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***doc. Ing. arch. Jakub Vorel, Ph.D.,** Faculty of Architecture, CTU Prague, CZ*

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What Makes Public Transport a Public Space?

Louise Sträuli[a,*]

[a] Tallinn University, Tartu Mantee 25 10120 Tallinn, Estonia
∗ corresponding author: louise.strauli@tlu.ee

This research examines public transport as an overlooked public space and the potential of such an approach to urban social justice. In three mainly qualitative case studies conducted in Tallinn and Brussels, I explore different experiences and practices of everyday mobility and how they contrast with the provision and planning of public transport as a liberal public space. I outline effects of the COVID-19 pandemic on atmospheres and experiences of transport dependency, and practices of care and fare evasion that result from mobility constraints encountered on the social, physical or financial level.

Keywords: public transport, public space, daily mobilities, care mobilities, fare evasion

1. Introduction

Similar to walking down a city street or sitting in a public park, when travelling on buses, trams or metros, passengers share enclosed spaces with a variety of users, experience conflictual or convivial encounters, and interact with the materialities of the built environment (Wilson, 2011). The daily journeys and the environments they move through affect the passengers and, conversely, the passengers shape and create the spaces they move in and through (Bissell, 2018). Through these often-neglected experiential and lived aspects of public transport, I trace definitions of public space. Although the literature on public space in urban theory and sociology is diverse, when discussing public space in contemporary European cities we usually think of streets, squares or parks. It is only in recent scholarship in the social sciences and humanities that public transport has been analysed and recognised as a public space (Kemmer, et al., 2022; Rink, 2022).

Thus, this study examines the interpretation of public transport as a public space. To understand transport related social-inequalities, I contrast the provision and planning of public transport with the daily experiences of its users. To conduct my analysis, I investigate the daily mobility habits of passengers in Tallinn (Estonia) and Brussels (Belgium). Specifically, I focus on individuals' encounters with various strangers and their surroundings, as well as how they navigate transportation spaces and restrictive infrastructures, and adapt their mobility practices to appropriate urban space(s). I argue that through observing everyday practices and experiences on a bodily level, we can identify features of public transportation that categorise it as a relational and processual public space that is shaped by reconciliations of disparities, the creation and sharing of knowledge, and the prevailing social or formal rules of conduct.

I position this research at the intersection of social justice research, public space literature, and the New Mobilities Paradigm. The latter emerged from a critique of prior transport studies for their quantitative and a-mobile approach and transport planning and engineering for their technocratic focus (Sheller & Urry, 2006). Seeking broader empirical and interdisciplinary

approaches to studying interconnected (im)mobilities across scales, scholars have delineated three dimensions of mobility: mobility as an empirical matter or pure movement, mobility as representation, and mobility as a constituent of existence that encompasses mobility practices, experiences, or lived instances (Cresswell, 2006).

2. Materials and Methods

This study draws on insights from three primarily qualitative case studies. A first mixed-method study was conducted after the outbreak of the COVID-19 pandemic in collaboration with colleagues from the PUTSPACE project ('Public Transport as Public Space in European Cities'). We conducted an online survey (n=2164) and 49 semi-structured interviews with passengers in various European cities with the aim to analyse personal mobility experiences, public transport atmospheres, and disparities in usage or avoidance, before and after the pandemic. Secondly, I conducted ethnographic observation studies in Brussels' metro stations and online communities, along with 27 interviews with passengers who frequently travel without buying or validating tickets, to analyse their experiences of mobility constraints and fare evasion practices. Thirdly, I recruited 22 passengers with various care responsibilities for an iterative travel-diary and interview study. In this research, I focused on the experiences of diverse mobility constraints according to a time-geography approach and the impact of fares and infrastructures on passengers' mobility practices.

3. Results

Based on the research findings, I conclude that public transport is not only a liberal or communal public space where planning norms and individual experiences collide. In contrast to previous literature that idealise public space as open and accessible to all or as a space for conviviality and civic encounters (Neal, 2010), I propose additional dimensions of publicness to include visibility, codes of conduct, deviance and resistance. Accordingly, publicness appears not as a fixed or inherent characteristic of a static space, but rather as a process influenced by multiple publics, agencies and individual biographies. Consequently, public transport is a dynamic public space shaped by practices of negotiating difference, experiencing deviance and appropriating space. Hence, I deem public transport a valuable yet under-researched topic for analysis. In exploring public transport, it is evident that encounters with deviance and mobility constraints experienced by marginalised and, at times, criminalised transport users reveal exclusionary governance. Moreover, these occurrences offer an understanding of how city residents perceive accessibility to public spaces and facilities in light of socio-economic growth strategies, urban sprawl, land use and transport policies.

Acknowledgements

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Investigating Soundscape Preferences, Evaluation, and their Role in Advancing Urban Mobility

Pedram Pourghasem Omandania[a,*]

[a] Czech Technical University in Prague, Jugoslávských partyzánů 1580/3, 160 00 Prague 6 Dejvice, Czech Republic
∗ corresponding author: pedram.pourghasem@gmail.com

Abstract:

Urban mobility is a pivotal concern in contemporary urban design, with a growing focus on the sensory aspects of the urban experience. This research explores the influence of soundscape perception, evaluation, and sound masking on the quality of urban environments. Through a multidisciplinary approach encompassing urban sound categorization, virtual reality simulations, and participant feedback, the study addresses critical questions regarding contextual variability, subjective experiences, and challenges in integrating sound masking techniques into urban mobility. The outcomes of this research include strategies to enhance acoustic comfort and privacy in urban mobility, optimal sound masking strategies, and quantifiable assessments of sound masking benefits. By integrating soundscape preferences into urban mobility discourse, this research contributes to a more inclusive and appealing urban living environment.

Keywords: Soundscape preferences, Sound masking, Acoustic comfort, Virtual reality simulations, Urban sound categorization.

1. Introduction

The intersection of urban mobility and sensory experience is a critical consideration in contemporary urban design and architecture [1]. This research delves into the realms of soundscape perception, evaluation, and sound masking, exploring their profound influence on the quality of urban environments [2]. By incorporating these auditory elements into the discourse of urban mobility, My research aims to contribute to a more holistic approach that enhances the overall well-being and livability of cities [3]. In the intricate dance of urbanisation and human progress, cities have emerged as the epicentres of modern civilization. As these sprawling metropolises continue to evolve, the very essence of urban life undergoes profound transformations. The contemporary urban experience is an amalgamation of sights, sounds, and sensations, shaping our daily routines and impacting our well-being in ways often overlooked but undeniably significant [4]. Within this evolving urban landscape, the concept of urban mobility, with its focus on the movement of people and goods within cities, has become a central concern in urban design and architecture [5]. This research embarks on a journey to investigate the nexus of urban mobility and the sensory dimension of our cities, with a particular emphasis on soundscape preferences, evaluation, and their pivotal role in advancing urban mobility.

The phenomenon of urban mobility is emblematic of our era, where an increasing number of people are drawn to cities, seeking opportunities and a vibrant urban lifestyle. It encompasses the ways in which individuals navigate these complex urban ecosystems, from daily commutes to leisurely strolls, and it is intricately linked to the quality of life and well-being of urban dwellers [6]. As urbanisation

accelerates globally, the challenges associated with urban mobility have grown more pressing. Traffic congestion, environmental concerns, and the need for efficient and sustainable transportation systems have spurred innovative approaches to reimagining urban mobility. Amid these transformations, it is imperative that we do not overlook the sensory experiences that accompany urban mobility, as they play a significant role in shaping our urban lives [5]. Urban mobility is not merely a matter of moving from point A to point B; it is an experience deeply intertwined with the sensory fabric of the city [5]. Every journey through the urban landscape is accompanied by a symphony of sounds, some soothing, some jarring, and some that go unnoticed but leave an indelible mark on our subconscious [1]. These urban soundscapes are dynamic and ever-changing, reflecting the pulsating rhythm of city life. The sounds of footsteps on bustling sidewalks, the hum of traffic, the echoes of conversations in public spaces all contribute to the sonic tapestry of the city. Our individual perceptions and preferences regarding these urban soundscapes influence our sense of place, our comfort, and even our mental and physical health [7].

As we delve deeper into this intricate relationship between urban mobility and soundscape preferences, we are guided by a set of fundamental research questions:

1. Contextual Variability and Sound Masking: How does the contextual variability in different urban environments affect the effectiveness of sound masking techniques within the context of urban mobility?

2. Subjective Experiences and Preferences: How can researchers capture and analyse the subjective experiences and individual preferences related to sound masking effectiveness in the context of urban mobility?

3. Challenges and Solutions: What are the challenges involved in integrating sound masking techniques into urban mobility solutions, and how can these challenges be overcome?

2. Materials and methods

My research employs a multidisciplinary methodology that encompasses urban sound categorization, virtual reality (VR) simulations, and participant feedback.The research commences with an essential step systematic urban sound categorization. This involves the meticulous classification of urban sounds based on specific criteria. Among the criteria considered are the intensity levels of sounds and their proximity to their sources. This categorization is critical as it lays the foundation for understanding the complex auditory landscape of the city. By categorising sounds, the research aims to create a comprehensive database that will be used in subsequent stages of the investigation.
Urban sound categorization is pivotal in discerning the various components that constitute the urban soundscape. It allows researchers to identify distinct sound profiles associated with different urban environments, from bustling city centres to quieter residential neighbourhoods.
This, in turn, provides valuable insights into how the soundscape varies across urban contexts and influences the effectiveness of sound masking techniques in enhancing acoustic comfort during urban mobility. A VR simulation, set in the dynamic urban centre of Prague, offers various scenarios, each incorporating soundscapes that simulate sound masking techniques and urban design variations relevant to urban mobility. Participants' experiences and perceptions are captured through evaluations, surveys, and interviews.

Expected Outcomes:

1. Enhanced Acoustic Comfort and Privacy in Urban Mobility: My findings provide valuable strategies for improving acoustic comfort and privacy in urban mobility solutions by integrating sound masking techniques.
2. Optimal Sound Masking Strategies for Urban Mobility: I identify sound masking strategies that are best suited for different urban mobility contexts, taking into account factors such as noise sources, transport modes, and cultural preferences.
3. Quantifiable Assessment of Sound Masking Benefits: I establish evaluation frameworks to assess the impact of sound masking on individuals' experiences, well-being, and performance in urban mobility scenarios.

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Can Theory of Planned Behavior predict the effect of built environment on walking behavior?

Anindita Mandal[a,*], Charlotta Johansson[a,], David Lindelöw[b]

[a] Luleå University of Technology, Department of Civil, Environmental and Natural Resources Engineering, Laboratorievägen 14, Luleå, SE-971 87, Sweden
[c] WSP, Fabrikstorget 1, SE-412 50 Göteborg, Sweden
∗ corresponding author: anindita.mandal@ltu.se

Walking is not only the most basic and sustainable means of transport [1, 2], but it is also recognized for its physical and mental health [3–7] and economic benefits [8, 9]. Based on the outcome variable of the study, walking/pedestrian studies can be put into two main groups: walkability and walking behavior, since they are rarely studied together. Walkability (measured usually at the neighborhood level) can be broadly defined as "the extent to which the built environment is pedestrian friendly and enables walking" [10]. Walkability studies focus on the built environment (specifically the infrastructure and amenities from a pedestrian point of view), whereas walking behavior studies focus on the people walking (i.e., the walkers or pedestrians) or the act of walking. In this study, we focus on walking behavior (and its multiple dimensions and measures).

Theory of planned behavior (TPB) is a social cognition model that proposes that human behavior is guided by three kinds of considerations: behavioral, normative, and control beliefs. That is, the decision to perform or not perform a behavior is based on one's attitude, subjective norm, and perceived behavioral control. While TPB is being increasingly applied to travel behavior studies, the studies focus mainly on motorized means of transport. Pedestrian studies from the behavioral point of view, especially those based on TPB are not only a few but also measure walking and the built environment subjectively, have very generic measures of TPB constructs that do not account for built environment and measure perceived neighborhood built environment (instead of the built environment along the route). Pedestrian studies from the urban planning point of view, on the other hand, focus on the relationship between built environment and walking. Though objectively measured, they often do not consider the individual or psychological aspects, due to which they have been criticized for physical determinism [11].

The aim of this study is to develop a detailed understanding of the psychological and environmental factors that affect individuals walking and the interaction between them. Further two main research questions were developed:

- How does the objectively measured built environment along the walking route affect walking behavior?
- How do psychological and environmental factors interact to affect walking behavior?

Data was collected in the autumn of 2021 in Umeå, Sweden using a smart-phone app in the form of GPS-based travel data (i.e. distance, time, location, activity) and survey questions (i.e., demographic data, perceived built environment and psychological constructs of TPB). 84 individuals provided 3949 trip data, of which 30% were walking trips. Objective built environment data was collected from various national and municipal databases.

Firstly, we developed a conceptual framework to analyze the interaction between walking, built environment (objective and perceived), and TPB constructs (Figure 1), based on existing literature from urban planning and travel behavior fields. While McCormack et al. [12] argue that "much of the research to date has focused mainly on what associations exist, rather than examining how and under which circumstances the built and social environments determine physical activity" it is also true of walking. Our conceptual framework helps us explore the "what" along with the "how and under which circumstances" questions related to walking behavior.

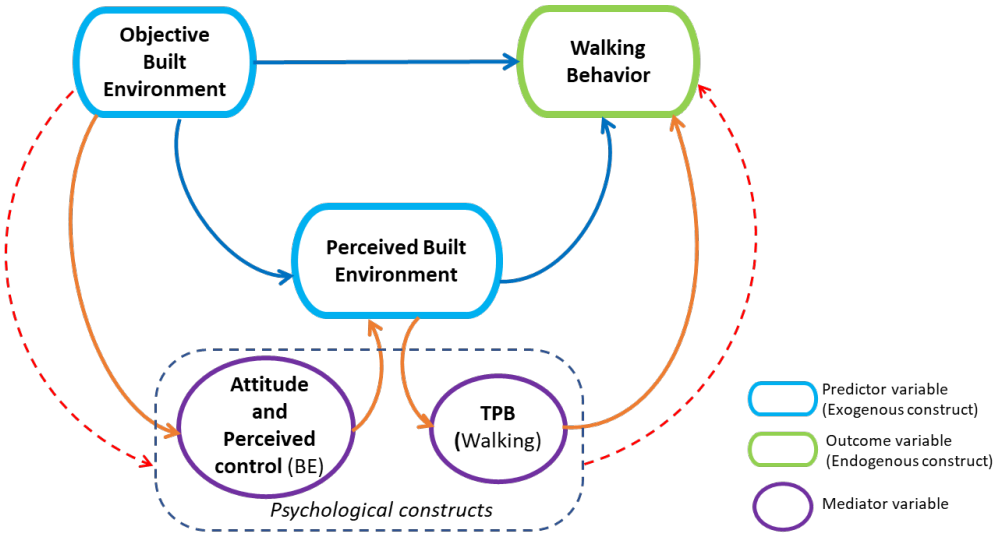

Figure 1: Conceptual framework

In addition to objectively measuring both walking and built environment, we measured attitude towards and perceived control over both the behavior (i.e., walking) and the built environment. While belief-related questions pertaining to built environment have been asked in some cycling studies, they have not been systematic or consistent [13, 14]. Therefore, we developed a TPB questionnaire that distinctly measures both behavioral and environmental factors at the individual and trip levels, based on existing literature from both urban planning and travel behavior fields.

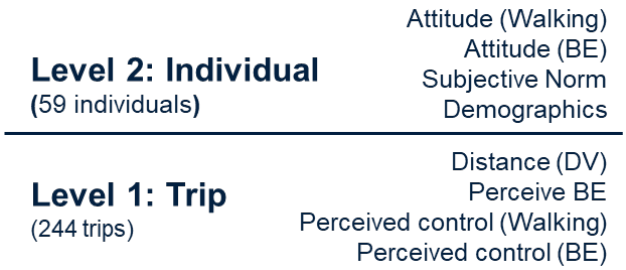

Figure 2: Hierarchical/multilevel data

Secondly, we apply this model to analyze walking behavior in Umeå, Sweden. Statistical and spatial analysis is carried out on data collected in the autumn of 2021. Multilevel analysis needs to be conducted as the data collected is in two levels: individual and trip level (Figure 2). Two-level random intercept regressions were conducted for each individual variable at level 2 and two-level random coefficient regressions were conducted for each individual

variable at level 1, with distance per trip being the dependent variable. With respect to attitude towards walking:

- How much people like walking compared to other modes of transport had significant negative correlation
- Reason people like to walk had significant positive correlation to “for economic reasons” only
- Barriers to walking had significant positive correlation to “physical environment”

With respect to attitude towards the built environment and subjective norm, no statistically significant correlations to distance were found. With respect to demographic characteristics, size of household and access to car have significant negative correlations whereas gender, Age, education, income, license, mobility level, activity level, and health condition produced no significant results. With respect to perceived built environment, “short and direct connection to destination” had significant negative correlation whereas “room for walking on the walking path” had a significant positive correlation to walking distance. With respect to perceived control over walking, the total control has a significant positive correlation to walking distance, but none of the individual variables had any significant correlations. With respect to perceived control over built environment, none of the variables had any significant correlations to walking distance.

Due to the complexities of the multilevel data, only the statistically significant results from the regression models would be included in the multilevel structural equation models to evaluate relationships between the constructs in the conceptual model.

Thus, this paper makes an important methodological contribution towards using TPB to analyze the correlation between objectively measured walking and built environment that would assist urban planners and designers to develop better pedestrian environments, while accounting for the individuals’ beliefs and perceptions of the built environment.

Keywords: theory of planned behavior, objective measure, walking, built environment

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Temporal Displacement and Spatial Unbinding of Commute in the Case of the Brno Metropolitan Area

David Gorný [a*]

[a] Masarykova univerzita, Přírodovědecká fakulta, Geografický ústav, Kotlářská 2, 602 000, Brno-střed

∗ corresponding author: gorny.david@mail.muni.cz

Keywords: Commuting, commuting changes, temporal displacement, spatial unbinding, spatio-temporal rhythms, Brno

Introduction

Commuting as an important element in individuals' daily lives has been undergoing gradual changes. In connection with the increasing importance of the tertiary sector in the economy and the flexibilization of working hours and work location, the redistribution of commuting flows in time and space is observed.

Research design and methods

The subject of this study is to analyse the current spatiotemporal characteristics of commuting. Based on a mixed-research design, this research works with primary data obtained by the researcher. The article is composed of two interconnected parts. The first contains an analysis of commuting based on a questionnaire survey and the second consists of specific stories of individuals that arose through semi-structured interviews. The survey was conducted electronically at the beginning of 2023 in the Brno metropolitan area (BMA). Questionnaires were collected from 1, 004 respondents (402 males and 602 females). The sample was stratified by gender, education, age and place of residence to have the most balanced ratio between individuals living in and outside Brno, in terms of age, and gender. The questions were focused on the spatiotemporal features of contemporary commuting. In addition to emphasizing temporal and spatial features, the questionnaire included a second type of question to ascertain circumstance and context. The questionnaire survey results served as the basis for the semi-structured interviews.

The main purpose of the semi-structured interviews was to provide in-depth information on the topic that the questionnaire survey would not allow. This information relates to specific commuting practices, including their justification. Gaining this information helped to understand the specific rhythms involved in commuting.

Results and conclusion

First, the data obtained indicate that commuting is staggered over time. The morning journey to work is spread over four hours, the afternoon journey from work appears intense over six one-hours intervals. In particular, the return commute home from work is becoming significantly deconcentrated. These results are being explained by the growing representation of individuals with the ability to address these journeys flexibly, according to their needs and preferences. If individuals have flexible working hours with a floating starting time, it is to some extent up to them what time they leave for work. It turns out that individuals have their

own set mode, but this mode is only partially under their control. Other fixed constants also enter into the commute that affect the individual's daily life, such as the start of school and the opening hours of various offices. However, the choices given to individuals by their type of employment are quite clearly expressed in the commuting data as well as in the stories of specific individuals. The specific routes of individuals often depend on day-to-day decisions. In the context of increasing flexibilization, individual journeys have become more complicated, that is, the journeys do not take the form of work–home / home–work but consist of several unique stops. This higher intensity of trip chaining is associated with the afternoon journey from work (in line with Thorhauge, Cherchi & Rich, 2016). Furthermore, the increasing possibility of leaving work at a time of one's own choosing contributes to the existence of a large number of trip variations that disperse the commute in time and space. Thus, one can agree with the statements of the authors Strambach and Kohl (2015) about the loosening patterns in individuals' daily lives. The most frequent stops include shopping, running necessary errands, entertainment and fitness and, of course, picking up/dropping off kids. All these activities are connected to the journeys to or from work, very individually with varying frequency. For this reason, all activities can be considered as part of work-related mobility.

Second, the phenomenon of the daily commute is clearly weakened. The data proves that commuting only on certain days of the week is not the exception. The three or four-days of commuting within a week is becoming more typical. However, the characteristic feature of job-related mobility is that the non-commuting days of the week vary, not only between individuals but even when comparing between weeks in the same individual. The weakening of the daily commute is a direct consequence of the home office's increasing role in the area's regional economy. Third, the spatial dimension of commuting is also changing. As the semi-structured interviews with the participants show, in addition to the home, cafés, means of transport, and other originally non-working places become conventional commuting centres. This trend also leads to the transformation of commuting flows in space. Last but not least, another aspect of the changes is the increase in new journeys not related to commuting but taking place during the commuting peaks. In this respect, the findings are consistent with Lachapelle, Tanguay and Neumark-Gaudet (2017); Wöhner (2022). This was found to be the effect of the previously mentioned duties and the persistence of habit. As commuting is a deeply embedded behaviour (Thorhauge, Swait and Cherchi, 2020), some individuals working in the home-office emulate it in some modified form.

The aim of this contribution was to show that there are processes that can be described as temporal displacement and spatial unbinding. These processes are not only related to the temporal and spatial characteristics of commuting but express plenty of qualitative changes in commuting patterns that become visible at the individual level.

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Time-Space Mobility within Prague‘s Suburbs

Jiří-Jakub Zévl [a *] , Martin Ouředníček [a]

[a] Charles University, Faculty of science, Albertov 6, 128 00, Praha 2, Czechia
∗ corresponding author: zevlj@natur.cuni.com

Keywords: suburbanization; mobile phone data; mobility ; Prague Metropolitan Area; time geography

1. Introduction

Urban areas around the world are experiencing dynamic changes in population distribution and commuting patterns. Understanding these shifts is essential for effective urban planning and development. This extended abstract presents an analysis of commuting to work and services in the suburban zone of Prague, focusing on the utilization of mobile phone location data to identify commuting flows, temporal variations, and mobility relations. Through the creation of synthetic maps, this study aims to provide insights into the evolving urbanization processes in the Prague Metropolitan Area, particularly highlighting the impact of tangential commuting.

2. Methodology:

To investigate commuting patterns in the suburban zone of Prague, we utilized mobile phone location data. This rich source of information allowed us to identify and analyze commuting flows throughout the day, with a particular emphasis on two distinct timeframes representing varying proportions of commuting purposes. Additionally, we introduced a hierarchical classification of mobility relations to categorize and understand the nature of these flows.

3. Results:

The findings of this study yield several significant outcomes. Firstly, we delineate the local centers within the suburban zone of Prague and their associated commuting areas. This spatial analysis helps us identify the hubs of economic and social activity.

Secondly, our analysis reveals distinct patterns of human activities when comparing the two identified timeframes. This temporal dimension provides valuable insights into how urban areas function at different parts of the day, emphasizing the importance of adaptable urban planning strategies.

Our research highlights the ongoing deconcentration of functions within the Prague Metropolitan Area, which signifies a shift in the urbanization processes. The identified growth of autonomy in Prague's hinterland suggests that suburban areas are becoming more self-sufficient and less dependent on the city center. This phenomenon has broader implications for urban areas in Central and Eastern Europe (CEE), which are still undergoing phases of suburbanization.

This study makes a significant contribution to the theoretical understanding of the role of mobility in contemporary metropolitan areas. By examining commuting patterns and their temporal variations, we provide a nuanced perspective on the evolving dynamics of

urbanization. Our findings offer insights that can be applied to other CEE cities currently experiencing similar transformations.

4. Research highights

- A total of 53 focal points for peripheral commuting were detected within the Prague Metropolitan Area.
- The delineation of commuting zones exposes their fluctuating nature as the role of these focal points shifts throughout the day.
- The dispersion of employment opportunities and services has resulted in a degree of self-sufficiency in the surrounding regions.
- We introduced a hierarchical categorization of mobility connections.
- The sociogeographical regionalization approach was adapted to leverage mobile phone location data.

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Practices and Technologies of Social Distancing on Milan's Public Transport

Federico La Bruna [a] [*]

[a] Università degli Studi di Milano, Via Festa del Perdono, 7, 20122 Milano MI, Italy
[*] Corresponding author: federico.labruna@unimi.it

Keywords: Public Transport, Social Distancing, Urban Atmospheres, Rhythms, Practices

Abstract: Since the first months of 2020, the transport systems of most cities have had to face transformations of public spaces due to COVID-19. Despite social distancing practices have become a primary tool to face the pandemic, there is more than a doubt about what social distancing is. The unremitting flourishing of mainstream narratives that discuss social distancing, unknowingly referring to physical distancing, triggered the indignation of most sociologists. Indeed, many scholars distinguish between mere physical distancing and what Simmel defines as a more structural social separation among individuals or groups. However, this last theorisation did not consider any form of materialistic thinking, minimising the power of the body, the senses, and the emotions in the space of micro-interactions and offering a non-comprehensive overview of the phenomena.
This presentation is part of a broader ethnographic project that explores Milan and Amsterdam's urban public transport systems beyond the pandemic, suggesting a definition for social distancing driven by a phenomenological ontology and an interactionist approach. Social distancing can be intended as the normative outcome of a negotiation practice immersed in the affective atmosphere of the jurisdictional environment. Affective atmospheres may be interpreted as a way for individuals to subjectively perceive and collectively build their experiences in everyday life interaction rituals, leveraging the power of senses and emotions. Atmospheres are, ethnomethodologically speaking, the social air in the ecological context where norms and meanings are negotiated. Marc Augé, in "Un Ethnologue dans le métro", affirms: "It is a Parisian privilege to use the metro map as a synoptic table, a device for memories." This quotation encloses three main elements that constitute the public transport experience in a metropolitan city: privileges, devices (intended here as the objectification of dispositions), and memories. Privileges, dispositions, and memories are not separate compartments into which narratives and urban experiences flow but rather phenomenological elements that combine and recombine, shaping urban space's normativity, materialities, and narratives.
This presentation focuses only on one of the three phenomenological elements: dispositions. How do social distancing practices emerge from face-to-face interaction rituals? Investigating this issue through an ethnographic approach allows an in-depth view of the infra-ordinary experience (Perec, 1987), shedding light on the hidden practices of reproduction of social structure that involve the Simmelian stranger and make the invisible visible. The profound qualitative nature of this project enables the investigation of the diverse choreographies of distance and how they take shape between peculiarities and more abstract models. Distancing remains the project's focus as a metaphor and tautology for the relationships between actors and participants. Interactions, as manifested through normative, material, emotional, and discursive entanglements, create the situations and urban atmospheres that users individually perceive and collectively construct.

Rhythmic dispositions: practices and technologies

When boarding buses, trams, or subway trains, we enter a specific level of interaction: face-to-face interaction or, more precisely, the interaction within the carriage. Carriage interaction refers to a form of interaction that encompasses not only individuals paired up, as suggested by the term "face-to-face," or small groups, but all actors, actresses, and actants on public transportation within the intimacy of the carriage. In this case, social position (Bourdieu, 1977; 2018) assumes a material significance and becomes a collective resource. However, in this case, the focus moves from the structure of the relational forms to the practices and technologies adopted in carriage interaction, where power is embodied (Foucault, 2012) within the interaction dynamics. This presentation offers an overview of different rhythmic dispositions that emerged from the Milanese fieldwork on public transport, where general and specific practices and technologies of social distancing can be recognised.

We need to rethink public transport from a different perspective. Instead of defining it as a "special place in the city with unique characteristics," it can be rather seen as a complex urban form that, as suggested by Navarini and Colombo (1999) in "I Confini Dentro la Città" when referring to Milan's central station, encompasses places of transit and stationing, meeting and dwelling, as well as spaces for work and research. In essence, the practices associated with public transportation in Milan are, first and foremost, urban practices that must be contextualised within the various frames of meaning, which the actors themselves attribute to the travel experience through their interactions. These practices should, therefore, be analysed as crystallisations of specific urban processes that converge, overlap, blend, and separate in this context. Distance on public transportation extends beyond being merely a category for studying actors and their relationships; it allows us to define the metaphysics of public transportation, shaping the relationships between different urban narratives and experiences.

The core issue is that the urban public transportation system, as revealed by the study of the Milanese case, is deeply rooted in the urban experience to the extent that it transcends its mobility service purpose and assumes more multifaceted and complex characteristics. It is interesting to note how these service arrangement modalities (or dispositions), resulting from the generalisation of various distancing (and proximity) practices and the application of distancing (and proximity) technologies, translate into rhythmic arrangements. The rhythms of the metropolitan city and its inhabitants do not always coincide (Lefebvre, 2013), and social distance can, therefore, appear in the form of temporal distance. Passing, staying (Colombo & Navarini, 1999; Bissell, 2007), returning, and living are the main dispositions that emerged: they have different rhythms and temporalities that characterise the practices from which they are abstracted.

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Is the mixed use city of short distances equally shorter for everybody? Evidence from the universe of Czech commuters

Lukas Makovsky[a,*]

[a] University of Reading, Henley Business School, Department of Real Estate and Planning, Whiteknights Campus, Reading, RG6 6UD, United Kingdom
∗ corresponding author: l.makovsky@henley.reading.ac.uk

Keywords: Urban mix use, Commuting, Skilled workers

1. Introduction

The aim of this paper is to revisit underlying assumptions and feasibility of the new-urbanism concept of mixed use city in recent European context. The analysis focuses in particular on jobs' accessibility and mobility implications of functionally mixed neighbourhoods when compared to purely residential ones. Key argument developed in the paper is that mixed neighbourhoods shorten commutes to jobs, but predominantly for workers in low skilled occupations.

Implications of various characteristics of built up form have been studied, mostly on very local level. For a review see Ewing and Cervero (2010)[1]. Lee and Lee (2020)[2] have for instance shown on evidence from the US that mixed use on average leads to less vehicle miles travelled (VMT) and least educated workers drive less on average.

It is important to note separation of workplaces and residences in cities is not a result of modernists' planning. In theory, Lucas and Rossi-Hansberg (2002)[3] developed a model where urban structure and functional zoning arises endogenously. Regarding empirical evidence, Heblich, Redding and Sturm (2020)[4] show that introduction of passenger railway in London lead to massive specialization of the city centre as a place of work and surrounding districts as bedroom communities. Barr (2016)[5] shows historical evidence of similar specialization in the Manhattan's tip and residential midtown at the turn of the 20th century.

There is substantial body of literature arguing the reason for spatial concentration of jobs in space is due to existence of agglomeration economies described already by Marshall at the end of the 19th century (for theoretical background see review by Duranton and Puga (2004)[6] and for empirical evidence Combes and Gobillon (2015)[7]). There is also some evidence of these agglomeration economies to rise with workers' skills (Ahlfeldt et al. 2021[8]) and this seems to hold also in case of the Czech Republic (Makovsky, 2023[9]). Another observation is these agglomeration economies dissipate quickly across space (Arzaghi and Henderson, 2008[10], Rosenthal and Strange, 2003[11]). One corollary is the higher skills workers on average have, the more likely their jobs cluster in cities to exploit agglomeration economies of scale. Therefore, if workers choose their residence independently of their job location, high skilled and more specialised are much less likely to find a good matching job opportunity close to their residence than low skilled.

2. Body

The aim of the paper could be illustrated with two case studies serving as anecdotal evidence. Distance and commuting time to two large Prague employment centres, Czech Technical University Dejvice campus and BB centre, is measured for three groups of workers – those without high school diploma (maturita in Czech), with high school diploma and with university education. Theory implies

individuals with higher achieved education who are more specialised are more likely to commute for longer distances unlike low skilled workers who are mutually more substitutable and as a result have wider range of acceptable jobs which are likely located closer to their residence. Evidence presented in Table 1 broadly confirms the theory. Both medium and high educated workers working in both CTU campus and BB centre on average commute longer and over longer distance when compared to low educated, although the results are not in all cases statistically significant on conventional levels (In general, this is likely partly driven by large share of unexplained variation in the data. Adding control variables improves precision of estimated models. Specification in logs also outperforms specifications in levels. Despite these shortcomings, the simplest models in levels are presented due to their intuitive interpretation).

	(CTU, mins)	(CTU, km)	(BB, mins)	(BB, km)
(Intercept)	33.853***	10.533**	34.318***	12.554***
	(2.446)	(3.344)	(1.801)	(2.901)
edu2_med	**2.632**	**1.408**	**5.424****	**8.185****
	(2.795)	(3.826)	(1.941)	(3.127)
edu3_high	**5.141***	**4.310**	**2.448**	**5.782·**
	(2.539)	(3.473)	(1.888)	(3.042)
R2	0.006	0.003	0.007	0.004
Adj. R2	0.004	0.001	0.006	0.003
Num. obs.	947	951	2153	2156
***p < 0.001; **p < 0.01; *p < 0.05; ·p < 0.1 Individual observations are commute flows weighted by number of commuting workers. Unadjusted standard errors in parentheses.				

Table 1. Commuting time and distance to CTU and BB Centre.

2.1. Methods

The key problem to be tackled in the statistical analysis of commuting behaviour contingent on urban functional use and workers' education is non-random pattern of spatial distribution of mix use and purely residential neighbourhoods. Whereas functionally mixed use neighbourhoods are located rather in city cores, solely residential ones are more likely at urban peripheries. Simply comparing commuting patterns of the two would lead to bias as more centrally located mixed use neighbourhoods are located closer to employment centres and trips commencing there are mechanically shorter.

To address this omitted variable problem, method of matched controls is used. For each of total 22,654 elementary statistical units (ESU) is calculated share of jobs on jobs and working residents. ESUs with share below 0.3 (less than 0.4 job per 1 residing worker) are classified as residential neighbourhoods while ESUs with share between 0.4 and 0.6 (from 2/3 to 1.5 jobs per working resident) are classified as mixed use neighbourhoods. For each residential neighbourhood were selected all mixed use neighbourhoods which are located within 1.5 kilometres, measured by Euclidean distance between ESU centroids. Each resulting pair was assigned a unique pair code.

In the regression models, commuting distance and commuting time, as well as logs of these variables, are regressed on categorical variable whether commuters live in residential or mixed use neighbourhood interacted with commuters' education level. Unique pair codes are included as fixed effects. Individual observations are commute flows originating in residential and mixed use neighbourhoods resulting from the matching. Each observation is weighted by number of commuters. This approach is similar to spatial boundary discontinuity design (BDD) as if each pair of ESUs is hypothetically sharing a common boundary.

2.2. Data used

The analysis is based on individual-level 2011 Czech Census data covering the whole universe of the Czech population. The sample used consist of 1.98 million workers who filled-in location of their job and who commuted daily (approximately one third of workers did not reveal location of their job, or this location was not processed by the statistical office). Observations of individual workers by their education were initially aggregated to roughly 700,000 commute flows between places of residences and workplaces. These aggregated flows contain information about number of workers, their mean age, and their mean commuting time which is originally reported in 15 minutes bins.

Place of residence and place of work in the data is reported at the ESU level. Using spatial data provided by the Czech Cadastral Office, coordinates of ESUs were merged with the commute flows dataset.

2.3. Results

Following described matching procedure, 2,622 residential – mixed use neighbourhood pairs were defined. Measures of commuting distance were regressed on workers' education interacted with type of their residence: residential or mixed use.

Table 2 reports results of four considered models. Baseline category for neighbourhood type is 'residential' and for education the baseline is 'low education'. In terms of commuting distance reported in columns (1) and (3), low educated workers living in mixed use neighbourhoods commute on average 0.7 km less (1), or 50% (3), compared to those living in residential neighbourhoods. However, the effect is much lower for workers with medium and high education as the last two interaction coefficients show. There is curiously no heterogenous effect on commuting time. All workers living in mixed use neighbourhoods commute for 2 minutes (2), or 9% (4), less. This could be likely explained by using different modes of transport.

	(1) [km]	(2) [mins]	(3) [log(m+1)]	(4) [log(mins)]
type2mix	**-0.674*** **	**-1.954*** **	**-0.736*** **	**-0.095*** **
	(0.133)	(0.220)	(0.040)	(0.010)
edu2_med	1.101***	0.740***	0.574***	0.025*
	(0.098)	(0.199)	(0.028)	(0.010)
edu3_high	3.138***	2.809***	1.063***	0.099***
	(0.186)	(0.277)	(0.034)	(0.012)
type2mix:edu2_med	**0.382** **	**0.086**	**0.212*** **	**0.002**
	(0.143)	(0.260)	(0.042)	(0.013)
type2mix:edu3_high	**0.464**·	**-0.349**	**0.282*** **	**-0.015**
	(0.243)	(0.346)	(0.051)	(0.015)
Age and age squared controls	YES	YES	YES	YES
Num. obs.	434780	425861	434780	425861
Num. groups: as.factor(BND_KOD)	2662	2662	2662	2662
R2 (full model)	0.085	0.153	0.211	0.179
R2 (proj model)	0.070	0.079	0.184	0.090
Adj. R2 (full model)	0.080	0.147	0.206	0.174
Adj. R2 (proj model)	0.070	0.079	0.184	0.090
***p < 0.001; **p < 0.01; *p < 0.05; ·p < 0.1 Individual observations are commute flows weighted by number of commuting workers. Robust standard errors clustered at the ESU of residence in parentheses.				

Table 2. Commuting time and distance by typology of residence and education.

3. Summary

Although this research project is in its early stage and reported preliminary results have to be interpreted with caution, the results are promising and aligned with economic theory. Comparing commuting behaviour of workers living in either residential or mixed use neighbourhoods has shown that mixed use neighbourhoods shorten commutes by more than one half for low skilled compared to high skilled, arguably due to higher specialisation of high skilled workers.

This finding has an important implication for policy making. As cities are getting increasingly more educated, contemporary efforts to design more mixed used neighbourhoods might have much lower impact on mobility than initially anticipated.

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What are the Shortcomings of Public Facilities under the Concept of Life circle - An Empirical Research based on Walkability of Facilities in Neighbourhoods

Lu LIU[a,*]

[a] Tongji University, No.1239, Yangpu District, Shanghai, China
∗ corresponding author: liulu1205@tongji.edu.cn

Abstract:
Walkability is a crucial indicator for accessing the rationality of public facilities layout in the 15-minute life circle concept. This study conducted a quantitative analysis on the central area of Karamay city, evaluating the spatial coverage, spatial service level, and spatial match between supply and demand of various facilities in the 15-minute life circle. The findings reveal that medical and cultural facilities have higher walking accessibility than educational and elderly care facilities, and facilities in the 10/15-minute circles are more prevalent than those in the 5-minute circle. Additionally, facilities in urban center areas exhibit higher walking accessibility than the fringe belts areas, with old town zones surpassing new town zones and high-tech zones. Overall, the walking accessibility of facilities is average, while the spatial service level and spatial match between supply and demand are relatively low. In response to these results, recommendations for enhancing public service facilities include increasing their distribution in new town zones, high-tech zones, and old town fringe areas. Furthermore, prioritizing the needs of the elderly and children, controlling facility scales, improving facility quality, and emphasizing demand-oriented strategies should be implemented.

Keywords: 15-minute city, walkable city, accessibility, public facilities

1. Introduction

The concept of life circle was initially used to explore the interactive relationship between residents' behaviors and living spaces, which is mainly popular in Asian countries such as Japan, South Korea, and China (Xiao, et al., 2014). A functional neighbourhood environment should enable residents to easily access public services on foot. After Shanghai concretely translated this concept into "15-minute Life Circle" (Shanghai Municipal Planning and Land and Resources Administration, 2016), various cities have carried out "15-minute Life Circle" planning. These plans require organizing various types of public facilities in 5-15 minute walking ranges, to create a walking-friendly and age-friendly environment. This study takes the central area of Karamay city as an example to find out the shortcomings of neighbourhood environment in public facilities.

2. Materials and methods

2.1. Materials

1) POI data
The POI data of public facilities include kindergartens, primary schools, junior high schools, community health centers; elderly day care centers, neighbourhood committees,

administrative offices, cultural facilities, sports facilities and green spaces. The POI data for these facilities mainly comes from the Internet.

2) Urban road network data
The traffic network data is obtained from transportation departments, including main roads, side roads and walking path in residential areas.

3) Residential land use data
The residential land use data come from the "Third National Land Survey" data. In this study, the data are used to characterize population distribution.

2.2. Methods

There are many methods for assessing the walkability of public facilities. Researchers from different disciplines tend to use different analytical methods. Buffer analysis (Li Meng, 2017; Liu Quan et al., 2020; Wang Lan, 2021) and walk score (T. Litman, 2003; Y. J. Kim et al., 2015; S. Shiliang et al., 2017) are more popular in urban planning. Network analysis (Chen Lufeng et al., 2022; Wang Ai et al., 2023) and path planning method (Guo Chencheng et al., 2022; Zhang Chenlong et al., 2022) are more popular in human geography.

Gravity model (Song Zhengna et al., 2010; Tang Pengfei et al., 2017; Cheng Min et al., 2018) and 2SFCA methods (Tao Zhuolin, 2016; Zhan Dongsheng et al., 2020; Zhang Zhonghao et al., 2022) are widely used nowadays as taking supply capacity, demand scale, and distance decay effect of facilities into account, making the analysis results restore the actual travel costs of residents.

Based on a comparison of the applicable scenarios and calculation accuracy of these methods, this study selected the Network analysis method. This method takes facilities as starting points and calculates the proportion of residential land area that can be reached by walking within the corresponding time frame (Table 1). This method can examine the matching degree between facility distribution and residents' demand, which is beneficial for planning adjustments in facility location and land use layout. The disadvantage of this method is that it cannot reflect the difference in population size among different building densities, nor can it reflect the characteristics of residents' walking willingness as distance decays.

Tab1. Walking time and length in different levels

Service zone	Walking Time	Walking Length	Walking Speed
5-minute level	5 min	350m	70m/min
10-minute level	10 min	700m	70m/min
15-minute level	15 min	1050m	70m/min

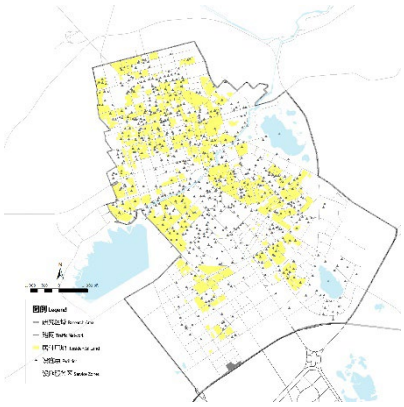
2.3. Technical Approach

This study is mainly carried out in the following steps: 1) Using network POI data and on-site research to acquire spatial locations of public facilities in the research area; 2) Constructing a GIS spatial information database by combining POI data, traffic network data and residential land use data; 3) Using network analysis to analyze the spatial location of facilities with ArchGIS 10.4; 4) Matching the service areas with residential land use and calculating the walkable coverage ratio and supply-demand spatial matching degree of facilities.

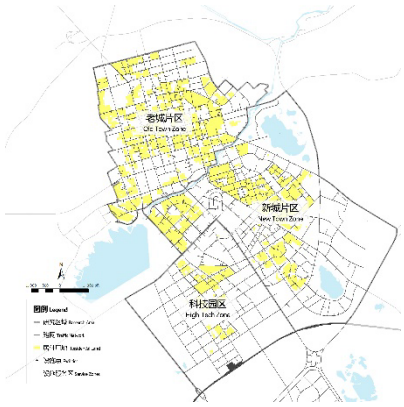
3. Results

3.1. The walkability of public facilities

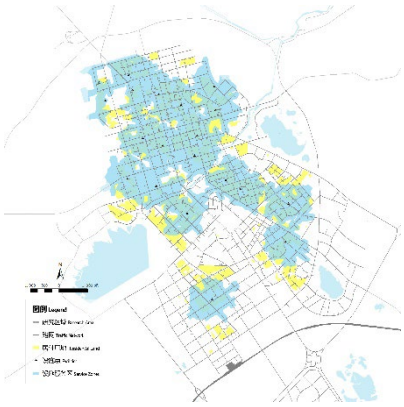
The walkability of public facilities varies with functions, levels and locations, mainly manifested in three aspects (Figure 1): medical and cultural facilities are better than educational and elderly care facilities, 15-minute facilities are better than 5-minute facilities, and old urban areas have better facilities than new urban areas.



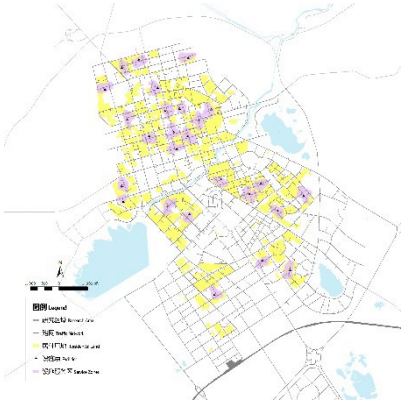
a.Research region



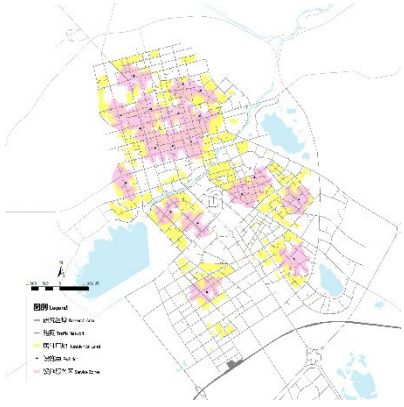
b. Three main areas



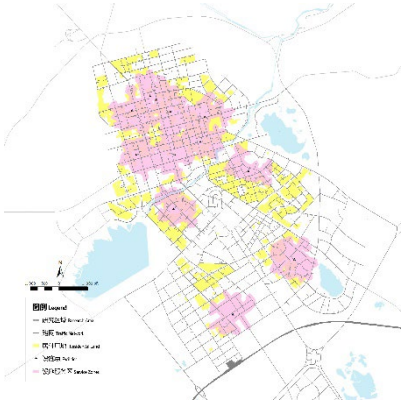
c.Medical facilities



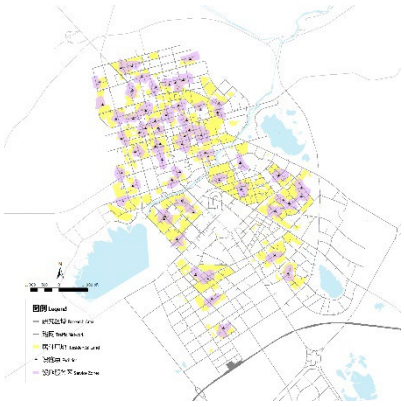
d.Kindergartens



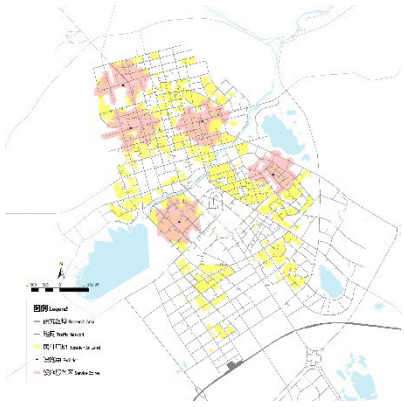
e.Primary schools



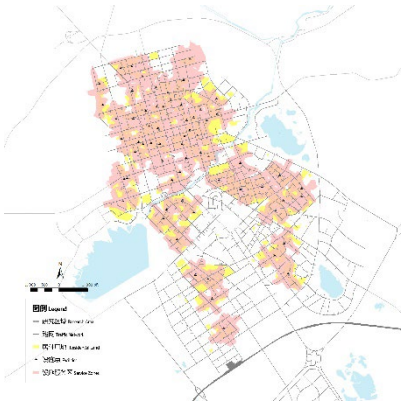
f.Middle schools



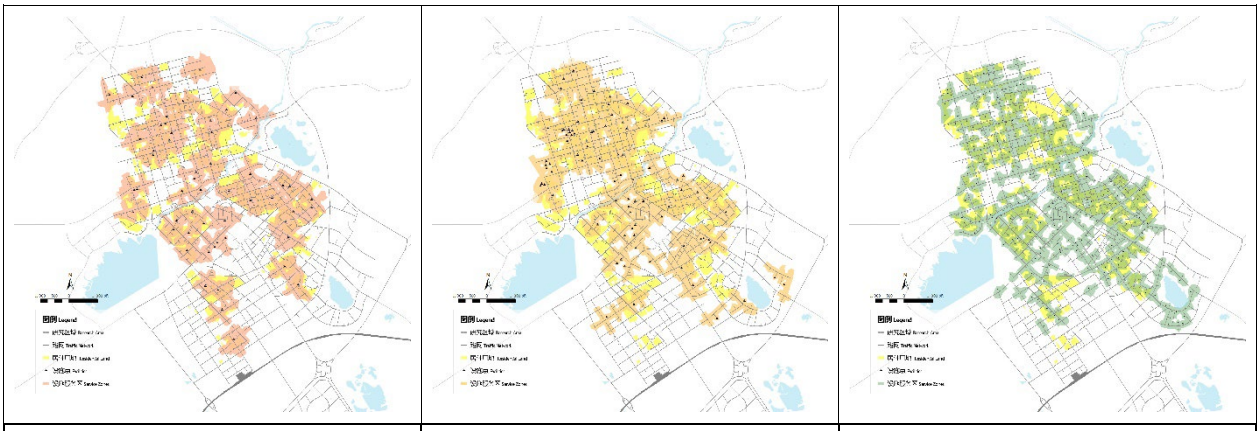
g.Daycare centers



h.Administrative offices



i.Community centers



j.Cultural facilities	k.Sports facilities	l.Green spaces

Figure 1.Walkable coverage of public facilities

3.2. The spatial mismatch of supply and demand

The mismatch of spatial supply and demand for facilities in the region is relatively high (Table 2). The mean values of the matching degrees between 5-15 minutes living circle facilities are 0.5, 0.4, and 0.3, which means that only about 50%, 40%, and 30% of service zones of facilities have spatial distributions that match with residential land use. Insufficient matching of spatial supply and demand led to lower actual utilization efficiency of facilities, resulting in a coexistence of waste of resources and inadequate coverage of facilities.

Table2. Evaluation results of various indicators for facilities

Type	Level	Walkable coverage ratio (%)				Spatial match of supply and demand			
		Avg.	Old Town	New Town	H-T Zone	Avg.	Old Town	New Town	H-T Zone
Medical facilities	**15 min**	68	78	63	36	0.3	0.3	0.4	0.2
Kindergarten	**5 min**	15	15	17	4	0.5	0.4	0.6	0.3
Primary School	**10 min**	35	42	28	20	0.4	0.4	0.4	0.4
Middle School	**15 min**	40	51	31	12	0.3	0.4	0.4	0.1
Daycare center	**5 min**	29	35	24	22	0.5	0.4	0.5	0.4
Administrative facilities	**15 min**	26	31	25	-	0.4	0.4	0.4	-
Community center	**10 min**	73	75	72	61	0.4	0.4	0.4	0.3
Cultural facilities	**10 min**	66	59	75	61	0.3	0.3	0.4	0.3
Sports facilities	**10 min**	53	62	48	23	0.3	0.4	0.2	0.1
Green space	**5 min**	63	60	77	25	0.3	0.3	0.3	0.1

4. Conclusions

The Study suggests that the main shortcomings of public facilities in the neighbourhood level are: education and elderly care facilities, 5-minute level facilities, and facilities in urban fringe areas and high-tech areas. In addition, there is a problem of low efficiency in allocation of facilities due to the spatial mismatch of supply and demand.

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Relation Between Accessibility of Local Amenities and Residential Transport Behaviour in Prague Suburbs

Jan Bittner[a*]

[a] Department of Spatial Planning, Faculty of Architecture, Czech Technical University in Prague, Thákurova 9, 166 34 Prague 6 – Dejvice, Czech Republic
∗ corresponding author: jan.bittner@cvut.cz

Keywords: Suburbs, Transport, Local Amenities, Urban Planning, Built Environment, Prague

1. Introduction

Researchers across the globe have been scrutinising the built environment and transport relations for the last two decades (1). Such works mostly focus on regional levels in the US or Western European regions (2), whereas in the Czech Republic, there is a significant lack of research in this particular field. Moreover, the Czech urban and transport planning discourse is still based on a traditional modernistic approach, failing to contain already well-defined and well-known challenges. In the context of Prague, one of the main challenges lies in the car dependency of suburban residents (3). Therefore, the starting point of the thesis was to examine ways of reducing transport volume and car dependency in the suburbs through means of spatial planning. Since Czech spatial planning mostly concerns the local municipal level through Municipal Land-use Plans, the location of civic amenities was chosen as a perfect representative. Thus, the thesis aims to verify the influence between the accessibility of local amenities and the travel behaviour of Prague suburban residents.

2. Contribution

The contribution presents intermediate working outcomes of the dissertation thesis. The work is based on quantitative analysis of transport diaries (containing activities, destinations, transport modes, and socio-economical attributes) combined with GIS data on the built environment, location of amenities and transport infrastructure (4).

The first part of the contribution defines the research questions and establishes a methodology framework to answer the questions.

Research question	**Hypothesis**	***Methodology***
Does the accessibility of local amenities influence residential transport patterns in the Prague Metropolitan Region?	Accessibility of local amenities **decreases** the total volume of residential transport.	*Regression model; a combination of GIS and questionnaire (+ mobile phone data)*
	Accessibility of local amenities **decreases** car share in the residential modal split.	

Table 1 – research questions

The framework is based on the Activity-Based Modelling (ABM) approach (5), focusing on individuals participating in activities spread across the space at a specific time. The method is

described and extended into a hierarchical diagram of partial factors. Individual parts of the diagram are categorised, and interrelationships are described.

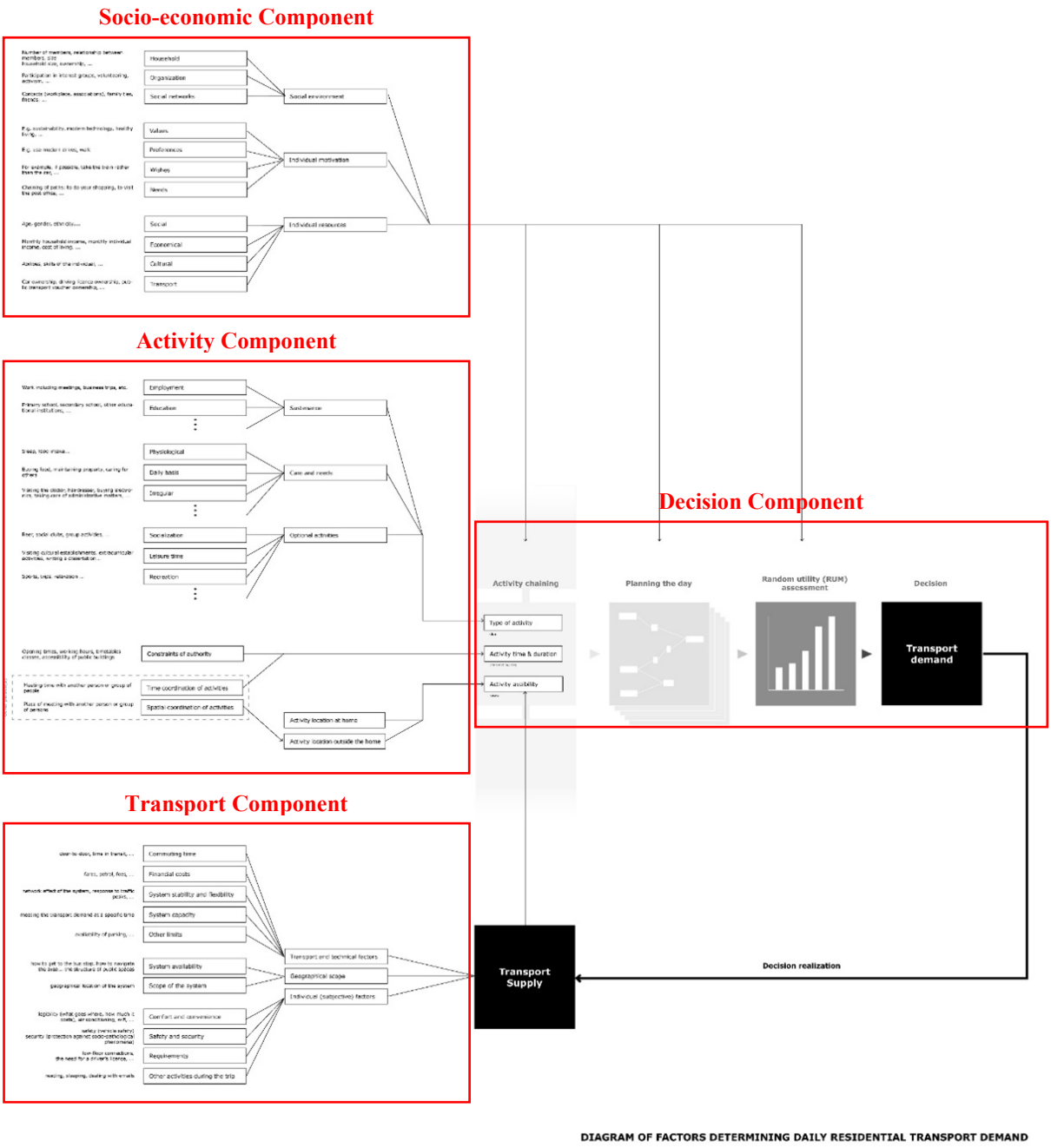

Figure 1 – a preview of the ABM diagram, based on (4)

The third part of the contribution presents the application of ABM framework to the second, central research question by regression modelling. Prague suburban residents' travel survey dataset (N = 453 respondents, 3339 trips) is described and visualised.

Figure 2 – a preview of the dataset (suburban zones grey according to (6))

Components of linear regression are defined and discussed.

Type	**Group**	**Variable**
Dependent	Total length of all journeys per day by all means of transport	
	Total length of all journeys per day by car	
Independent	Walking time to the nearest kindergarten Walking time to the nearest primary school Walking time to the nearest medical centre cat. I Walking time to the nearest kindergarten Walking time to the nearest cultural/community centre Walking time to the nearest post office Walking time to the nearest park or open landscape	
Independent – control	Household	House size Household income Persons in household Children in household
	Demographics	Sex Age Education
	Economic	Job
	Transport behaviour	Driving licence Car use PT use Cars owned
	Built environment: Density	Residential density in the respondent's residential area
	Built environment: Diversity	Land-use mix in the respondent's residential area Job-housing balance in the respondent's residential area
	Built environment: Design	Size of urban blocks in the respondent's residential area Street conectivity in the respondent's residential area Street redundancy in the respondent's residential area

Table 2 – regression components

Attention is paid to interdependencies between independent–control variables, especially heavily correlated socio-economic and transport behaviour, causing a high volume of distortion in preliminary results. The relationship between independent variables (red cells in the dataset structure in figure 3) is investigated through Component Analysis (CA) (7).

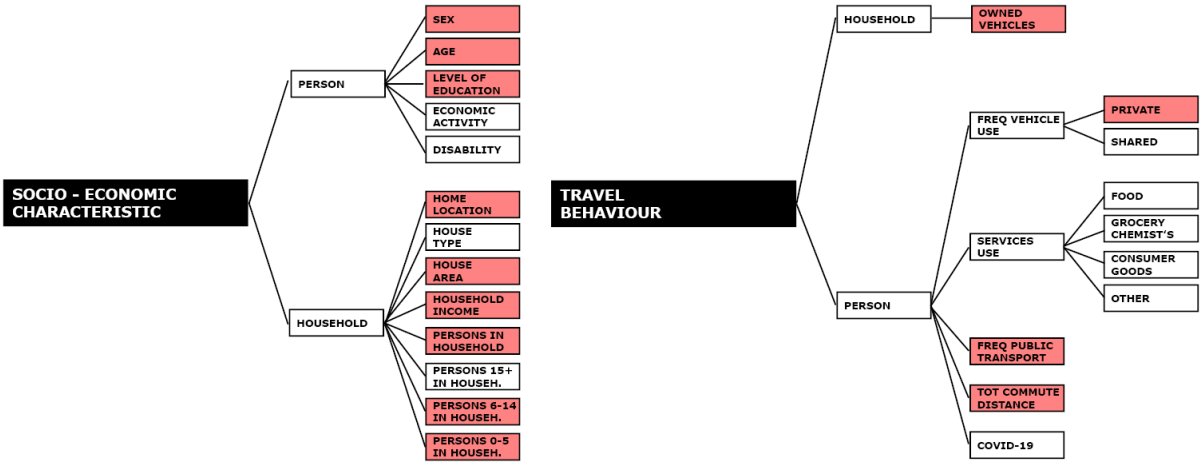

Figure 3 – Dataset controls structure (red cells analysed in CA)

CA works on the principle of dataset dimension reduction to visualise relations between variables. Two dimensions (Dim) with the highest variance contained (eigenvalues) are put into a correlation circle. In the circle, there are vectors showing direction and magnitude. Each arrow represents one variable. The direction is composed by correlation with Dim1 & Dim2. Variables with similar directions show a similar correlation with Dims and thus are similar. On the other hand, opposite directions show a negative correlation – variables indirect relations. And arrows at the right angle show no relations between variables at all. The arrow magnitude describes the strength of the correlation. Long arrows indicate a strong correlation, whereas short ones indicate a weak. The significance is also described by cos2 colour.

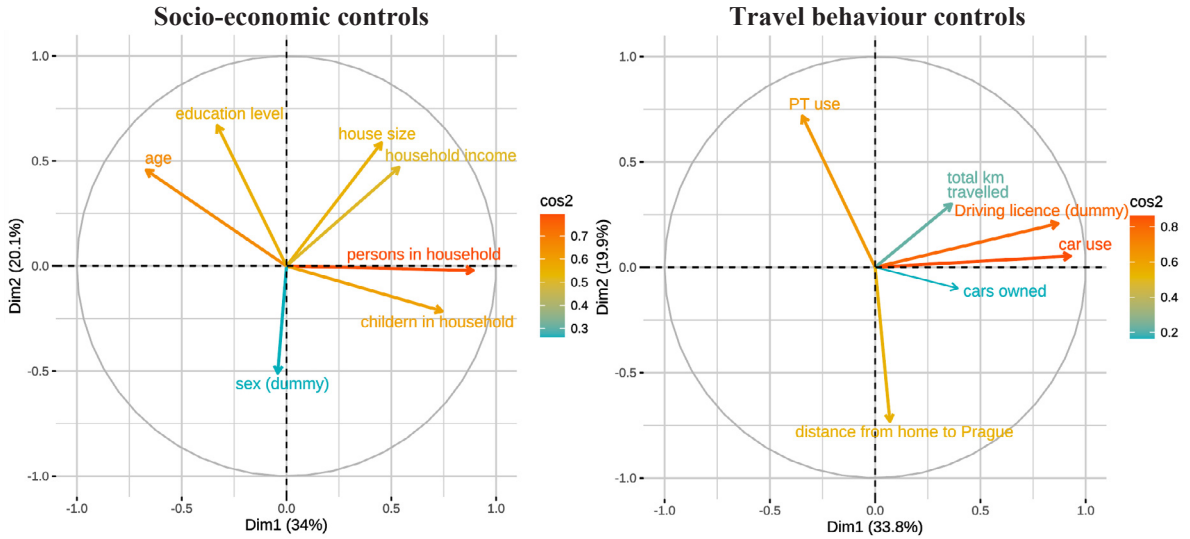

Figure 4 – Partial CAs correlations circles: socio-economic controls and travel behaviour

In case of socio-economic CA, clear correlation was identified unsurprisingly 1) between house size & household income, and 2) between total persons in household & children in household. Also, age is indirectly correlated with number of children in household (older respondents tends to have more children[1]). Education level shows mild connection with age (older respondents may have higher education[1]). Respondents sex appears not to be relevant at all.
In case of travel behaviour CA, correlation was also unsurprising find between driving licence & car use. On top of it, total distance travelled shows moderate correlation with car use, suggesting there is a mild trend of increased mobility by car use. On the other hand, PT use is strongly independent form car use & driving licence ownership (suggesting that responders having driving licence obviously tends to drive, however, it does not prevent them from using PT). House distance to Prague centre is indirectly correlated with PT use (further respondents live, mote PT use), however, both variables are independent to car ownership & usage (frequency of PT use & distance from home to Prague do not mean more car use).

Socio-economic and travel behaviour controls in one CA

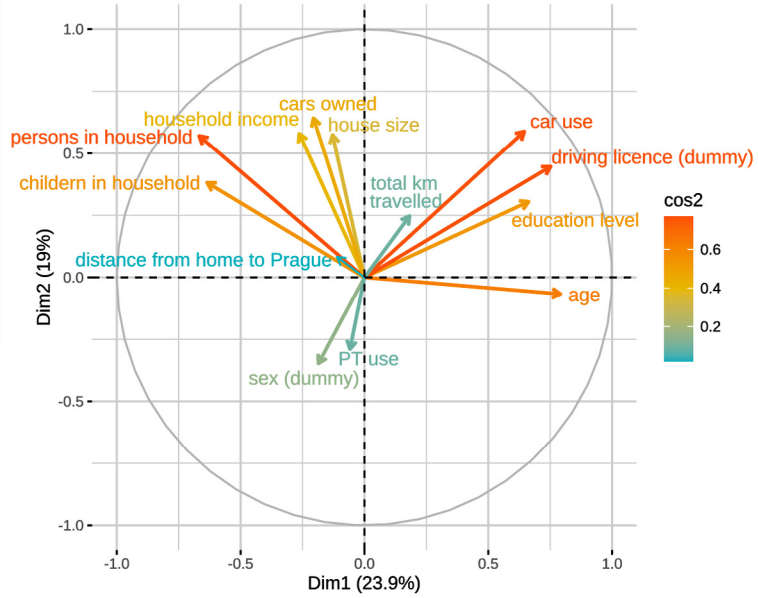

Figure 5 – Joined CAs correlation circle

Combining socio-economic and travel CAs together reduces overall variance coverage in Dims from 53% (socio-economic) or 52% (travel behaviour) to 43%, meaning the combined correlation plot explains 10% less data variation. However, most correlation groups identified in previous CAs remain; persons in household & children, driving licence & car use, household size & income. On top of it, driving licence & car usage is extended by education level (more educated responders have driving licence, however, may be strongly disrupted by underage respondents), Household size & income is extended by variable number of cars (higher income means bigger house and owning more cars). Frequency of PT use & total distance travelled still remains indirectly correlated, nonetheless, loses portion of significancy. Conversely, distance from home to Prague becomes insignificant at all. Respondent sex remains isolated with low significancy.
The CA outcomes shows possible grouping of variables into wider groups and thus avoiding their interdependencies.

[1] important to remember, that also children are included into the sample

The last part of the contribution outlines the next steps, especially quantifying control built-environment variables through 5D methodology (8) and primary regression outcomes.

Density	Residential density Jobs density Commercial FAR
Diversity	Land-use Mix Jobs-residents ration Local amenities count
Design	Street intersections density Cul-de-sac density
Destination accessibility	Jobs within one mile Amenities within one mile
Distance to transit	Closest mass transit stop

Table 3 – 5D framework (8)

3. Conclusions

The contribution presents intermediate progress in the dissertation thesis, focusing on the methodological framework and constructing a regression model based on the transport survey dataset of Prague suburban residents. The main outcome presents quantification of interdependences between control variables, showing potential for grouping and reducing. The next steps are to quantify the built environment on the basis of 5D methodology and to load the model.

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Exploring the Influence of Air Quality on Travel Behavior in European Cities: A Multilevel Analysis of Modal Choices

Szymon Wójcik [a,*]

[a] University of Lodz, Faculty of Economics and Sociology, Department of Econometrics, Rewolucji 1905r Street, No. 41/43, 90-214 Lodz, Poland
∗ corresponding author: szymon.wojcik@uni.lodz.pl

Keywords: travel behavior, homogeneity, multilevel logit model, transport mode choice, air quality, PM10

According to data published by the IPCC in 2021 (IPCC, 2021, p.5), human activity has led to a global temperature increase of 1.1°C compared to pre-industrial levels. In the sixth IPCC summary report (IPCC, 2022, p. 10), anthropogenic net greenhouse gas (GHG) emissions in 2010-2019 reached their highest recorded levels, with approximately 15% of emissions attributed to the transportation sector. Unlike other sectors such as energy (34%), industry (24%), or agriculture, forestry, and land use (22%), the transportation sector has not witnessed a decrease in the average annual emission growth rate. In the European Union, transportation accounts for one-quarter of GHG emissions, with road transportation alone contributing to 72% of emissions in 2019. This sector's emissions intensity primarily results from the growing demand for motorized transportation modes (EEA, 2022, p. 5).

These data underscore the transportation sector's significant contribution to global emissions, particularly concerning urban areas, which accounted for 62% of global GHG emissions in 2015 and an estimated 67-72% of total global emissions in 2020 (IPCC, 2022, p. 12). Reducing emissions in urban transportation is, therefore, a crucial issue.

One effective approach to combat emissions in cities is influencing residents' choice of transportation modes for daily travel. However, before this can be achieved, it is essential to identify the factors that determine travel behavior (Wójcik, 2019). Scholarly literature extensively examines travel behavior analysis, with a focus on identifying its determinants over several decades. Much of the research has concentrated on individual cities, seeking to uncover correlations between resident characteristics and their travel mode preferences (Wójcik, 2022). While many studies have analyzed the influence of air quality on health and the environment, the relationship between air quality and travel behavior has received less attention (Singh et al., 2021).

In our investigation, we explore disparities in travel behavior across diverse European cities through the lens of local homogeneity, with an emphasis on the influence of both perceived and measured air quality on travel mode choice. This approach remains relatively rare in existing literature, enabling us to examine distinctions in daily travel mode selection beyond commonly scrutinized factors such as respondent characteristics, travel patterns, or built environmental attributes.

Our study integrates data from the Perception Survey of Quality of Life in European Cities conducted by the European Commission in 2019. This survey includes a representative

sample of respondents queried about their most frequently utilized travel mode for daily commuting, encompassing data from 83 cities and approximately 58 thousand respondents. We enhance this database with information on the annual mean concentration of particulate matter with a diameter of less than 10 microns (PM10) in the cities, sourced from the World Health Organization's Ambient (outdoor) air pollution database for 2018.

The data exhibits a hierarchical structure, with respondents clustered within cities and cities further grouped within countries. We employ a multilevel logit model to account for this hierarchical structure and derive robust estimates of parameters elucidating the influence of specific variables on travel mode selection. Three distinct models were estimated to scrutinize the determinants associated with buses, private cars, and bicycles as the most commonly chosen daily travel modes. We also utilize conventional single-level models as a benchmark to assess the significance of local homogeneity.

Our findings align with existing literature regarding the sociodemographic attributes of respondents. Regarding environmental consciousness, neither individually perceived air quality nor noise levels within the urban setting exerted a statistically significant effect on mode choice, except for a positive impact of perceived air quality on the choice of private cars. As perceived air quality cannot be considered an objective measure, we incorporate actual emissions levels in the model using data on PM10 particulate matter concentrations in cities. Our results show that increasing air pollution decreases the probability of choosing bicycles and increases the likelihood of selecting public transport modes, confirming previous findings (Hu et al., 2017; Zhang et al., 2021).

In terms of analyzing local homogeneity among diverse cities, we find statistically significant effects at the individual city level, while insignificance prevails at the national level concerning homogeneity. This signifies that behavioral uniformity among respondents is discernible within specific cities but does not extend to the national level. Consequently, this outcome underscores the necessity for individualized analysis of travel behavior within cities and the importance of accounting for city-level clustering in broader investigations of travel behavior. Moreover, the disparities between actual and perceived air quality's impact on travel behavior provide an intriguing setting for further analyses.

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The Role of Energy and Transport related Built Environment Characteristics in Residential Location Choice

Tanja Scheffler[a,*], Eva Heinen[a,b]

[a] Norwegian University of Science and Technology (NTNU), Department of Architecture and Technology, 7491 Trondheim, Norway
[b] TU Dortmund University, Department of Spatial Planning, August-Schmidt-Straße 10, 44227 Dortmund, Germany
∗ corresponding author: tanja.scheffler@ntnu.no

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1. Introduction

Household consumption regarding mobility and shelter is a significant contributor to climate change accounting for 33% of anthropogenic emissions [1]. Both travel and energy consumption behaviour are closely linked to the residential location and are impacted by its built environment [e.g. 2, 3]. Thus, households predetermine the boundary condition for their carbon footprint when relocating. The extent to which energy and transport related built environment characteristics influence residential location choice is not fully resolved and requires further investigation.

Residential location choice is primarily studied for understanding travel behaviour. Models regard various characteristics of the residential unit, surrounding built environment measures, proximity to points of interest and socioeconomic environment of the neighbourhood. However, studies considering characteristics of the previous residence are rare [4, 5].

Although it is known that characteristics like dwelling type and spaciousness are important in residential location choice and exert impact on the per capita energy consumption [3, 6], their role in residential location choice is understudied in comparison to travel-related characteristics. The impact of energy standard on dwelling choice, which nowadays has to be stated for dwellings offered for rent or sale, has not been subject to location choice studies.

Furthermore, for mitigating household emissions, it is essential to study travel and energy-related characteristics together, as they are not mutually exclusive. For example, density and distance to the city centre, which impact travel distances and mode choice, go along with different dwelling types, sizes and age classes, which impact energy consumption. Therefore, this paper addresses the following questions.

- To what extent does the rated importance of energy and transport related built environment characteristics influence the residential location choice regarding those characteristics?

- To what extent does the previous residential location and its characteristics have an additional influence on residential location choice?

2. Materials and methods

The used data was collected in the wider Trondheim region. Between January and July 2023, invitations were sent to households who recently acquired residential property. Additional recruitment was performed via social media. 333 respondents filled in an online questionnaire covering topics such as the respondents' previous residential location, pre-relocation energy consumption and travel behaviour, the relocation process, and key data about their new dwelling.

2.1. Response variables

Three attributes of the new residential location related to energy use and three related to travel behaviour were selected as outcome variables:

- Dwelling type (binary): Apartment or house
- Energy standard (binary): good (ratings A to C) or bad (ratings D to G)
- Floor area per person (continuous)
- Parking spot at the dwelling (binary): yes or no
- Public transport stops in < 5 min walking distance (binary): yes or no
- Distance to the Trondheim city centre (continuous)

2.2. Predictors

The respondents rated the importance of characteristics related to the response variables on a seven-point scale from unimportant (1) to important (7), which are used as continuous predictors (Table 1). Further independent variables refer to the characteristics of the former residential location.

	1	**2**	**3**	**4**	**5**	**6**	**7**
Dwelling type	7	5	4	60	45	59	153
Energy standard	31	21	30	123	60	43	24
Usable floor area	1	6	5	42	72	91	112
Parking spots at or close to the dwelling	55	21	12	41	33	54	117
Quality of public transport connections	17	4	12	40	61	73	126
Proximity to the city centre*	15	10	13	36	54	49	46
Proximity to open nature*	11	3	9	42	54	55	49
Proximity to the workplace*	38	4	8	42	44	34	50

* Reduced sample of movers within Trondheim municipality

Table 1: Distribution of importance of characteristics in residential location choice

2.3. Statistical analysis

Linear and logistic regression are used to analyse the impact of rated importance and previous residential location characteristics on the characteristics of the new residential location. The continuous response variables are transformed using square root and logarithmic transformations respectively to fulfil model assumptions.

3. Results

3.4. Linear regression

Both floor area per person and distance to the city centre are significantly related to the characteristic of the former location. The rated importance of usable floor area has an additional significant effect on the spaciousness of the dwelling, while the importance of proximity to the city centre has not. Instead, a moderating effect of importance of proximity to the workplace was detected, affecting households with previous locations further away from the city centre to move closer. Re-transformed predictions are displayed in Figure 1 and Figure 2.

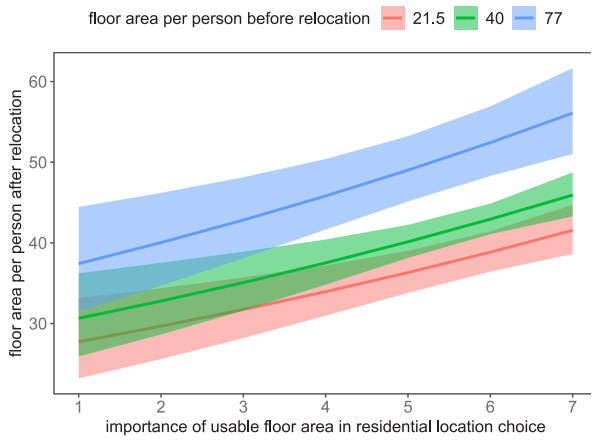

Figure 1: predicted floor area per person after relocation with 95% confidence intervals. Predictions are performed for the 10th, 50th and 90th quantile of floor area per person before relocation.

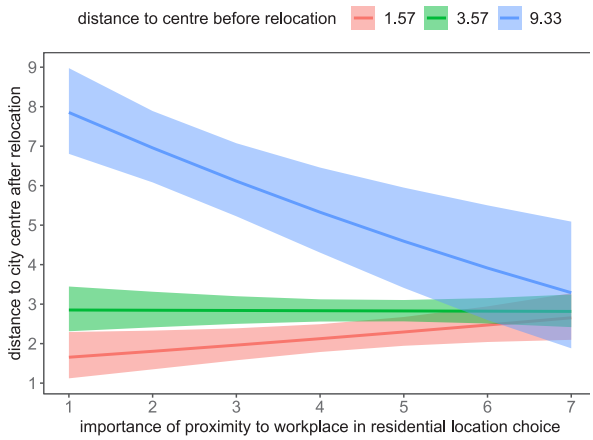

Figure 2: predicted distance to city centre after relocation with 95 % confidence intervals. Predictions are performed for the 10th, 50th and 90th quantile of distance to centre before relocation.

3.5. Logistic regression

The rated importance of dwelling type, energy standard and parking spots significantly affect the likelihood of opting for an apartment, for good energy standard and for having a parking spot respectively. Conversely, the importance of public transport did not serve as significant predictors of location choice. All examined characteristics, except dwelling type, are additionally influenced by the amenities available at the old residential location (Table 2).

	Dependent variable: characteristic of the new residential location			
	dwelling type: apartment	energy standard: good	parking spot at the dwelling	public transport nearby
	(model 3)	(model 4)	(model 5)	(model 6)
importance of dwelling type	0.953**			
apartment before relocation	1.004			
importance of energy standard		1.114***		
good energy standard before rel.		1.340***		
importance of parking spots			1.057***	
parking spot available before rel.			1.233***	
importance of PT connections				1.018
PT stop nearby before relocation				1.447***
Constant	2.476***	0.941	1.438***	1.483***
Observations	284	160	333	333
CoxSnell R^2	0.021	0.211	0.021	0.169
Log Likelihood	-194.627	-97.539	-148.795	-164.623
Akaike Inf. Crit.	395.254	201.078	303.589	335.246
Note:	*p<0.1; **p<0.05; ***p<0.01			

Table 2: logistic regression of characteristics of the new residential location (odds ratios)

4. Conclusions

The results indicate self-selection effects for both energy and travel-related characteristics which are significantly related to the rated importance. Floor area per person, energy standard, distance to the city centre, parking spot availability and proximity to public transport were additionally determined by the previous location's characteristic, which indicates that residential self-selection is a multi-faceted phenomenon, dependent not only on preferences for certain characteristics but also on a reluctance to change from what one is accustomed to in their residential surroundings. Aversion to moving far from the previous location and negative changes in dwelling size align with existing research [5, 7]. The present results suggest similar aversions to the loss of transport mode accessibility and good energy standard.

The low model fit of the models for floor area, dwelling type and parking spot availability suggest missing important predictors. Based on previous findings of different residential preferences among socioeconomic groups [8], it is expected that socioeconomic household characteristics might predict a greater portion of variance in the outcome variables. Future analyses will include predictors such as household type, income, education level, and job status.

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