIT) and decreasing PT share from urban core to suburban neighborhoods and travel attitudes as indicated by other studies (e.g. Schwanen and Mokhtarian, 2005) though residents in urban-rural neighborhoods fall apart. A comparison of residents in the urban core with those living in suburban neighborhoods indicates that the influence of the neighborhood type dominates the influence of travel attitude type on mode choice. For instance, the share of MIT for suburban residents is higher than for urban core residents regardless of their travel attitudes (i.e. their matching). Though the difference between consonant and dissonant residents in the modal split illustrates the relevance of travel attitudes for mode choice. For instance, consonant residents use less MIT and more non-motorized transport (NMT) and PT than dissonant residents in the urban core, emphasizing the attitudinal influence on mode choice. Contrary to Schwanen and Mokhtarian (2005) who reported that travel attitudes were more important for the modal split of urban than of suburban residents, Figure 3 shows that differences in

PT and MIT shares between consonant and dissonant residents are more substantial in urban-rural areas. Hence, depending on the neighborhood type, residential dissonance has a different effect on mode choice.

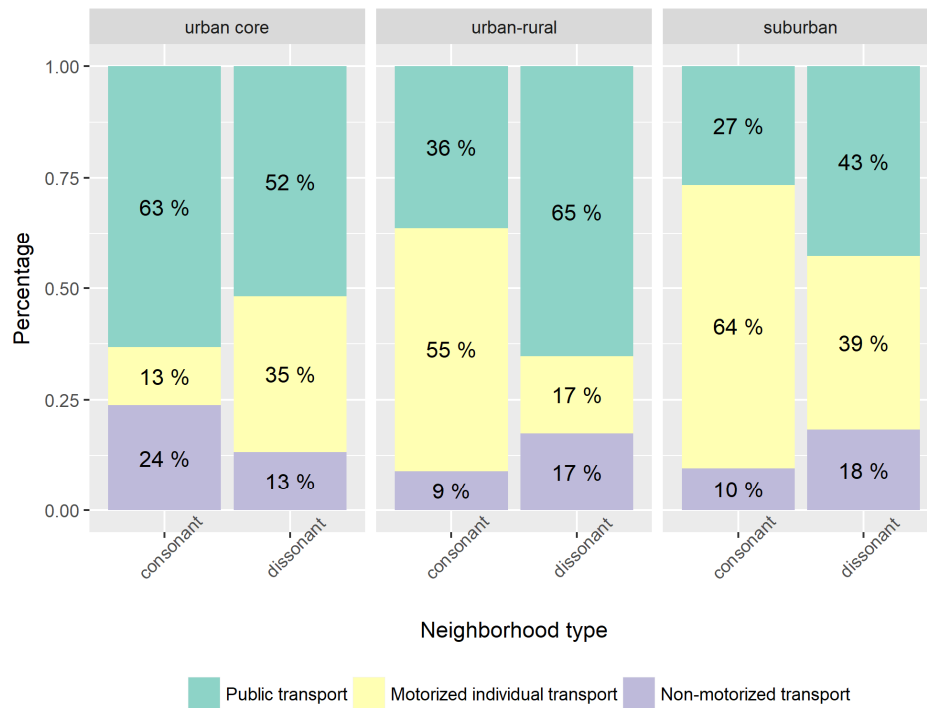


Figure 3 Modal split by residential dissonance and neighborhood type

Residential dissonance on individual level does not significantly differ between genders (based on chi-square test statistic) though significant differences emerge with respect to residential dissonance between partners. The residential dissonance indicator was aggregated on household level and indicates that 195 households were matched, 63 households included consonant women and dissonant men, 62 households with dissonant women and consonant men and 79 households with both partners mismatched. Although reasons for matches and mismatches may be diverse this descriptive statistic reveals that residential dissonance may be attributed to heterogeneity in travel attitudes among partners. 125 households included one partner who was mismatched and another partner who was matched representing 31% of the sample. Figure 4 shows the distribution of residential dissonance on household level between partners by neighborhood type. More women are consonant in urban core neighborhoods compared to their male partners while the opposite is true for suburban neighborhoods. For most households who live in urban core neighborhoods, both partners are well matched. In contrast, for 38% of the households who live in suburban neighborhoods, both partners are mismatched.

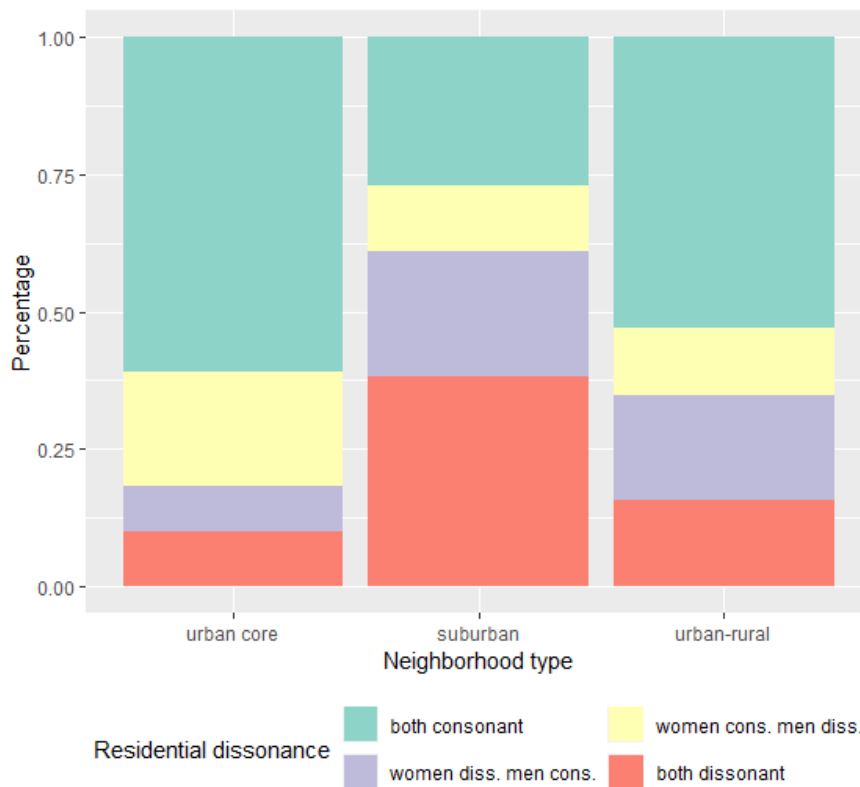


Figure 4 Residential dissonance on household-level by neighborhood type

4.3. Model results

4.3.1. Model performance

An important assumption for multinomial logit models states that the ratio of the probabilities for two alternatives should not depend on another alternative – also known as the independence of irrelative alternatives (IIA) assumption (Louviere et al., 2010). Hausman and McFadden (1984) proposed a test to evaluate the IIA assumption. However, the typical Hausman test does not allow for clustered observations since the variance matrix of the coefficients of the two models is not well defined in this case. The observations of this study are clustered on the household level with two observations per household. The seemingly unrelated estimation test provides a good alternative to test for the IIA assumption as it estimates simultaneously variance and covariance matrices of the coefficients between different models⁴. I test the IIA assumptions for the three models (neighborhood selection including residential dissonance, mode choice of women and men including travel attitudes). The chi-squared statistic and p-values of this test indicate that the H0-hypothesis of equal coefficients between models with different alternatives cannot be rejected⁵ and hence the IIA assumption seems not to be violated. Multinomial logit models were solved using STATA and the maximum likelihood method. McFadden’s pseudo R-squared, chi-square test and BIC have been used

⁴ The seemingly unrelated estimation test calculates the differences between the coefficients of different models $V(b-B)$ by $V(b)-cov(b,B)-cov(B,b)+V(B)$ and allows to include clustered observations (Stata 2020).

⁵ For the neighborhood selection model without urban core (chi2= 32, pvalue= 0.08), without suburban (chi2= 18, pvalue= 0.72), without urban-rural (chi2= 25, pvalue= 0.32), for the mode choice model for women without MIV (chi2= 12, pvalue= 0.78), for women without NMT (chi2= 13, pvalue= 0.75), for women without PT (chi2= 14, pvalue= 0.67), for the mode choice model for men without MIV (chi2= 16, pvalue= 0.49), for men without NMT (chi2= 13, pvalue= 0.72), for men without PT (chi2= 20, pvalue= 0.28).

to assess model performance (cf. Table 6)⁶. The likelihood ratio (LR) chi-square test indicates that all models perform better than the model including only constants. The pseudo R-squared is lower for mode choice models of women compared to those of men. This study compares the effect of residential dissonance on neighborhood selection by including the residential dissonance indicator and tests for the RSS hypothesis by including travel attitudes in the mode choice models. The BIC, penalizing for additional loss of degrees of freedom, takes the lowest (and best) value for the model that includes residential dissonance though is slightly higher for models including travel attitudes in mode choice.

⁶ Log-likelihoods of each model: -431.3 for the model without predictors (columns 1-4), -385.1 (columns 1-2), -344.9 (columns 3-4), -409.8 for the model without predictors (columns 5-8), -343.5 (columns 5-6), -323.8 (columns 7-8), -394.5 for the model without predictors (columns 9-12), -326.1 (columns 9-10), -306.4 (columns 11-12).

4.3.2. Neighborhood selection

The first model shows the selection of one of the three neighborhood types (urban core, suburban, urban-rural) on household level (column 1). Including residential dissonance improves the model fit (based on BIC) and increases the level of significance of travel attitudes (column 2). This result highlights that the influence of travel attitudes gains in importance (coefficients of travel attitudes increase) considering residential dissonance. In the model that does not account for residential dissonance (column 1), travel attitudes only weakly influence neighborhood type selection with a low significance level for one female travel attitude type. Including residential dissonance increases the significance level of women's travel attitudes (column 2). Disapproving car driving is relevant for neighborhood selection. Female anti-PT-pro-car-bike and anti-bike-pro-PT-car types are more likely to live in suburban and urban-rural neighborhoods than female anti-car-pro-PT-bike types. Particularly disliking public transport increases the probability of choosing suburban over an urban core neighborhood. Travel attitudes of both, women and men, seem to not influence the choice of urban-rural over urban core neighborhoods. The coefficients of the residential dissonance indicator highlight that couples of dissonant partners are more likely to live in suburban rather than in urban core areas. Residential dissonance seems to be more prevalent in suburban and to a lesser degree in urban-rural environments. Dissonant women living with a consonant partner are more likely to live in suburban areas though this is not true for consonant female and dissonant male partner. Residential preferences of both, women and men, significantly influence neighborhood type selection. Persons seeking a car-friendly residential location are more likely to locate in suburban and urban-rural than in urban core neighborhoods. Men are also more likely to live in suburban areas if they care for a walkable and bicycling-friendly environment. Relating to sociodemographic variables, women with a college degree are less likely to choose suburban and men less likely to choose urban-rural over urban core neighborhoods. Households with more than two persons have a higher chance to live in urban-rural areas. The significance level of income decreases if residential dissonance is considered.

4.3.3. Transport mode choice

Testing the residential self-selection (RSS) hypothesis, Table 6 compares mode choice models without and with travel attitudes (columns 5 to 12). The results support the RSS hypothesis since travel attitude type affects mode choice and alters the effect of neighborhood type on mode choice though only to a limited extent for the male partner. Including travel attitudes in mode choice decreases the coefficients of the neighborhood types. Notwithstanding, the results demonstrate an autonomous significant effect of neighborhood type on transport mode choices. For the male partner, neighborhood type and travel attitudes only have limited influence on his mode choice (columns 9 to 12). Neighborhood type seems to have a larger and more significant effect on women's mode choice (column 5 compared to 7 and 6 compared to 8). Living in a suburban and for woman also in an urban-rural rather than in an urban core area makes it more likely to choose car over public transport (PT) (columns 5 and 7). For women, suburban neighborhoods have a positive effect on the likelihood of choosing non-motorized modes (NMT) over PT (columns 6 and 8). In general, travel attitudes seem to influence car mode choices more than NMT for daily traveling. Women and men who appreciate car driving and bicycling, but dislike PT are more likely to choose MIT over PT (columns 7 and 11). While women have a higher chance of choosing MIT (column 7), men have a lower chance of choosing NMT if they dislike bicycling (column 12). The results do not provide strong evidence for interaction between partners' travel attitudes and their mode choices (columns 7, 8, 11, and 12). Only women affect men's mode choice but at a weak significant level (p -value < 0.1) (column 12). Women have a negative influence on men's likelihood to choose NMT over PT if they do not like using PT (column 12). Women seem to use more PT than car for commute trips (columns 5

and 7). In general, trip purpose seems to be more influential on women's mode choice (columns 5 to 8) while for men trip distance reduces the chance of choosing NMT over PT (columns 10 and 12). Interestingly, variables related to household size or structure only affect women's mode choice although at a weak significance level (columns 5 and 7). Women who live in households with more than two persons are less likely to choose car over PT for their daily trips except if they live with their children (columns 5 and 7). Living in a family or semi-detached house increases the likelihood to choose car over PT for men and women (columns 5, 7, 9, 11). In contrast to men, women are more likely to choose MIT over PT if they are unemployed (column 7). However, unemployed men have a negative impact on women's likelihood of choosing car over PT, while women's employment status does not affect men's mode choice.

5. Discussion and conclusion

5.1. Discussion

An initial objective of this study was to identify whether heterogeneity in travel attitudes between partners of a common household alters residential self-selection (RSS). The results indicate that heterogeneity in travel attitudes and influence among partners affect the process of RSS. Travel attitudes of women were more influential on neighborhood type selection than those of men. This result may be explained by the fact that women were more affected by neighborhood type in their transport mode choice than men. Addressing the first research question, these results highlight that the impact and relevance of travel attitudes on residential location choices may vary between partners. Additionally, women in our sample used more non-motorized transport (NMT) and public transport (PT) whose use is generally more dependent on built environment than car driving (Ewing and Cervero, 2010). In contrast to my results, Guan and Wang (2019) reported that travel attitudes of both partners influenced land use characteristics of the residential location with a larger effect of male attitudes. Corroborating the results of this study, several studies have found that built environment affects women's travel behavior more than men's. For the UK, Susilo and Liu (2016) observed that mothers whose reasons for residential relocation related to a better neighborhood and living closer to work or school increased their walking and cycling and decreased their car use after relocation though no significant effect was found for fathers. Supporting this result, Spence et al. (2006) found in a Canadian study that women's physical activity was more strongly correlated to perceived environment. Results from previous studies have highlighted that negotiating power of partners and the role of gender in location choices depend on the social and cultural context. For studies in Japan and China, researchers found that men's attitudes were more influential for location choices than those of women (Guan and Wang, 2019; Zhang and Fujiwara, 2009) while a Canadian study found the contrary (Abraham and Hunt, 1997). The findings of this study on intra-household interaction suggest that women and men exert a different influence on location choices and show distinct sensitivity to built environment. These results may be difficult to capture by including a gender variable only. To the contrary of travel attitudes, also men's residential preferences influenced neighborhood selection. Property seeking and car-orientated persons tend to locate more often in suburban and urban-rural areas but also persons who favor walkable and bicycling-friendly environments. Residential preferences are more relevant for choosing a residence in suburban than in urban-rural neighborhoods. As other studies suggested before (e.g. Kroesen, 2019), living in a certain neighborhood may change travel attitudes over time, pointing to a reverse causality between built environment and travel attitudes. For instance, persons who live in a car-friendly neighborhood may increasingly appreciate and enjoy car driving over time inducing a change in their attitudes

towards car use. Although the author acknowledges potential reverse effects this relationship was not tested in this study due to the cross-sectional data.

The second research question addresses the extent to which heterogeneity in travel attitudes between partners lead to residential dissonance. The descriptive analysis revealed that 125 households include one consonant and one mismatched partner. Although other reasons may be relevant, the observed heterogeneity in attitudes between partners may explain residential dissonance. According to the descriptive statistics, more consonant women lived with dissonant male partners in urban core areas while the opposite was true for suburban areas. These patterns may be explained by different travel patterns among genders which are discussed in more detail in the following section. The second research question also thought to determine the role of residential dissonance for RSS. As the model results suggest residential dissonance may explain limited evidence for RSS. Some respondents seem not to live in the neighborhood type matching their travel attitudes. Including residential dissonance into the location choice model improved the model fit but also the significance of travel attitudes. Considering dissonance, the influence of travel attitudes on neighborhood type and hence RSS gained in importance. Moreover, heterogeneity in travel attitudes between partners contributes to the understanding of the relationship between RSS and residential dissonance. Dissonant women and consonant men were more likely to locate in suburban areas while dissonant men only had a weakly significant effect on neighborhood selection. Hence male travel attitudes may indirectly affect location choices. Heterogeneity in travel attitudes between partners may explain mismatches and hence limited evidence for RSS. In general, residential dissonance had the highest effect on location choice if both partners were mismatched. It is important to bear in mind that residential dissonance, as defined in this article, only relates to travel attitudes and is based on manual matching. Residents may in general be satisfied with their current location with respect to other non-travel related criteria. More generally, the results of this analysis provide evidence for RSS since travel attitudes significantly influenced mode choice while controlling for neighborhood characteristics. The results highlight an autonomous effect of neighborhood type next to travel attitudes on mode choice though only at a weak significance level for men's mode choice. Including travel attitudes in mode choice decreased the size of the coefficients and partly the significance level of neighborhood type. The literature has been discussing the direction of RSS on built environment and has found evidence that considering travel attitudes increased the effect of built environment on travel behavior (Chatman 2009; Ewing and Cervero, 2010) as well as negative effects hence decreasing the effect of built environment on travel behavior (Cao et al., 2009; Mokhtarian and van Herick, 2016).

In this study, travel attitudes mainly affected the use of MIT modes and not NMT use. These results contrast findings in the literature emphasizing the predictive power of travel attitudes for the level of bicycling (Handy et al., 2014). One explanation may relate to the fact that a low share of respondents bicycled, and most respondents walked. This result may indicate that persons do not travel with their preferred modes on daily trips. Surprisingly and contrary to findings in other studies (e.g. Guan and Wang, 2019), partners influenced each other's mode choice via their travel attitudes only to a limited extent. Women only weakly influenced NMT choice of men. The descriptive analysis showed that partners seem to differently evaluate car- and bicycling-related attitudinal statements and have rather similar opinions on public transport. Returning to mode choice, the influence of travel attitudes between partners may be more prevalent for discretionary trips compared to mixed (commute, other mandatory, and discretionary) trips used in this paper. The descriptive analysis revealed that the relevance of travel attitudes for mode choice varies among neighborhood types. The neighborhood effect on mode choice seems to dominate that of travel attitudes though this relationship is less pronounced for urban-rural environments. These findings corroborate the results

of other studies (Naess, 2009, 2010) though also highlight that in urban-rural environments in the proximity of an agglomeration, residents may more easily realize their travel attitudes (De Vos et al., 2012) although this may not be the case for suburban residents. In this study, urban-rural environments still provide access to bus and train public transport. Persons with public transport affine attitudes may still use public transport in these less well served areas. Contrary to the population, households in this sample detained on average a higher educational degree which correlates with higher income in Austria (Vogtenhuber et al., 2012). Respondents may be less likely to be captive riders than persons with lower educational degree. This effect may be strengthened by the fact that all households in this sample own a car. These households may be less sensitive to determinants influencing mode choice (e.g. expensive parking in the urban core) because they can afford to travel by car. Hence travel attitudes may have a higher impact on mode choice in this study compared to a population with a higher share of lower income classes and car ownership.

5.2. Policy implications

Interestingly, households with dissonant women and consonant men were more likely to choose suburban over urban core areas. Although women preferred the urban core they may be bound by other constraints (e.g. housing prices) or compromises with their partners to choose suburban areas. In general, women differ in their travel pattern and use of public space from men: their trips are shorter, they use more public transport (PT) and do more trips chauffeuring persons (VCÖ, 2010). Transport planning agencies and transport service providers may emphasize their strategies providing women with a good experience using PT and facilitating trip chaining. This may be beneficial in two ways. According to the results of this study, women's travel attitudes seem to be more influential for location choices than those of men and more affected by built environment in their mode choices. First, improving female user experience of PT may increase PT use and in the long-run may decrease the attractiveness of residential locations with poor PT service levels. Second, in this study women used more PT than MIT for commuting. Providing better PT service levels may improve women's access to labor markets. This is particularly pertinent since previous studies demonstrated that car access helped women to overcome spatial limitations to the job market (Chidambaram and Scheiner, 202; Gil Solá, 2016). Providing affordable residence with good PT access may also favor gender equality in the labor market.

This paper explains some of the potential interconnections between residential location and travel decisions. The results indicate that dissonant couples more often live in suburban areas characterized by a relatively poorer public transport access and higher car dependency. Although persons may prefer taking more environmentally friendly modes, they locate in more car-dependent areas. Households with a college degree and potentially higher income are less likely to locate in suburban areas. Both results may point to pressures in the residential housing market in the urban core of Vienna. With an anticipated population growth of 10% in Vienna between 2013 and 2025 (Stadt Wien, 2014a), housing demand will increase and further constrain the housing market. Population growth within Vienna is mostly expected in the suburban districts that are characterized by a "poorer" public transport access (out of the catchment area of high level or secondary public transport modes) and a higher use of MIT (Fersterer et al., 2019). Another challenge lies in the cooperation between transport and planning agencies of Vienna and its greater agglomeration area. The current tariff system and lack of tangential public transport routes hampers PT use between Vienna and its agglomeration (Stadt Wien, 2014b). These trends augment the challenges in providing attractive residential location and environmentally sustainable mobility services in Vienna and its agglomeration area.

Future studies may qualitatively explore in more detail negotiating processes for location choices and interaction in travel behavior between partners. Schwanen et al. (2007) found that men perform more out-of-home duties in more densely and mixed neighborhoods than men living in lower density and less diverse neighborhoods. Do more gender-equal households locate in densely urban neighborhoods, or do built environment characteristics favor more gender-equal behavior? Moreover, partners may adapt and converge their attitudes over time to avoid negotiating processes. As demonstrated in several studies, neighborhoods may shape attitudes, pointing to a reverse causality (Kroesen, 2019). Future research may explore these adaptation processes towards specific built environments and maybe also investigate adaptation processes between partners over time. It would be interesting to test the results of this paper in other geographical areas and with a larger sample. As previous studies indicated (e.g. for Germany Kuhnimhof et al., 2012), couples belonging to different generations may differ in their travel behavior, location choices and negotiating processes. It would be worth comparing these processes and choices between generations. As previous research pointed out (Janke et al., 2020), millennials may reproduce gender disparities of previous generation with respect to active travel once they enter the life stage of parenthood. Millennials may also behave differently in their residential choices and show different negotiation processes between genders than previous generations. It would be interesting to test results related to gender with a larger sample, more specifically if such effects change between renters and homeowners as Plaut (2006) suggested for the US. A larger sample also would allow for testing for differences between mandatory (commute) and discretionary trips since RSS may be more relevant for discretionary trips.

6. Appendix

Table 7 Comparison of sample with population statistics

		Vienna		Lower Austria	
		population*	sample	population*	sample
Household size	2 persons	52 %	64 %	48 %	53 %
	3 persons	23 %	17 %	24 %	22 %
	4 persons	16 %	15 %	19 %	20 %
	5 and more persons	9 %	4 %	10 %	5 %
Gender	Men	48 %	50 %	49 %	49 %
Age	15 to 19	6 %	2 %	7 %	2 %
	20 to 24	8 %	3 %	7 %	5 %
	25 to 29	9 %	7 %	7 %	9 %
	30 to 34	9 %	13 %	7 %	7 %
	35 to 39	8 %	10 %	8 %	9 %
	40 to 44	9 %	11 %	10 %	9 %
	45 to 49	9 %	12 %	10 %	9 %
	50 to 54	8 %	10 %	9 %	11 %
	55 to 59	7 %	10 %	7 %	12 %
	60 to 64	6 %	8 %	7 %	11 %
	65 to 69	6 %	6 %	6 %	7 %
	70 and older	14 %	8 %	16 %	9 %
	Educational degree	Primary education	26 %	4 %	24 %
Secondary education		53 %	60 %	64 %	72 %
Tertiary education		21 %	36 %	11 %	22 %

* Statistik Austria (2019a, 2019d, 2013)

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