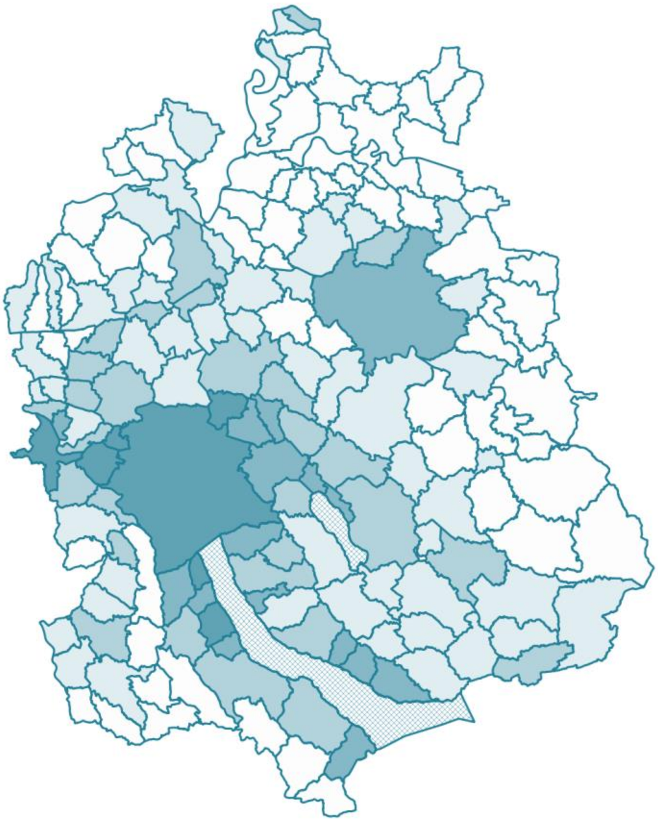

On the trade-off between proximity to social contacts and commuting time: results from a residential location choice model

Sergio Guidon,
Michael Wicki,
Thomas Bernauer,
Kay W. Axhausen

Institute of Science, Technology and Policy (ISTP)

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Sergio Guidon
ISTP ETH Zürich
Zürich

sergio.guidon@ivt.baug.ethz.ch

Michael Wicki
ISTP ETH Zürich
Zürich

michael.wicki@istp.ethz.ch

Thomas Bernauer
ISTP ETH Zürich
Zürich

thbe0520@ethz.ch

Kay W. Axhausen
ISTP ETH Zürich
Zürich

axhausen@ivt.baug.ethz.ch

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Abstract

Commuting has been found to be one of the least enjoyable activities in an individual's day. As commuting is a consequence of a choice made by each individual, the choice of home and work location, the question arises how the disutility of commuting is compensated. Classical urban location theory suggests a compensation in the housing or the labour market, which has been confirmed by previous research. While these observations provide part of the explanation, individuals' personal networks are ignored in most studies. We use data from a social network survey that was conducted in the year 2017 in the canton of Zürich, Switzerland, to investigate proximity to social contacts as a factor in residential location choice. We find evidence of a trade-off between proximity to individuals' contacts and commuting time. The notion that the disutility of commuting is not compensated (which was suggested by previous research) might, therefore, be a consequence of ignoring the effect of individuals' social contacts and their personal networks.

Keywords

Travel behavior; commuting; residential location choice; urban location, social network analysis

1. Introduction

Commuting has been found to be one of the least enjoyable activities in an individual's day, ranking below working and housework (Humphreys *et al.*, 2013; Kahneman *et al.*, 2004). Stutzer and Frey (2008), therefore, noted that to agree with classical economic theory, according to which individuals behave rationally, a longer commuting time and the associated additional psychological burden should either be compensated by a more rewarding job (intrinsically or financially) or by additional welfare from a more attractive living situation (price, size, comfort etc.). Previous research has indeed provided strong evidence of a relationship between housing prices and distance to job opportunities and longer commutes are generally associated with higher wages (Ommeren *et al.*, 2000). However, in terms of reported subjective well-being (SWB) Stutzer and Frey (2008) find that, individuals with longer commuting times are systematically worse off. As they take SWB as a proxy for individual utility, they found that this contradicts rational behavior and they observed a "commuting paradox". However, the notion of a commuting paradox is problematic in two ways: on one hand, SWB might not accurately reflect utility in general as individuals might choose to accept a suboptimal situation because it increases their prospect for a better situation in the future. On the other hand, factors beyond the housing or the labor market may compensate for the commute. However, even if there is no such thing as a commuting paradox, it is still unclear whether and how the burden and the associated disutility of commuting is compensated.

Commuting is a consequence of the combined choice of home and work location. Thus, individuals make a trade-off between commuting time and distance, the characteristics of home and work location, and opportunities that arise by combining the commute with other activities (such as shopping on the way home). The effect of individual characteristics on location choice and their trade-offs can be investigated with discrete choice modelling (DCM). With the increasing availability of spatial data, a number of studies have used DCM for location choice modelling. Schirmer *et al.* (2014) conducted a review of these studies for residential location choice: they find that a wide variety of variables is used in literature and they propose a common classification. Depending on the unit of analysis (zones or buildings), the studies include characteristics of the following categories: residential unit, the built environment, the socio-economic environment, points of interest, access and accessibility, and previous location and social networks. While many studies take the first six categories into account, only a very limited number of studies take into account the previous home location and social networks. This is not surprising, as data on the first six categories is readily available from national or regional statistics. In contrast, data on individual social networks is usually not available. As data collection is generally expensive, data availability most likely often determined the choice of the variables that were included in previous models. However, this is problematic, as recent studies such as Stokenberga (2017) and Belart (2011) have shown that social networks are an important factor in residential location choice. If social network effects are indeed important, previous studies might not only suffer from ignoring an important factor, they might also be subject to an omitted variable bias that might lead to incorrect conclusions regarding the included variables.

In this paper, we investigate distance to individuals' contacts as a factor in residential location choice. We argue that proximity to social contacts is an important factor as it increases the accessibility of the resources provided by social contacts (which is a part of their social capital) and thus provides utility. Furthermore, we investigate whether there is a trade-off between commuting time and proximity to an individual's contacts. We propose that individuals compensate the disutility of commuting with the utility of the opportunities that arise by living closer to their contacts.

2. Background

2.1 The disutility of commuting and its effects

The notion that commuting is a burden and, therefore, a disutility, is a common assumption in transportation planning and research. Redmond and Mokhtarian (2001) challenge this assumption and suggest that commuting is not solely a source of disutility, but also provides benefits for some people as it can support the transition between home and work. The authors suggest that there is an optimal commuting time, but they still find that most people perceive their commute as too long. In addition, Martin *et al.* (2014) propose that active commuting (i.e. walking and cycling) is associated with higher wellbeing and a reduced likelihood for certain psychological symptoms. However, the authors still observe a clear disutility of commuting for drivers. Regarding the effect that commuting has on individuals, Stutzer and Frey (2008) report that there is a negative association between commuting and SWB. The authors use SWB as a proxy for individual utility and they find no evidence for a compensation. Therefore, they assert that commuting is irrational from a perspective of individual utility maximization, which seems too strong of a conclusion given the limited data availability. Furthermore, this finding is not confirmed by other studies. Lorenz (2018) finds no negative association between commuting and general satisfaction with life. However, the author relates commuting to lower satisfaction in specific domains of life, i.e. satisfaction with family life and leisure time. Morris *et al.* (2018) find no association between commuting time and life satisfaction. Roberts *et al.* (2011) report a negative effect of commuting on psychological health (but only for women and not for men). The authors hypothesize that the greater sensitivity to commuting time of women is a result of greater responsibility for household tasks such as housework and child-care. Dickerson *et al.* (2014) find no evidence of a negative effect of commuting and explain their findings with cultural differences between Germany and the UK and the choice of the well-being measure.

2.2 Modelling residential location choice

The origins of location theory can be traced back to the work of von Thünen (1826) who sought to determine the most profitable use for his property. The author developed the first model to explain land-use patterns relative to a central market location, using the bid-rent curve, which takes into account transportation costs. Alonso (1964), Muth (1969) and Mills (1967) developed more refined models, known collectively as the Alonso-Muth-Mills (AMM) model. The AMM model explains household location choice in a monocentric city with a central business district and a fixed population. The basic assumptions are that households spend their income on housing, a composite consumption good, and transport. Households ultimately choose their location by maximizing their individual utility. After McFadden (1977) introduced DCM to residential location choice, a number of studies using the approach followed. A clear advantage of DCM over previous modelling approaches is that various characteristics of the location, the household, and the individual can be taken into account and the trade-offs between the different characteristics can be investigated. Schirmer *et al.* (2014) review the existing studies that make use of residential location choice models and classify the variables that are used.

2.3 Personal networks and residential location choice

A number of studies have shown that social networks play an important role in international migration flows and social network analysis (SNA) is a central component of migration analysis (Boyd, 1989). It is, therefore, not far-fetched to assume that personal networks are also a factor in residential location choice in a more regional context (i.e. within countries or states). SNA has attracted some attention in the field of mobility research after Axhausen (2007) proposed some hypotheses on the relationship between activity spaces and social networks. Mobility patterns are tightly connected to the locations where individuals perform their activities and the home location (together with the work location) is one of the central locations in an individual's activity space (Schönfelder and Axhausen, 2004). In transportation research, Ettema *et al.* (2011) discuss the effect of social influences on residential location, mobility and activity choice with a focus on including social network effects in land-use-transportation interaction models. The authors note that social networks provide information about choices and, therefore, potentially influence long-term decisions such as the choice of home or work location. Belart (2011) estimates a multinomial logit model to investigate residential location choice in the greater Zürich area. Among other variables, the model includes distance to work location and the average distance to subjects' social network members. Distance to social network members was calculated as a weighted average distance with contact frequencies as weights. The author finds a significant influence of personal networks on residential location choice. The effect of distance to social network members was stronger than the effect of distance to workplace. In a more recent study, Stokenberga (2017) investigates the role of family networks on residential location choice. The author conducts a stated choice experiment with time to the nearest extended family member as a variable. This variable is interacted with specific types of assistance the subject receives from family network members such as childcare assistance and help in crises. The study shows that individuals exhibit a strong preference to live close to their extended family and even prioritize proximity to family stronger than accessibility to the central business district. The preference was stronger for individuals who received help from their family, specifically help with childcare, which also underlines the connection to individual social capital.

To sum up, there is a clear lack of data on the effect of personal networks on household location choice. Given that that the effect of personal networks is potentially very strong, further analyses could significantly contribute to the understanding of residential location choice in general. Furthermore, knowledge about the trade-offs between proximity to social network members and other factors that influence household location choice is scarce. In this paper, we therefore use distance to social network members as a factor in a residential location choice model. We test the hypothesis that a shorter overall distance to social network members increases the choice probability of a municipality as residential location. We compare the magnitude of the effect to the effect of commuting time to determine the relative importance of proximity to social contacts.

3. Methods

3.1 The conditional/multinomial logit model

As a basis, we use the conditional logit model introduced by McFadden (1973), as the primary focus is on explaining residential location choice in terms of characteristics of the alternatives. However, we also use individual characteristics to complement the analysis and, therefore, estimate a model that can best be described as a conditional/multinomial logit model.

The modelling approach can be described as follows: U_{nj} represents the utility of alternative j for decision maker n. U_{nj} is composed of a deterministic part V_{nj}, and a random error term ε_{nj}, and is, therefore, a random variable itself:

$$U_{nj} = V_{nj} + \varepsilon_{nj}.$$

We assume that individuals seek to maximize their utility. They choose an alternative i if it provides more utility than any other alternative j. We obtain

$U_{ni} > U_{nj}, \forall j \neq i$, and after rearranging, $V_{ni} - V_{nj} > \varepsilon_{nj} - \varepsilon_{ni}, \forall j \neq i.$

The probability that decision maker n chooses alternative i is therefore:

$$P_{ni} = Prob\{\varepsilon_{nj} < \varepsilon_{ni} + (V_{ni} - V_{nj})\},\ \forall j \neq i.$$

This probability can be calculated by solving the integral

$$P_{ni} = \int f(\varepsilon)\, d(\varepsilon).$$

Assuming independent and identically distributed (IID) error terms and a Gumbel distribution for ε, this integral can be solved analytically and it can be shown that

$$P_{ni} = \frac{e^{V_{ni}}}{\sum_j e^{V_{nj}}}.$$

As described by Croissant (2003), the deterministic part of the utility, $V_{nj,}$ consists of an alternative specific constant α_j, alternative specific variables x_{ij} with a generic coefficient β, individual specific variables z_n with alternative specific coefficients γ_j, and alternative specific variables w_{ij} with alternative specific coefficients δ_j:

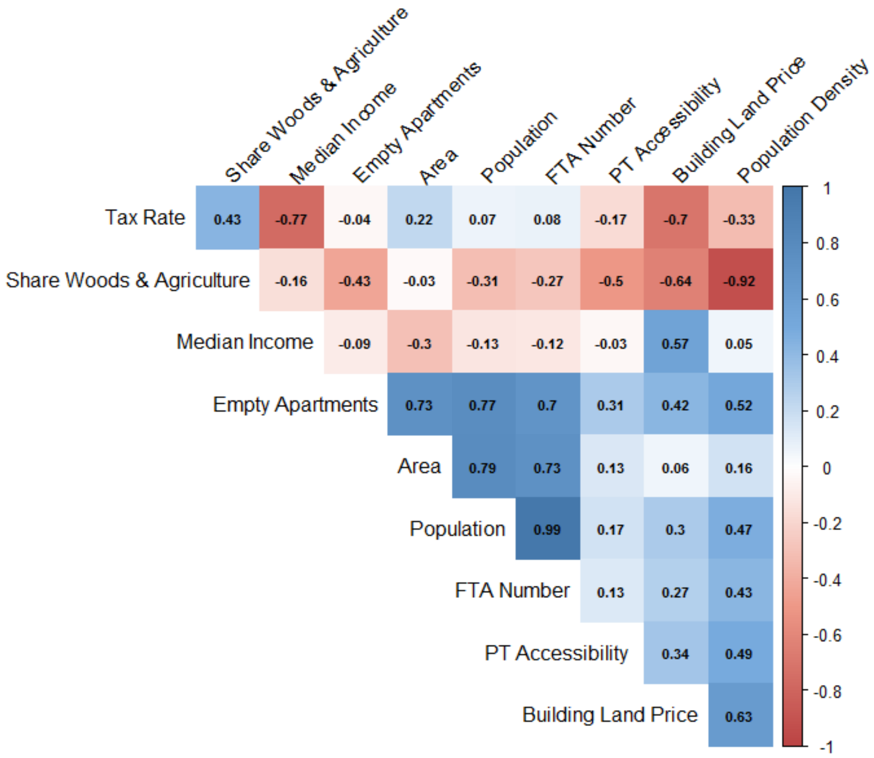
$$V_{ij} = \alpha_j + \beta x_{ij} + \gamma_j z_n + \delta_j w_{ij}.$$

We use the mlogit package for R to estimate the model (Croissant, 2003).

3.2 Data source

The main data source for the analysis is a mobility and social network survey that was conducted in June 2017 in Zürich, Switzerland (Guidon *et al.*, 2018; Wicki *et al.*, 2018). The survey consists of two parts: a mobility survey and an egocentric social network survey. The second part includes coordinates of the home locations of subjects' contacts and thus allows for a calculation of the distance of the subject to his or her social network members. The survey data was enriched with data on the municipalities of the canton of Zürich from the cantonal office of statistics (Statistisches Amt Kanton Zürich, 2017). Figure 1 shows the variables from the municipality data that were considered for the residential location choice model. The variable "Share of Woods and agriculture" was not included in the models because of its high negative correlation with population density. The number of full time equivalents ("FTA Number") was also not considered in the models because it is nearly perfectly related to the total population. Commuting times between the municipalities were determined with the Google Maps API (with municipality polygon centroids as origins/destinations). Individuals were included in the analysis if they both live and work in the canton of Zürich and if they moved there after the year 2006. The original dataset included 1387 subjects that have completed the social network study. With these restrictions, 338 individuals could be included in this analysis. The choice set was composed of the 168 municipalities of the canton. The full choice set would also include municipalities of other cantons. In this analysis, however, only the canton of Zürich was considered because of the available data.

Figure 1 Correlations between variables from the cantonal municipality data



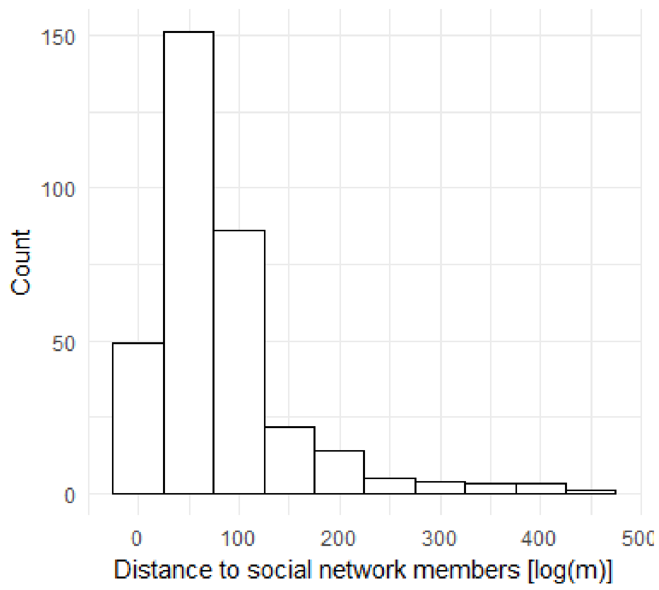
Variable description: tax rate: municipal tax rate of the canton; Share of Woods and agriculture: share of total municipality area; median income: median income in CHF p.a; empty apartments: number of empty apartments in 2017<, area: total area; population: total population of the municipality; FTA number: number of full time equivalents; pt accessibility (train and bus): percentage of residents that live within 400 meters of a bus station or 750 meters of a train station; building land price: price in CHF/m2.

3.3 Distance to social network members

The distance of an individual n to his or her social network members m, D_n, was measured as the sum of the logarithms of the great circle distances between the subject and his or her contacts: $D_n = \sum_j \log(d_{nm})$. The logarithm diminishes the effect of contacts that live far away, which are assumed to have a minor influence on location choice. Contacts that live in the same household were excluded from the analysis to avoid perfect predictions due to cohabitation.

Figure 2 shows the distribution of the distances D. The median distance is 65.6 log(m) with a mean of 80.1 log(m) and a standard deviation of 70.1 log(m).

Figure 2 Distribution of distances to social network members



3.4 Residential location choice: model specification

Table 1 provides an overview over the variables that were included in the residential location choice models.

Table 1: Variable description

Variable	Description	Source
commTc	Commuting time car [h]	Own survey*/ Google API*
commTpt	Commuting time public transport [h]	Own survey/ Google API
accPc	Access to private car [0,1]	Own survey
noAccPc	1 – accPc [0,1]	Own survey
distAlt	Distance to social contacts [log(m)]	Own survey/ Google API
popDens	Population Density [pop/ha]	Cantonal statistics*
landPr	Building land price [kCHF/m2]	Cantonal statistics
ptAcc	Transit accessibility [%]	Cantonal statistics
emApp	Number of empty apartments and houses [#]	Cantonal statistics
taxRate	Communal tax rate [%]	Cantonal statistics
incM	Median income community [kCHF]	Cantonal statistics
inc	Personal income [kCHF]	Own survey
age	Age [years]	Own survey

*Own survey described in Guidon et al. (2018) and Wicki et al. (2018); the Google Maps API was used for geocoding and routing; the cantonal data was obtained from Statistisches Amt Kanton Zürich (2017)

We estimated three residential location choice models, models 1-3. Model 1 includes commuting time, population density, building land price, public transport accessibility, the number of empty apartments and the municipal tax rate. The distance to social network members is considered in model 2. Model 3 includes additional interaction terms. The interaction between population density and access to private car is assumed to be important because low population density is often associated with private car ownership as collective modes of transport are less efficient and, therefore, often less available. The interactions between commuting time and distance to social contacts were added as people have limited time budgets. Long commutes could, therefore, have a more negative effect on residential location choice if social contact members also live further away and more time is needed to visit them. The interaction between population density and age reflects the observation that young people tend to prefer urban areas and the interaction between land prices and income should reflect that the effect of land prices depends on income. The systematic part of the utility functions are as follows:

Model 1:

$$V_1 = \beta_{commTc} \cdot commTc \cdot accPc + \beta_{commTpt} \cdot commTpt \cdot noAccPc + \beta_{popDens} \cdot popDens + \beta_{landPr} \cdot landPr + \beta_{ptAcc} \cdot ptAcc + \beta_{emApp} \cdot emApp + \beta_{taxRate} \cdot taxRate.$$

Model 2:

$V_2 = \beta_{commTc} \cdot commTc \cdot accPc + \beta_{commTpt} \cdot commTpt \cdot noAccPc + \beta_{distAlt} \cdot distAlt + \beta_{popDens} \cdot popDens + \beta_{landPr} \cdot landPr + \beta_{ptAcc} \cdot ptAcc + \beta_{emApp} \cdot emApp + \beta_{taxRate} \cdot taxRate.$

Model 3:

$V_3 = \beta_{commTc} \cdot commTc \cdot accPc + \beta_{commTpt} \cdot commTpt \cdot noAccPc + \beta_{distAlt} \cdot distAlt + \beta_{popDens} \cdot popDens + \beta_{landPr} \cdot landPr + \beta_{ptAcc} \cdot ptAcc + \beta_{emApp} \cdot emApp + \beta_{taxRate} \cdot taxRate + \beta_{popDens,accPc}\ popDens \cdot accPc + \beta_{commTc,distAlt}\ commTc \cdot distAlt + \beta_{commTpt,distAlt}\ commTpt \cdot distAlt + \beta_{popDens,age}\ popDens \cdot age + \beta_{landPr,inc}\ landPr \cdot inc + \beta_{accPc,popDens}\ accPc \cdot popDens.$

4. Results

The results of the model estimations are shown in Table 2. The effects of commuting time and distance to social network members (*distAlt*) are significant and negative in all models. When comparing model 2 and 1, it can be observed that including *distAlt* significantly increases the explanatory power of the model and the effect of commuting time decreases. This could be due to an overestimation of the effect of commuting time in model 1, which could be the result of an omitted variable bias. The number of empty apartments has a significant and positive effect on the choice probability. Including the interaction terms in model 3 further increases the explanatory power. The interactions between population density, access to a private car and age are highly significant and negative. The interaction between car commuting time and *distAlt* is significant at the 10% level. The effects of the municipal tax rate and public transport accessibility are small and not significant.

Table 2: Estimation of conditional/multinomial logit models

	Model 1 Coef./(SE)	Model 2 Coef./(SE)	Model 3 Coef./(SE)
commTc * accPc	-4.436*** (0.353)	-4.086*** (0.365)	-3.955*** (0.508)
commTpt * noAccPc	-3.788*** (0.319)	-3.515*** (0.329)	-3.598*** (0.682)
distAlt	-	-0.290*** (0.034)	-0.286*** (0.035)
popDens	0.000 (0.010)	-0.006 (0.011)	0.102*** (0.022)
landPr	-0.375 (0.318)	-0.457 (0.325)	-1.194** (0.506)
ptAcc	-0.002 (0.002)	-0.001 (0.002)	0.000 (0.002)
emApp	0.005*** (0.001)	0.005*** (0.001)	0.005*** (0.001)
taxRate	0.005 (0.007)	0.006 (0.007)	0.005 (0.007)
popDens * accPc	-	-	-0.041*** (0.013)
commTc * distAlt	-	-	-0.008* (0.004)
commTpt * distAlt	-	-	0.007 (0.007)
popDens * age	-	-	-0.002*** (0.000)
landPr * inc	-	-	0.000* (0.000)
# estimated parameters	7	8	13
Choice observations	338	338	338
Log-Likelihood (null)	-1732	-1732	-1732
Log-Likelihood (model)	-1411	-1365	-1345
Mc Fadden Pseudo R2	0.19	0.21	0.22
LR test (null model)	p < 2.2e-16***	p < 2.2e-16***	p < 2.2e-16***
LR test (previous model)	-	p < 2.2e-16***	p = 8.413e-08***

*p < 0.1; **p < 0.05; ***p < 0.001; *Reference Category: BFS number 1: Aeugst am Albis*

To compare the magnitudes of *distAlt* and commuting time by car (*commTc*), the coefficient on *distAlt* can be divided by the coefficient on *commTc* to obtain the marginal rate of substitution. The coefficient is calculated at the median commuting time of 0.59 h and we obtain:

$\frac{\beta_{distAlt}+\beta_{distAlt \times \text{commTc}} * \overline{\text{commTc}}}{\beta_{\text{commTc}}} = \frac{-0.286\left[\frac{1}{\log(m)}\right] - 0.008\left[\frac{1}{\log(m)*h}\right]*0.59\, h}{-3.955\, \left[\frac{1}{h}\right]} = 0.074\left[\frac{h}{\log(m)}\right]$. This implies that, for example, the effect of the median *altDist* of 65.6 log(m) is equal to the effect of a commuting time of $0.074\left[\frac{h}{\log(m)}\right] * 65.6\, [\log(m)] = 4.85\, [h]$.

5. Discussion

The estimation of the residential location choice models shows that distance to social network members is an important factor. In our models, omitting distance to social network members leads to an overestimation of the effects of commuting time. In addition, there is a significant (but small) interaction between commuting by car and distance to social network members, which implies that commuting by car is perceived more negative for higher distances to social network members. This could be due to the limited time budget for activities in individuals' days. However, the interaction for commuting time by public transport is not significant.

Regarding the marginal substitution rate of commuting time with distance to social network members, a value of 4.85 h at the median distance was obtained. This value is of course unrealistic in terms commuting time, but it shows that distance to social network members is, in the estimated models, much more important. However, it might also indicate the limitations of the chosen model specifications. It is likely that when individuals choose their home location, they only consider options that do not exceed a certain maximum accepted commuting time. In addition, the mean travel time by car between all municipalities of the canton of Zürich is approximately 40 min with a standard deviation of 16 min. This could, for most individuals, be below the threshold where commuting time becomes an important factor for residential location choice.

The analysis exhibits a number of limitations: other household members most likely have a significant influence on household location choice that should be taken into account if the data is available. Furthermore, in this analysis, it is assumed that the workplace location is fixed. However, it is more likely that individuals make a combined choice of home and work location, which is hierarchical when they first arrive in an area (Lee and Waddell, 2010). Depending on the individual, the choice of the home or the work location might be made first and the other location is then chosen depending on the first choice. In addition, previous research has shown that distance to social network members is correlated with distance to the previous residential location (Schirmer *et al.*, 2014). However, in this analysis, we cannot separate the two effects. The strong effect of distance to social contacts we observed is potentially only partly a result of the contacts themselves and the resources they provide to the subjects in terms of access to individual social capital. Thus, future research could also consider place attachment and the propensity to choose residential locations that are close to the previous residential location. In addition, a future analysis of this data will also take into account the time subjects' have known their contacts to determine whether subjects knew their contacts before they moved to a certain municipality.

6. Conclusion

We estimated residential location choice models that take into account distance to individuals' social network members. We observe that proximity to social network members is an important factor in residential location choice and omitting the variable might lead to an overestimation of the effect of commuting time. Only a very limited number of previous studies have taken proximity to subjects' social contacts into account. This might be due to the fact that data on social network members (including their home location) is usually not collected and is not part of standard regional or national statistics. However, such data is important for a better understanding of residential location choice on the individual level and has potential implications for urban planning and development. For instance, social network effects might be important for the success of housing developments that are intended for a specific social group. If social network effects play a decisive role, individuals of these groups might not be willing to relocate (Stokenberga, 2017). In addition, there could also be implications for policies that seek to reduce commuting by providing housing closer to employment centres. The success of such policies could be overestimated if social network effects are ignored.

To overcome the limitations of this analysis, future research and data collection efforts should take into account all household members. In addition, data on the previous home location should be collected and included in the analysis to separate the effect of the previous home location and proximity to social network members. In addition, future studies should also include measures of place attachment. The unit of analysis could be changed from municipalities to individual buildings to be able to consider detailed characteristics of the house or apartment. Furthermore, in this analysis, we used a relatively simple model specification to demonstrate the effect of proximity of social network members. Future studies could make use of more refined hierarchical model specifications to also account for individuals who have not moved. In addition, data on the workplace and individuals' qualifications could be collected with the goal of estimating a combined home and work location choice model.

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