Sustainable Cities and Society 135 (2025) 106991



Contents lists available at ScienceDirect

Sustainable Cities and Society

journal homepage: www.elsevier.com/locate/scs



Compensating for limited private living space through outsourcing of activities? Panel data analysis of the link between living space and spatial behaviour

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ARTICLE INFO

Keywords:
Housing sufficiency
Spatial behaviour
Eating and drinking out
Panel data analysis

ABSTRACT

In order to deal with the environmental footprint of housing, researchers call for per capita living space in high-income countries to stabilise or decrease. The concept of housing sufficiency refers to approaches that mitigate living space consumption while ensuring decent housing conditions for everyone. This study investigated, whether there is empiric evidence supporting the idea that residents compensate for limited private living space through outsourcing activities, which could be utilised by sufficiency strategies to encourage downsizings. We examined the link between size of living space and out-of-home activity participation using eating and drinking out (EDO) as an example.

To our knowledge, our study is the first to quantitively identify correlations between size of living space and participation in out-of-home activities. Applying dynamic panel data modelling on data of the German Socio-Economic Panel, our results show, that below a threshold of 25 m^2 of living space (equivalised based on OECD modified scale) downsizings correspond with increases in EDO frequency.

These findings need to be cautiously interpreted with regard to policy implications, since over 50 % of people living in 25 m^2 or less of equivalised living space experience feelings of overcrowding, which could affect their mental health and well-being.

1. Introduction

The way in which we dwell and move around strongly affects sustainability of cities and regions. When we engage in activities outside the home, we generate trips that are associated with negative externalities such as resource consumption, noise and greenhouse gas emissions, unless they are undertaken using active modes of transport. The amount of living space that households consume is the main determinant of a household's residential energy consumption (Huebner et al., 2015; Huebner & Shipworth, 2017). Since generating this energy consumes resources and emits greenhouse gases, size of living space affects the ecological footprint of housing. Additionally, size of living space is closely linked to socio-economic issues such as affordability and distribution of housing, making it a crucial factor in sustainable urban and regional development (McKinlay et al., 2019).

Average per capita living space consumption has increased substantially in many countries worldwide in recent decades, particularly in high-income countries (Ellsworth-Krebs et al., 2021). In order to achieve climate change mitigation objectives, researchers are advocating for per capita living space to stabilise or even decrease (Grubler et al., 2018; Lorek & Spangenberg, 2019; Cohen, 2021).

The concept of housing sufficiency addresses these calls and refers to approaches to limit excessive living space consumption while ensuring decent housing standards for everyone. The key idea of sufficiency is to satisfy human needs without exceeding the planetary boundaries. Conceptually, this means defining sufficient consumption corridors through rationale and normative reasoning (Gough, 2023). Thus, scholars who apply the concept of sufficiency to the domain of housing discuss minimum and maximum levels of different metrics to determine what constitutes sufficient housing (Cohen, 2021; Arceo et al., 2025b; Horn et al., 2025). Using a housing-related metaphor, Gough (2023) defines sufficiency as the conceptual space between a *floor* and a *ceiling*. The 'floor' ensures a decent minimum standard for all, while the 'ceiling' marks unsustainable luxury. As the needs and levels of conventional housing comfort that shape floor and ceiling benchmarks are highly contextual and socially constructed, the sufficient consumption corridor

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https://doi.org/10.1016/j.scs.2025.106991
Received 2 August 2025; Received in revised form 30 October 2025; Accepted 13 November 2025
Available online 14 November 2025
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for housing is not uniformly defined in the literature (Thomas et al., 2019; Arceo et al., 2025b; Horn et al., 2025). A summary of existing definitions for size of living space is provided by Arceo et al. (2025b). This key metric of housing sufficiency is also the main focus of our paper. Table 1 presents definitions of 'floor' and 'ceiling' as they relate to housing sufficiency in Germany, the spatial context of our paper.

In terms of policy, establishing a sufficient consumption corridor for housing means designing strategies to distribute residential space more efficiently and counteract misallocations. With regard to the floor, minimum housing consumption standards to avoid overcrowding are commonplace and widely accepted. For example, many countries' welfare systems operate with standards with regard to per-capita living space as prerequisite for rent support (Fuchs et al., 2021). However, approaches to limit excessive consumption of living space are less well-established. These approaches focus, for example, on senior citizens who often remain in family homes after their children have moved out and thus have high levels of per-capita living space (Horn et al., 2025; Liman et al., 2025). Measures such as supporting home swaps, sharing practices and collaborative housing, as well as tax policies, exemplify efforts to counteract overconsumption (Thomas et al., 2019; Kitzmann, 2024; Arceo et al., 2025b; Horn et al., 2025). Another area of action for sufficiency strategies is new-built housing. Here, the emphasis lies on implementing sufficient floor plan designs (Cohen, 2021; Arceo et al., 2025b).

Our study investigates an aspect that is frequently mentioned by scholars of housing sufficiency, yet rarely explored in depth: shared-used spaces and proximity to services or amenities outsides one's dwelling may compensate for private living space possessed (Stefánsdóttir & Xue, 2018; Cohen, 2021; Lehner et al., 2024; Arceo et al., 2025b). While it seems intuitive and intriguing, the existing literature does not coherently address how the idea of extending the dwelling by outsourcing activities to neighbourhood amenities, such as restaurants, cafés, public green spaces, and cultural facilities, relates to the concept of housing sufficiency. We identified two pathways in research on sufficiency that describe how size of living space and spatial behaviour are linked:

Pathway A: Persons who prefer a lifestyle, characterised by frequent use of the aforementioned services or amenities out of home, trade off housing costs, location, and private living space. By foregoing living space, residents can access this lifestyle, often referred to as 'urban', without being overburdened by the high housing cost levels typically associated with urban neighbourhoods that offer close proximity to a wide range of amenities (Fuchs et al., 2021; Preece et al., 2023; Hubbard, 2025). Accordingly, studies find that proximity to infrastructure and services is one of the reasons why individuals move into small dwellings (Clinton, 2018; Lehner et al., 2024). An increased interest in urban lifestyles, as reflected in the heated housing markets of global metropolises and secondary cities, could therefore help disincentivise overconsumption of living space, but could also result in extreme space reductions failing to meet minimum standards (Lorek & Spangenberg, 2019; Fuchs et al., 2021; Hubbard, 2025). This pathway suggests an indirect link between size of living space and spatial behaviour, which is mediated by both lifestyle-related preferences for certain neighbourhoods as well as housing costs.

Pathway B: This pathway considers how residents with smaller living spaces behave in comparison to those with more average living conditions. Studies interpret outsourcing of activities as a coping mechanism or a rebound effect of living in a confined space (Sandberg, 2018; Owen, 2023; Preece et al., 2023; Richter et al., 2024). This suggests that downsizing can lead to behavioural changes, regardless of whether it is desirable (Sandberg, 2018; Preece et al., 2023). According to this pathway, there is a causal relationship between the size of a living space and spatial behaviour.

While the pathway A seems to be well documented by several studies (e.g. Brun & Fagnani, 1994; Heinonen et al., 2013; Jansen, 2020), we were unable to find empirically based findings regarding pathway B, that are striking enough to inform strategies for housing sufficiency. Therefore, the aim of our study is to empirically investigate this pathway, which suggests that persons with low levels of living space consumption outsource activities to cope with limited private space.

The existence (or non-existence) of such a coping mechanism has implications for housing sufficiency, depending on the level of confinement at which it occurs and how residents who live this way experience it. It could either support or dispel existing narratives that portray living small as aspirational, which, for example, advocates of so-called 'micro-living' already utilise to promote their residential development projects (Frank, 2020; Harris & Nowicki, 2020; Owen, 2023). Behavioural changes triggered by downsizings would also emphasise potential implications of sufficiency for spatial planning which extend beyond environmental footprint and distributional issues related to living space consumption. For example, increased outsourcing of activities could revitalise neighbourhood and community life, whilst stimulating trips which could, depending on the chosen mode of transport, exacerbate negative transport-related externalities (Richter et al., 2024; Arceo et al., 2025a).

We focus on eating and drinking out (EDO) as an example, as these are activities that can take place both in and outside the home, making them particularly suitable for investigating the link between spatial behaviour and size of living space. Furthermore, studies have shown that the frequency of EDO correlates with the frequency of other activities outside the home, such as social activities (Spissu et al., 2009) and grocery shopping (Colaço & e Silva, 2025).

The spatial context of this paper is Germany, a country for which scholars have also stressed the relevance of approaches to housing sufficiency. For example, Cordroch et al. (2022) demonstrate model-based that, in order for Germany to meet its self-imposed greenhouse gas reduction targets for the housing sector, efficiency measures (e.g. improving building insulation and heating systems) and a transition towards renewable energy must be complimented by downsizing. At the same time, 11.5 % of Germany's population lived in overcrowded dwellings in 2024 (Federal Statistical Office, 2025).

Our findings have implications for transport research, particularly the study of trip generation. However, we primarily interpret them with regard to their implications for housing sufficiency.

The following section briefly outlines a theory-based explanation of how living space and spatial behaviour are linked and reviews existing research on determinants of the frequency of out-of-home discretionary activities as well as EDO. Based on this review, we also derive the relevant research questions for this paper. We then go on to describe the methods and data on which the analysis was based. Finally, we present and discuss the results.

Table 1
Definition of a sufficient consumption corridor for living space in Germany.

Sufficiency floor	Sufficiency ceiling	Source
10 m^2 per adult and 6 m^2 per child (legally binding in some Federal States)	35 m^2 per person	Research Services of the German Parliament, 2017; Zimmermann et al., 2023

2. Theory and empirical findings

2.1. Theory

Building on the work of Chapin (1968, 1974) and Hägerstrand (1970), research lines established that examine how individuals move in time and space. These lines can be summarised as activity-based approaches (Golledge & Stimson 1996). Hägerstrand (1970) contributes a theoretical framework investigating spatial behaviour in the context of three constraints, which are useful when analysing the link between of out-of-home activity participation and housing attributes: capability,

coupling and authority constraints.

Capability constraints primarily refer to individual needs, especially biological ones such as sleeping and eating, as well as available resources and distance-related factors, which are predominantly determined by properties of the built environment (Hägerstrand, 1970). While biological needs impose constraints on individuals — for example, we need to sleep, which requires us to be present at a rest place (usually our home) — resources refer to financial means as well as available means of transport (Hägerstrand, 1970). Persons with low incomes may not have enough money or the necessary means of transport to visit a restaurant regularly. Furthermore, a person's physical condition can limit their ability to perform activities outside the home. Older people, for example, may not be able to eat and drink outside their homes due to health issues.

The interplay of different capability constraints is of particular interest when investigating the relationship between size of living space and out-of-home activity participation. Persons residing in an urban area, which offers access to a high-quality transport system and a dense network of amenities such as restaurants, shops and parks, may experience fewer distance-related capability constraints than persons living in rural areas where the nearest bar or restaurant might be 30 min away by car. However, to ensure that the higher housing costs per square meter of an urban location do not outweigh the decrease in capability constraints related to distance through an increase in capability constraints related to financial resources (i.e. the disposable income after housing costs), it may be necessary to sacrifice living space. This would explain pathway A, through the lens of Hägerstrand's capability constraints.

At the same time, living in a small dwelling may restrict the activities that a person can perform at home conveniently. People living in small homes may not be able to host social gatherings or engage in leisure activities at home due to confined space. Daily routines such as meal preparation might be more inconvenient in small dwellings, where kitchens often are smaller and there is less space to move around. Consequently, downsizing can increase capability constraints experienced at home. As a result, and in line with pathway B, residents might more frequently outsource activities. However, living space may need to be below a certain threshold imposing enough constraints at home to cause people to perform substantially more activities outside the home.

On the other hand, further housing attributes, such as access to private gardens, balconies or terraces, expand the range of activities that can potentially take place at home. For example, on a warm summer evening, those with access to these facilities can choose to dine outside without having to leave their home. Thus, access to private gardens, balconies or terraces should be associated with fewer capability constraints at home and thus, fewer out-of-home activity episodes.

Where, when and for how long individuals have to interact or to coordinate activities with other people also determine how often and for how long people perform activities out of home. Resulting coupling constraints relate, for example, to employment or parenting tasks and are closely linked to societal roles and expectations of other people. With regard to the link between size of living space and spatial behaviour, members of households comprising more than one person might experience more coupling constraints when the living space is small, compared to those living in larger dwellings. For example, couples living in a large detached single-family home can choose which activities to perform more independently from each other. A social gathering involving one partner perhaps could take place at home without disturbing the other, which would probably not be possible in most smaller dwellings. Living in a neighbourhood where many quality amenities and services are within walking distance or easily accessible by bike or public transport on the other hand, is related to reduced coupling constraints because there is fever need for partners to coordinate private car use. Both aspects could result in more frequent out-of-home activity participation.

Authority constraints, which are less relevant for analysing out-of-home activity participation, describe that certain spaces may be accessible only to certain individuals or groups of people, either temporarily or permanently (Hägerstrand, 1970).

2.2. Empirical findings

For this paper, studies that empirically investigate the factors influencing how often people perform activities outside the home (activity frequency) and how much time they spend on in-home and out-of-home activities (time allocation) appear particularly relevant. We restricted our search for literature to studies that analysed activities whose out-of-home frequency and time-use are largely discretionary, as we assume this also accounts for EDO: We all have to eat and drink; how often and for how long we do this out-of-home is up to our discretion. The main focus of our literature review was on the existing studies on EDO.

2.2.1. Socio-economic determinants of EDO

Studies which investigate out-of-home activity participation find determinants such as gender (Bhat & Misra, 1999; Voorpostel et al., 2010; Akar et al., 2011; Pellegrini et al., 2021; Hu, 2023), household composition (Yamamoto & Kitamura, 1999; Ettema et al., 2007; Susilo & Avineri, 2014; Liu et al., 2020), age (Spissu et al., 2009; Ziems et al., 2010), financial and time constraints (Meloni et al., 2007; Meloni et al., 2008; Dane et al., 2015; Dharmowijoyo et al., 2016) as well as ethnicity and educational attainment (Bernardo et al., 2015). These determinants are also covered in research focussing specifically on EDO.

The relationship between gender and EDO varies in studies on this subject, with the selection of dependent and independent variables, as well as spatial and cultural context influencing results (Cheng et al., 2007; Akar et al., 2011; Díaz-Méndez & García-Espejo, 2014; Bernardo et al., 2015; Lund et al., 2017; Zang et al., 2018; Warde et al., 2019; Haddad et al., 2023, 2025). In the United States, members of ethnic minorities eat out less frequently (Warde et al., 2019; Haddad et al., 2023, 2025), potentially due to experiencing discrimination in restaurants (e.g. longer waiting times for seating or ordering food) (Brewster & Heffner, 2023).

EDO is more likely to be undertaken without children than with children (Akar et al., 2011). Thus, households with children tend to eat at home more regularly (Spissu et al., 2009; Lund et al., 2017; Warde et al., 2019; Haddad et al., 2023, 2025). People are also less likely to eat or drink out when they are married (Spissu et al., 2009; Zang et al., 2018; Haddad et al., 2023). Haddad et al. (2023) find a correlation between high levels of car ownership and eating out, reflecting high wealth on the one hand and, on the other hand, the effect of multiple car ownership in reducing capability and coupling constraints within households.

Younger people eat out more often and visit pubs more frequently than older ones (Bromley et al., 2003; Spissu et al., 2009; Vandevijvere et al., 2009; Akar et al., 2011; Lund et al., 2017; Zang et al., 2018; Warde et al., 2019; Haddad et al., 2023). Regarding income, most studies show that those with higher incomes eat and drink out more often (Fan & Khattak, 2009; Lund et al., 2017; Zang et al., 2018; Warde et al., 2019; Dias et al., 2020; Haddad et al., 2023; Luong et al., 2024). The likelihood of more frequent EDO increases with greater time allocated to work, independently of income (Spissu et al., 2009; Mills et al., 2018; Dias et al., 2020; Haddad et al., 2023). People who regularly work from home eat out less often, possibly because they generally prefer to carry out activities at home (Haddad et al., 2023; Colaço & e Silva, 2025; Haddad et al., 2025).

Some studies (Spissu et al., 2009; Mills et al., 2018; Zang et al., 2018) have found a positive correlation between higher educational attainment and more frequent EDO, whereas Haddad et al. (2023) found a negative correlation. A positive correlation could be explained by educational attainment functioning as a proxy for wealth or anticipated wealth (see e.g. Woessmann, 2016), meaning that wealthy households

have a higher budget for EDO. Conversely, households with higher educational attainment tend to have greater nutritional knowledge and health awareness (Gréa Krause et al., 2018), which could result in a preference for home-cooked meals.

2.2.2. Built environment and EDO

A further focus of research is the relationship between spatial behaviour and the built environment. Existing studies, conducted in different cultural and spatial contexts, found that increased out-of-home activity participation correlates with: a) higher densities and mixed land-use (e.g. Thill & Kim 2005; Lin & Yang, 2009; Merlin, 2015; Liu et al., 2020; Xiong et al., 2024); b) proximity to certain amenities, such as green spaces and convenient commercial leisure facilities (Kaczynski & Henderson, 2007; Fan & Khattak, 2009; Merlin, 2015; Liu et al., 2020; Xiong et al., 2024); c) the walkability of neighbourhoods and the accessibility of public transport (Tamura et al., 2017; Zhu et al., 2020; Xiong et al., 2024).

Only a few studies with a focus on EDO prevalence also consider built environment variables. Haddad et al. (2023, 2025) included population densities, employment densities, proportion of employment by type, walkability index, land-use mix and density of restaurants in their study. Only restaurant density showed a statistically significant positive correlation to more frequent EDO, as is evident in other studies (Spissu et al., 2009; Troncoso Parady et al., 2014; Hossain et al., 2024). Not considering restaurant density, Dias et al. (2020) found population density to be associated with EDO. Consistent with this, Brun and Fagnani (1994) and Lund et al. (2017) observed that people living in city centres of major cities eat and drink out more often.

These findings provide further empirical support for an indirect link between size of living space and spatial behaviour mediated by lifestyle-related preferences as well as housing costs. They demonstrate that individuals who frequently engage in out-of-home activities and EDO typically reside in neighbourhoods with good access to amenities and services, which are associated with high housing cost levels and smaller average living space consumption per capita.

Some studies also suggest that recent movers exhibit different spatial behaviours compared to long-term residents, even when socio-economic factors are controlled for (Verplanken et al., 2008; Clark et al., 2016; Kienast-von Einem et al., 2024). This effect could also influence the frequency of EDO.

We found two empirical studies that support a causal link between low levels of living space per capita and higher participation in out-of-home activities as well as EDO (in line with pathway B). In a study by Preece et al. (2023), residents in the United Kingdom reported spending more time outside the home and eating out more regularly after moving into very small apartments. Richter et al. (2024) confirmed these findings based on workshops conducted in various EU countries. Participants living in confined conditions (<30 m^2 of living space per person) reported more frequent EDO episodes as well as out-of-home activity episodes, stating that these were an important coping mechanism (Richter et al., 2024).

2.3. Research gap our study addresses

The variables used in many studies to describe built environment characteristics such as population density may contain indirect information about the average size of dwellings or the average size of living space per capita. However, existing research seldomly establishes a direct link between size of living space and either the frequency of EDO or the frequency of general out-of-home activity participation of the observation units. While the qualitative studies by Preece et al. (2023) and Richter et al. (2024) are notable exceptions, they are limited by their small sample sizes.

Although studies use a variety of indicators to describe socio-economic status and the built environment, we were unable to find any that quantitatively address EDO while accounting for size of living space. Looking at a broader range of discretional out-of-home activities, comprehensive reviews of literature investigating trip generation also name no studies in which individual behaviour is directly linked to the living space or other specific housing attributes of the observation units' homes (see Gruyter et al., 2021).

Our paper addresses this research gap by analysing people's spatial behaviour using panel microdata, while accounting for size of living space and further built environment properties. We conducted a secondary analysis of the German Socio-Economic Panel (GSOEP), focusing on Germany and representative data. The GSOEP is the only data source available which entails variables on built environment properties including housing attributes (such as size of living space), socioeconomics and EDO frequency of the units of observations. Other major quantitative, representative data sources, such as the German national transport survey 'Mobilität in Deutschland' (MiD), do not capture the housing attributes of respondents (for a description of the MiD survey method see Eggs et al., 2018).

The main contribution of this paper is to examine the link between size of living space and EDO, and to discuss the implications for sufficiency strategy design and housing policy by answering the following research questions:

- Is there a threshold below which size of living space must fall for higher EDO frequencies to occur? If so, what is this threshold?
- If it exists, how do residents with a living space consumption below this threshold judge their dwelling size?
- What are the empirical analyses' implications for sufficiency strategies and housing policy?

3. Data, methods and variables

3.1. Data and dependent variable

Our empirical analyses are based on data from the GSOEP (SOEP-Core v39). Conducted as a panel survey covering all members of participant households, the GSOEP microdata contains information on individual and household levels (Brücker et al., 2014; Brücker et al., 2017; Goebel et al., 2024). East German households first entered the panel after German reunification in 1990. Detailed descriptions of the GSOEP survey method and the core dataset can be found in Goebel et al. (2019). We used consumer price indices, measured by the German Federal Statistical Office as year-on-year changes, to adjust the monetary variables of the GSOEP data for inflation, with 2019 as the base year (for data access see Federal Statistical Office, 2023).

While the GSOEP contains detailed socio-economic data, as well as information on respondents' homes and their attributes, aspects of spatial behaviour are not the focus of the survey. For this reason, the variable 'frequency of eating or drinking out', which is particularly relevant in our study, was only surveyed at irregular intervals (1990, 1995, 1998, 2003, 2008, 2013 and 2019), with new individuals joining the panel in each of these waves. Therefore, our sample is an unbalanced panel (see Fig. 1). Compared to the large number of observation units (N = 21,885 in the sample used for econometric analyses), the number of survey waves is small, a detail we had to account for when selecting the modelling method.

The GSOEP questionnaire covers how often people eat and drink out, using a single question with five response options. According to GSOEP data, the median EDO frequency in all survey years was at least once a month (see Fig. 1). This is consistent with MiD data, which surveyed an average of 21 EDO episodes per person per year in Germany (own calculation based on MiD 2017). As Fig. 1 illustrates, those who eat or drink out every day remain a small minority (making up approximately 1–2 % of all respondents), while the other response categories are more prevalent. The proportions of the ordinal responses remained relatively stable over the survey period. More recent waves display a shift towards

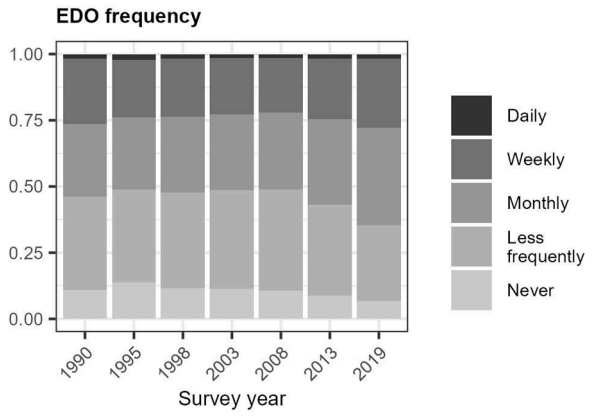

Fig. 1. Frequency of EDO across GSOEP survey years. Source: GSOEP v39, authors' calculations.

more regular EDO, with a declining proportion of respondents eating or drinking out less frequently than once a month.

Our econometric analysis is based on a subset of the entire GSOEP sample: a panel data sample that uses six of the seven waves in which information on EDO frequency and on our control variables was collected (see the 'Independent variables' section). The 1990 wave was excluded because no consumer price indices were available for East Germany that year, which would have resulted in confounded monetary variables.

After filtering out all observations with missing information for control variables, the sample for our analyses comprised of 94,857 cases. We only used observations of people aged 18 or over and who live in a dwelling with a kitchen (excluding 407 cases residing in dwellings without kitchens). Those living in student dormitories or retirement homes were also excluded from the sample (40 cases). Stating never to perform EDO means not even having a coffee in a café or a drink in a bar or pub once a year. We would argue that this indicates either a lack of physical ability or a very strong aversion to EDO in many cases. Since we wanted to analyse whether changes in the size of a person's living space correlate with changes in EDO, we reduced the sample to include only those who are generally able and willing to participate in this activity, filtering out those who never eat or drink out (8,720 cases). To be able to apply panel data econometrics, our panel data sample consists only of observations units with two or more consecutive observations. Table 2 contains detailed reporting of the number of excluded cases for each wave of the sample. Table 3 displays the descriptive statistics of the sample used for econometric modelling. All the statistics in Table 3, except the number of cases (n), were calculated using the GSOEP's case weights.

To show that the removal of observation units with fewer than two consecutive observations, and for which not all control variables were captured due to missing or implausible responses, did not cause a selection bias, Table A1 of the appendix displays basic socio-economic statistics of the sample, both before and after the filtering of observation units. To check how the results were affected by filtering out people who never perform EDO, those living in households without kitchens and those living in student dormitories or retirement homes, we also fitted models on samples including these groups.

3.2. Methods

After conducting descriptive analyses, we applied econometric techniques to the GSOEP data. According to our hypothesis that living space might need to fall below a certain threshold to affect EDO, we attempted to model this threshold, testing several size of living space variables.

The theory of a coping mechanism for adapting to capability constraints experienced at home implies a direction of change, from size of the living space to the frequency of EDO. Ideally, our econometric approach should control for unobserved, time-invariant confounders while modelling the direction of the relationship, as this would enable causal inference (Allison et al., 2017).

This led us to dynamic panel data models. Recent publications advocate the use of the *cross-lagged panel model with fixed effects* (FE-CLPM) for causal inference, as it has some advantages over available alternative modelling approaches such as CLPM (without fixed effects) and GMM estimation (Allison et al., 2017; Leszczensky & Wolbring 2022). However, the spacing of our sample with three-year to six-year gaps between waves makes it very difficult to establish temporal order and to account for reverse causality. Therefore, we decided to use a simplified version of the FE-CLPM, which however does still exploit some of the advantages of dynamic panel data models. The approach is based on Moral-Benito's (2013) work on estimating dynamic panel data models using the maximum likelihood (ML) method, which Allison et al. (2017) later incorporated into the structural equation modelling (SEM) framework. Following Allison et al. (2017), we fitted the subsequent model:

$$y_{it} = \beta_1 y_{it-1} + \beta_2 x_{it} + \delta w_{it} + \alpha_i + \mu_t + \epsilon_{it} \quad (1)$$

Individuals $i = 1, \ldots, N$ are observed for times $t = 1, \ldots, T$ where t represents the different waves (years) of the GSOEP data. The dependent variable y_{it} is individuals i EDO frequency at time (year) t. The variable x_{it} represents the size of living space. Accordingly, the scalar coefficient β_2 represents the effect of within-entity (within-person) changes of x_{it} on y_{it}. The vector w_{it} contains all time-variant control variables, with δ representing a vector of the within effects of w_{it} on y_{it}. The autoregressive parameter β_1 refers to the effect of the EDO frequency on itself at the succeeding observation period. Time-invariant individual effects α_i, an intercept that varies with time μ_t and the idiosyncratic error ϵ_{it} complete the equation. The original FE-CLPM also includes a lagged effect of x_{it} on y_{it}, which is modelled by entering x_{it-1} into Eq. (1). However, this lagged effect would be extremely difficult to interpret in our case due to our panel structure. People who live in small spaces seem to do so only on a temporary basis (see Fig. 3). Thus, the effect of x_{it-1} on y_{it} may be confounded by the fact that the person surveyed has changed size of living space again within the three- to six-year gap between waves. Even without this problem, the causal lag between a change in size of living space and a change in EDO (if such a lag even exists) may be much smaller than three years, in which case it would be captured by the so-called 'contemporaneous' effect β_2 (see Leszczensky & Wolbring,

Table 2
Reporting of the number of excluded cases. Source: SOEP v39, authors' calculations.

	1995	1998	2003	2008	2013	2019	Panel data sample
All obs. (age ≥ 18)	13,318	14,289	22,260	19,391	25,578	29,414	124,250
Missing response in control variable	3,076	3,614	4,739	3,671	5,554	8,739	29,393
No kitchen	88	82	83	54	59	41	407
Retirement home/student dormitory	0	0	5	11	8	16	40
Never eats or drinks out	1,408	1,134	1,738	1,438	1,655	1,347	8,720
Without two consecutive observations	1,646	1,127	3,122	1,739	4,594	9,243	21,471
Remaining obs.	7,100	8,332	12,573	12,478	13,708	10,028	**64,219**

Table 3
Descriptive basic socioeconomics and statistics of the variables used. Source: SOEP v39, authors' calculations.

	Sample used for econometrics ($n = 64{,}219$)						
	n	Mean (or distribution)	SD	Min	Pctl. 25	Pctl. 75	Max
EDO frequency							
… Daily	976	2 %					
… Weekly	14,081	23 %					
… Monthly	22,536	34 %					
… Less frequently	26,626	41 %					
… Never	0	0 %					
Dwelling size		101	42	10	74	130	470
Living space (equivalised)		63	27	3.7	44	75	350
Access to private terrace/balcony and/or garden							
… No terrace/balcony, no garden (ref.)	5,483	10 %					
… Terrace/balcony, no garden	15,138	26 %					
… Garden, no terrace/balcony	7,271	11 %					
… Terrace/balcony and garden	36,327	54 %					
Population at place of residence							
… 2,000 or fewer	5,294	8 %					
… 2,000 to 5,000	6,436	9 %					
… 5,000 to 20,000	16,384	25 %					
… 20,000 to 50,000	11,391	18 %					
… 50,000 to 100,000	5,549	9 %					
… 100,000 to 500,000	10,041	16 %					
… 500,000 or more	9,124	16 %					
Sex							
… Female	30,575	49 %					
… Male	33,644	51 %					
Age		52	17	18	38	62	102
Household type		2.4	1.2	1.0	2.0	4.0	16.0
… *Single*	8,549	22 %					
… Single Parent	3,479	5 %					
… Couple	22,815	36 %					
… Couple with Children	27,806	35 %					
… Other	1,570	2 %					
Marital status							
… Married	42,934	61 %					
… Not married	21,285	39 %					
Employment status							
… Employed	37,247	58 %					
… Not employed	26,972	42 %					
Household income (equivalised)		1,906	1,135	118	1,311	2,355	133,333
Household income after housing costs (equivalised)		1,563	1,105	−10,850	1,018	1,993	133,191
Migration background							
… No	55,697	87 %					
… Yes	8,522	13 %					
Educational attainment							
… General elementary	6,463	12 %					
… Middle vocational	33,055	54 %					
… Vocational	3,655	5 %					
… Higher vocational	4,994	8 %					
… Higher education	15,364	20 %					
… Inadequate	688	1 %					

2022). Consequently, we removed the lagged effect of size of living space from the original FE-CLPM equation, only modelling the contemporaneous effect of size of living space on EDO.

Unlike conventional panel data models relying on the ordinary least squares method (FE-OLS), our dynamic panel data model fitted via ML-SEM treats α_i as latent variable which is allowed to correlate with both time-varying covariates and y_{it} (Allison et al., 2017). Accordingly, the model controls for unobserved time-invariant heterogeneity and underlying relationships between these time-invariant latent factors (α_i) and time-varying covariates at different points in time (Bollen & Brand, 2010; Allison et al., 2017). For example, if stable personality traits affect the size of living space or EDO frequency differently over time, our modelling approach accounts for these relationships, which could otherwise confound estimated coefficients.

A second advantage of the dynamic panel data model over the FE-OLS model is that it allows the strict exogeneity assumption of the variables to be relaxed (Allison et al., 2017). By defining an explanatory variable as predetermined (or sequentially exogenous), current observations of this predetermined variable are permitted to corelate with all past errors ϵ_{it} (Allison et al., 2017; Leszczensky & Wolbring, 2022). We defined size of living space x_{it} as predetermined which means we assumed the current value of x_{it} is independent from all future errors ϵ but may be correlated with previous values of ϵ_{it}. Therefore, feedback effects from the current EDO frequency y_{it} on future observations of size of living space x are accounted for.

However, choosing this approach has two downsides for our analysis. Firstly, although recent works on econometric methods propose ways to estimate dynamic panel data models for binary or ordered responses (Honoré et al., 2025; Honoré & Weidner, 2025; Muris et al., 2025; Ouyang & Yang, 2025), none of these have been integrated into mainstream statistical software for applied researchers yet. Thus, we dichotomised the EDO frequency computing a binary response variable which indicates whether a person eats or drinks out at least weekly ($y_{it} = 1$) or less frequently ($y_{it} = 0$), and interpret the model results as linear probabilities, as is done in other studies applying the FE-CLPM (e.g. Hatcher et al., 2022; Chacón et al., 2025).

Secondly, estimation required considerable computational power, resulting in slow model convergence (see Allison et al., 2017). Therefore, we also fitted conventional FE-OLS models to test different model specification. For the FE-OLS models, which seem to perform well when estimating coefficients and standard errors in large-N-small-T situations (Kwak et al., 2023), the autoregressive parameter drops out of the equation:

$$y_{it} = \beta x_{it} + \delta w_{it} + \alpha_i + \mu_t + \epsilon_{it} \quad (2)$$

We used *R*'s *plm* and *dpm* packages to fit the models and estimated robust standard errors in order to handle the heteroscedastic nature of linear probability models (see Croissant & Millo 2008; Millo 2017; Croissant & Millo 2019; Long et al., 2024).

3.3. Independent variables

According to our research questions, the size of the living space was of key interest. This is why we tested several different variables (dwelling size, per capita living space, number of rooms, number of rooms per capita, judgement of living space adequacy and living space adjusted for household size using equivalence scales) to identify relationships with the frequency of EDO. It turned out that the size of the living space in square metres, adjusted for household size based on the modified OECD equivalence scale had the best explanatory power. This scale assigns a weight of 1 for the first adult in the household, 0.5 for each additional household member aged 14 or over, and 0.3 for each additional household member under 14 (OECD 2024). As hypothesised previously, we expected that the equivalised size of living space might need to be below a certain threshold to identify correlations with the frequency of EDO. Therefore, we sequenced the variable, testing different thresholds (τ) in 5 m^2 increments. Consequently, living space is represented by two linear variables: one indicating how many square metres a person's equivalised living space is below the defined thresholds τ (named 'square metres below τ'); and one variable, that indicates how many square metres a person's equivalised living space exceeds the threshold ('square metres above τ').

Fig. 2 illustrates the frequency distribution of living space consumption, equivalised based on OECD modified scale. It has implications for the interpretation of our results, which we will discuss later.

The length of time that people stay in a certain combination of dwelling size and household composition varies according to the size of the living space. On average, people residing in very confined conditions remain in these conditions for much shorter periods than those with larger equivalised living spaces (see Fig. 3). According to Fig. 3, changes in equivalised living space, particularly in cases where it is small, are highly likely to occur within the three- to six-year panel gaps in our sample. This is why we do not consider the lagged effects of equivalised living space size in our econometric analyses.

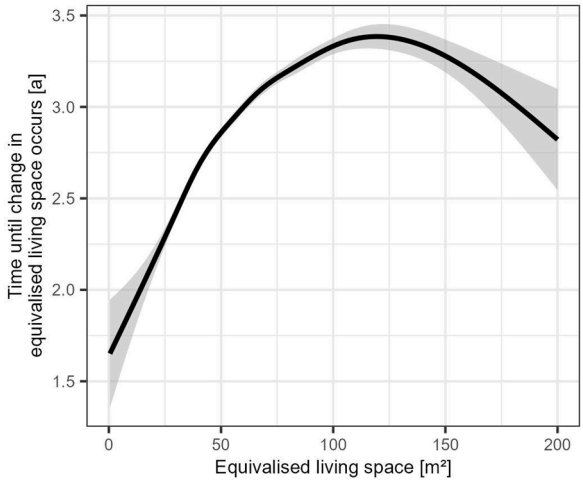

Fig. 3. Time until a person's size of living changes across equivalised living space (equivalised using OECD modified scale) in GSOEP waves 1995 to 2019. Source: GSOEP v39, authors' calculations.

We controlled for basic socioeconomics through household-type variables with single households representing the reference category and a 'married' dummy variable. Employment status was also considered through a dummy variable, which indicates whether the surveyed person works at least 30 h per week. The corresponding reference category thus mainly comprises individuals that are either senior citizens, part-time workers or unemployed persons receiving unemployment benefits. Further working-hour variables were also tested but dropped because they did not increase the goodness of fit of the models. Income was included as a continuous variable from which we deducted housing expenditures before equivalising based on the modified OECD scale. We also rescaled the computed variable so that an increase of one unit represents an increase of €500 in equivalised income after housing expenditure. We did not include variables for age and educational attainment, as these should be sufficiently accounted for by the individual- and period-specific fixed effects.

We fitted FE-OLS models to test various combinations of covariates which can control for properties of the built environment including further housing attributes. Among the tested variables were built environment dummies and grouped variables, which control for whether the

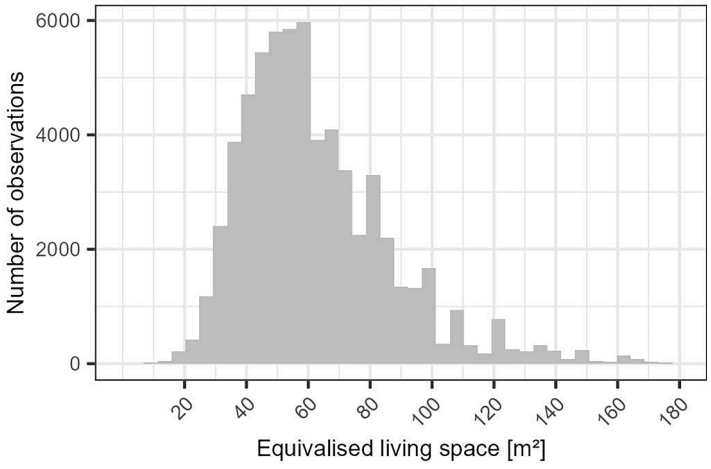

Fig. 2. Frequency distribution of equivalised living space (equivalised using OECD modified scale) in GSOEP waves 1995, 1998, 2003, 2008, 2013 and 2019. Source: GSOEP v39, authors' calculations.

residence is located in the centre of a major city or not (self-reported), and the self-reported walking distance to the nearest restaurant or pub. The natural logarithm of the population size at the place of residence was additionally included in the models. We used the logarithm of the population size because it increased the explanatory power of the models compared to model versions with a linear control. Additional housing attributes were represented via dummies that indicate whether the respondent lives in a dwelling with a balcony, terrace, or private garden access. The FE-OLS models, which included housing attributes and the logarithm of the population size at the place of residence had the best goodness of fit regarding AIC. Consequently, we dropped the 'residence located in city centre' dummy variable and the walking distance to the nearest restaurant or bar, since neither increased explanatory power nor had a statistically significant effect on EDO (see Appendix Table A2)

We hope to limit confounding due to pathway A by controlling for properties of the built environment and housing costs. To capture possible effects of relocations beyond changes of built environment properties, our models include a dummy variable indicating whether the surveyed individual moved within the last year, with non-movers used as the reference category.

4. Results

Before presenting the results of the econometric analyses, we first provide a descriptive overview of the relationship between EDO frequency and size of living space.

Fig. 4 illustrates how frequently individuals eat or drink out, depending on the size of their living space, equivalised according to the modified OECD scale. Generally, larger living spaces are associated with more regular EDO. However, this only applies to living spaces of 36–45 m^2 or larger. For smaller living spaces, the picture is reversed: the proportion of those who eat or drink out often (at least weekly) increases as the size of living space decreases. However, among those living with very limited space, the proportion of people who never participate in EDO is also larger.

While the descriptive analyses provide initial indications, size of livings space is obviously linked to other influencing factors, such as socioeconomics and further properties of the built environment. Econometric analyses help to control for these factors.

Table 4 presents seven dynamic panel models which were used to examine whether size of living space might need to be below a certain threshold to affect EDO. Root mean squared error of approximation (RMSEA) values of the models indicate very good model fits (RMSEA $<$ 0.05).

Estimates of all control variables' coefficients are stable across the models presented in Table 4. This means, changing the threshold of our two linear size of living space variables had almost no effect on the within effects of our controls. Within effects of socioeconomics largely align with expectations. The control variable, 'relocated within the last year', which is intended to capture the influence of having moved recently and the associated urge to explore the new neighbourhood, yields statistically significant, positive estimates. With regard to our built environment controls, relocating to a city with a larger population increases the probability of weekly EDO. When people move to a dwelling with access to a private garden and a private balcony or terrace, they participate in EDO less frequently which is an interesting finding for transport research into trip generation. However, this is not the emphasis of our paper.

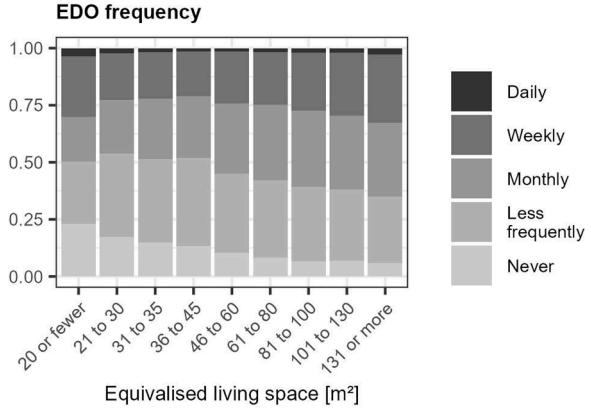

Fig. 4. Frequency of EDO across equivalised living space (equivalised using OECD modified scale) in GSOEP waves 1995, 1998, 2003, 2008, 2013 and 2019. Source: GSOEP v39, authors' calculations.

When examining the within effects of equivalised size of living space, we can see that its coefficients increase in magnitude when the threshold parameter τ is set at 25 m^2 or less. When resident's equivalised size of living space falls below 25 m^2, the EDO frequency increases with statistical significance at the 95 % level. The model with the best goodness of fit, with regard to Chi^2, is the one where we set the threshold τ to 20 m^2. This model will be used to exemplify the results.

In the context of panel data, the coefficients representing linear probabilities can be interpreted as follows: transitioning from living in a single-person household to a single-parent household decreases the probability of EDO at least weekly by approximately 5.2 %. Conversely, receiving a raise in income of €500 increases the likelihood of EDO at least once a week by around 0.6 %.

The results indicate, that for every square metre that equivalised living space falls below 20 m^2, there is a 1.4 % increase in the likelihood of an individual increasing their EDO frequency. This within effect is statistically significant at a 95 % confidence level. Reducing the equivalised living space from 20 m^2 to 15 m^2 thus would increase the predicted probability of weekly EDO around 7 % ($5 \times 0.014 = 0.07$). The same pattern is evident in the FE-OLS models, where the model with $\tau =$ 25 m^2 has the best goodness (see Table A3 in the appendix). Worth mentioning is that the FE-OLS models also show statistically significant within effects for downsizings, when the threshold τ is set to larger values. However, since these models cannot control for feedback effects and underlying relationships between covariates and latent factors, we think that the estimates of the dynamic panel models should be more reliable.

For the following discussion, it is helpful to consider the relationship between the size of a living space and residents' subjective judgement of its adequacy. Fig. 5 shows how residents judge the adequacy of their living space depending on how much space they consume. It illustrates that, among those with $<$25 m^2 of living space, over half evaluate their space conditions as 'too small' or 'much too small'. Intuitively, this proportion is substantially higher than that observed for larger sizes of living space per person. In the models where τ was set to 25 m^2 or fewer, the 'square metres below τ' variable therefore also indicates cramped space conditions in many cases, a fact that is important to bear in mind when discussing our econometric analyses.

5. Discussion

5.1. The link between size of living space and EDO

Our empirical analyses provided evidence that size of living space is linked to the EDO frequency of residents. However, it is important to note that, in the German context at least, the 25 m^2 threshold of equivalised living space below which correlations with EDO frequency occur should be classified as very small. Only very few people (1.3 % of all cases of our panel data sample) live in such confined conditions.

Although we did not model the causal direction of the link between size of living space and EDO, we will discuss the results in this regard. The modelling results can be interpreted as empirical support for hypothesised pathway B, which interprets increased EDO as a coping

Table 4
Results of the dynamic panel data models fitted via ML-SEM, $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

	$\tau = 15$ m²		$\tau = 20$ m²		$\tau = 25$ m²		$\tau = 30$ m²		$\tau = 35$ m²		$\tau = 40$ m²		$\tau = 45$ m²	
	Coefs.	s.e.	Coefs.	s.e.	Coefs.	s.e.	Coefs.	s.e.	Coefs.	s.e.	Coefs.	s.e.	Coefs.	s.e.
Equivalised living space														
Square metres below τ	0.023	0.013	0.014*	0.006	0.006*	0.003	0.002	0.002	0.001	0.001	0.000	0.001	0.001	0.001
Square metres above τ	−0.000	0.000	0.000	0.000	−0.000	0.000	−0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
EDO frequency (t-1)	0.159***	0.007	0.159***	0.007	0.159***	0.007	0.159***	0.007	0.159***	0.007	0.159***	0.007	0.159***	0.007
Access to private terrace/balcony and/or garden														
No terrace/balcony, no garden (ref.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Terrace/balcony, no garden	−0.010	0.008	−0.009	0.008	−0.009	0.008	−0.009	0.008	−0.009	0.008	−0.008	0.008	−0.009	0.008
Garden, no terrace/balcony	−0.019	0.010	−0.017	0.010	−0.016	0.009	−0.015	0.009	−0.014	0.009	−0.014	0.009	−0.015	0.009
Terrace/balcony and garden	−0.035***	0.009	−0.035***	0.009	−0.033***	0.009	−0.032**	0.009	−0.032**	0.009	−0.032***	0.009	−0.032***	0.009
Population at place of residence [10,000] (log)	0.005*	0.003	0.005*	0.003	0.005*	0.003	0.005*	0.003	0.005*	0.003	0.005*	0.003	0.005*	0.003
Household type *(ref.: single household)*														
Single Parent	−0.053***	0.012	−0.052***	0.012	−0.051***	0.012	−0.051***	0.012	−0.051***	0.012	−0.051***	0.012	−0.052***	0.012
Couple	−0.005	0.009	−0.004	0.009	−0.005	0.009	−0.005	0.009	−0.006	0.009	−0.006	0.009	−0.006	0.009
Couple with Children	−0.051***	0.010	−0.050***	0.010	−0.050***	0.010	−0.052***	0.010	−0.052***	0.01	−0.051***	0.010	−0.052***	0.010
Other	−0.046**	0.016	−0.045**	0.016	−0.046**	0.016	−0.048	0.016	−0.048**	0.016	−0.048**	0.016	−0.048**	0.016
Marital status *(ref.: not married)*	−0.119***	0.007	−0.118***	0.007	−0.119***	0.007	−0.118**	0.007	−0.118***	0.007	−0.118***	0.007	−0.118***	0.007
Income after housing costs [€500 s]	0.006***	0.001	0.006***	0.001	0.006	0.001	0.006***	0.001	0.006***	0.001	0.006***	0.001	0.006***	0.001
Employed *(ref.: not employed)*	0.008	0.005	0.008	0.005	0.008	0.005	0.008	0.005	0.008	0.005	0.008	0.005	0.008	0.005
Recently moved *(ref.: not moved)*	0.043**	0.013	0.042**	0.012	0.043**	0.013	0.042**	0.013	0.042**	0.013	0.042**	0.013	0.041**	0.013
Num.Obs.	64,219		64,219		64,219		64,219		64,219		64,219		64,219	
Chi^2	859.056		853.518		855.021		865.849		861.472		858.383		859.044	
RMSEA	0.007		0.007		0.007		0.007		0.007		0.007		0.007	
	90 % CI [0.006, 0.007]		90 % CI [0.006, 0.007]		90 % CI [0.006, 0.007]		90 % CI [0.006, 0.007]		90 % CI [0.006, 0.007]		90 % CI [0.006, 0.007]		90 % CI [0.006, 0.007]	
p(RMSEA < 0.05)	1		1		1		1		1		1		1	
SRMR	0.007		0.007		0.007		0.007		0.007		0.007		0.007	

Fig. 5. Judgement of living space adequacy of different groups in GSOEP waves 1995, 1998, 2003, 2008, 2013 and 2019. Source: GSOEP v39, authors' calculations.

mechanism for very low levels of private living space and capability constraints experienced at home. The fact that more than half of residents with <25 m² of equivalised living space judge their dwelling as too small indicates that coping with limited private space through more frequent EDO is often not a matter of preference, rather it is an economic necessity. In many cases, people might end up with very limited living space – often temporarily as Fig. 3 suggest – due to a lack of affordable alternatives in the location they prefer to live in. This interpretation implies a causal link where downsizing triggers outsourcing of activities.

However, among those residing with <25 m² of equivalised living space, approximately 40 % evaluate their dwelling as adequately sized. These people's downsizings may also be a result of economic trade-off decisions. However, for these residents living with limited private space while participating in EDO more frequently, seems to work well. Perhaps residents developed a stronger habit of EDO after downsizing as a coping mechanism. This would again imply causation from size of living space to EDO. An alternative explanation for this, which is also in line with the results of our econometric analysis, is that some people may have actively considered to increase EDO when deciding to downsize, knowing that the option of outsourcing activities exists. This would suggest simultaneous, reciprocal causation. Both explanations would be in line with the qualitative studies of Preece et al. (2023) and Richter et al. (2024).

Lastly, we cannot exclude the prevalence of reverse causation. For instance, people may increase their EDO frequency for reasons that our control variables and the latent variable do not account for. Spending more time out-of-home could lead them to downsize (even without economic necessity). If such – in econometric terms – a shock in EDO occurs in the panel gap before the change of living space occurs, our modelling approach accounts for this reverse causation by letting size of living space correlate with past residuals. If both, the shock and the downsizing it prompts happen in the same panel gap, this would cofound our estimate. However, existing research provides no evidence that exemplified changes in EDO frequency are a quantitatively relevant causal driver of changes in living space size (Sandberg 2018; Owen 2023; Preece et al., 2023; Richter et al., 2024).

Thus, increased EDO rather seems to be the result of downsizings than the reason for downsizings.

5.2. Implications for sufficiency strategies and housing policy

As discussed above, the link between downsizing and an increased frequency of EDO suggests that residents cope with limited private space

through outsourcing activities. Therefore, if the sufficiency strategies were to successfully shift consumption levels towards the proposed corridor for Germany (see Table 1), more activities would take place outside people's homes. Increased outsourcing could have positive effects on the liveability of neighbourhoods if it is complemented by good access to amenities and services, which urban and transport planning needs to enable. On the other hand, our descriptive analyses indicate that >50 % of those already residing in equivalised living spaces below the size of 25 m^2 where higher EDO frequency occur, evaluate their dwelling as too small. Generally, the proposed sufficiency corridor for Germany seems to be very ambitious, especially for single households, for which the ceiling is set to 35 m^2 of equivalised living space. Thus, despite the possibility to cope with limited living space through outsourcing activities, more people residing in small accommodation may lead to repercussions for mental health and well-being in many cases, a conclusion that aligns with the findings of Preece et al. (2023) and Hubbard (2025). Existing findings also point to the risk that induced trips could, depending on the chosen mode of transport, exacerbate negative transport-related externalities (Sorrell et al., 2020; Richter et al., 2024; Arceo et al., 2025a). Therefore, transport planners are tasked with mitigating the environmental rebound effects of downsizing.

However, 40 % of residents whose size of living space corresponds with higher EDO frequencies report that it meets their expectations. Thus, our findings could be used to draw an intriguing picture of residents who need little private living space, as much of their daily life takes place outside their own home. Such a picture implies notions of lively neighbourhoods and a sense of cohesion, which could be exploited by sufficiency strategies to challenge existing spatial norms (Sandberg 2018). And, given the increased space expectations (Hein & Kuhnimhof 2025) and the continued preference among younger generations for detached single-family homes in Germany (Frank 2020), challenging spatial norms appears to be an important aspect of sufficiency strategies.

As desirable as such norm shifts might be, existing research rather points to economic considerations or necessities prompting downsizings (Clinton 2018; Fuchs et al., 2021; Preece et al., 2023; Hubbard 2025). The outsourcing mechanism could also be used to justify the mitigating effect of high rental rates on living space consumption. We can already see this happening in the marketing strategies of so-called 'micro-living' developments. Advocates promote these small, often high-priced housing units for single households as the key to vibrant city life (Frank 2020; Harris & Nowicki 2020; Owen 2023). So, does the rise of micro-living in Germany (Hein 2021) exemplify a sufficient consumption transition (Cohen 2021), promoted by outsourcing of activities as compensation strategy?

Again, we must highlight that >50 % of people with an equivalised living space of <25 m^2, which is common in micro-living units (Hein 2021), experience their dwelling as 'too small' or 'much too small'. This example shows, how complex the policy implications of our findings are. In order to support downsizing towards the defined sufficiency corridor for Germany, it seems advisable to ensure access to amenities and services in residential neighbourhoods, an efficient transport system and quality design of public spaces. However, we still need a better understanding of the circumstances in which living in small spaces works well for residents without negatively affecting their health and well-being, and of the role that outsourcing activities plays in this regard. Until then, challenging norms by advocating to forego living space and frequent amenities outside the home more regularly seems to be unproblematic. Yet the 'compensation through outsourcing argument' could also be used to downplay the consequences of residents being forced to drastically reduce the amount of living space they consume due to affordability issues in many urban areas. Since high-priced, high-density rental accommodation has been booming in cities worldwide (see e. g. Harris & Nowicki 2020; Uyttebrouck et al., 2020; Hubbard 2025; Wang et al., 2025), this is also a relevant implication for geographical contexts beyond Germany.

With regard to the threshold we have identified, we do not know to what extent the 25 m^2 benchmark of increased outsourcing is transferable to other regions. Since expectations regarding dwelling size as well as spatial behaviour depend heavily on the spatial and cultural context, further studies are required.

5.3. Study limitations

Firstly, it is important to note that the presented results only cover individuals who are both willing and able to eat or drink out of home and who have access to a kitchen at home, enabling them to prepare meals at home. Our robustness checks show that, even when we include those who never eat or drink outside the home in the analyses, a statistically significant within effect is estimated for the size of living space (see Table A4 in the appendix). However, its magnitude is slightly lower. In contrast, including individuals without kitchens in the sample increases the statistical significance and the estimated magnitude of the within effects of downsizing on EDO (see Table A4).

The frequency of EDO is an interesting subject for investigating links between private space and how often people go out, because eating and drinking can take place both at home and outside the home. However, EDO tends to require more financial resources than consuming food and beverages at home. People living in very small spaces on low incomes may therefore be unable to outsource eating or drinking. Especially for these groups, further activities might be of higher relevance when coping with limited private space. For example, parks could be used for recreation or socialising with friends or relatives. For those working remotely, outsourcing labour tasks to libraries or cafés might be an option. The use of public spaces, such as playgrounds, is an additional aspect that could be explored when investigating the outsourcing idea for families with children, particularly in high-density urban neighbourhoods. Thus, considering further activities or an investigation of further variables, such as total time allocation for out-of-home activities, could provide additional insights. However, this was beyond the scope of our paper, as it would require additional data which covers spatial behaviour of individuals and properties of the built environment.

The GSOEP's use of subjective assessments via ordinal responses to survey EDO entails additional inaccuracies, such as a tendency to overestimate frequency of activity, which is why objective measurements are more preferable (Xiong et al., 2024). Ordinal scaling also results in the loss of further information: the response category 'at least weekly', for example, groups together people who eat or drink out once a week with those who do so six times a week — i.e. six times more often. The large differences between the ordinal EDO frequency categories on which our analyses are based could make it difficult to identify correlations with housing attributes.

It should also be noted that the GSOEP data allows only limited control of built environment properties. We tested all available built environment variables ('access to private terrace/balcony and/or garden', 'population of place of residence' and 'residence located in city centre') and used the combinations with the highest explanatory power. However, the built environment variables are probably unable to capture all the variance in built environment properties. We cannot rule out that the remaining variance may also be partially captured by our living space variables.

Lastly, we were unable to account for some of the determinants of EDO mentioned in existing studies, such as commuting duration, car availability, working from home, time use for other activities and walkability of the neighbourhood, because the GSOEP waves in which these variables were surveyed do not coincide with those that captured the frequency of EDO. Especially, car availability might be relevant, since gaining vehicle access directly improves a resident's ability to explore EDO options beyond their immediate neighbourhood. In addition, working from home is likely to affect both EDO frequency (Haddad et al., 2023) and the space expectations of residents (Qin et al., 2021).

6. Conclusions

Our study is the first to quantitatively identify correlations between size of living space and participation in out-of-home activities. We found that confined size of living space, is associated with higher EDO frequencies. Informed by theory and existing findings, we interpreted the results of our panel data analysis as indication that residents frequent out-of-home services and amenities, such as restaurants, pubs or bars, to cope with limited private space and capability constraints experienced at home. This interpretation suggests a causal link from changes in size of living space to changes in EDO or reciprocal causation, which should be investigated by further research. Our findings could also apply to other out-of-home activities whose frequency has been found to correlate with EDO (Spissu et al., 2009; Colaço & e Silva 2025).

On the one hand, the findings provide a basis for promoting smaller dwellings that are complemented by rich neighbourhood amenities and services. And in fact, developers of micro-living already use the 'compensation through outsourcing argument' to promote new apartment complexes. However, it is important to recognise that such a strategy of downsizing while relying on outsourcing of activities to cope with minimal private space could potentially exacerbate residents' feelings of overcrowding or deprivation (Hubbard 2025). When promoting housing sufficiency, policymakers must carefully balance spatial efficiency with residential dignity and well-being.

We found a link between the size of living spaces and EDO frequency, but we do not know whether a higher frequency of out-of-home activities affects space expectations. Since residing in an equivalised living space of <25 m^2, a size at which higher EDO frequencies occur, is accompanied by a substantial proportion of residents judging their space conditions as too small, we believe that the influence of outsourcing activities on space expectations and well-being should be the focus of future research. Ideally, future studies should include a wider range of activities and use objective measurements of activity rather than subjective, ordinal measurements. The design qualities of dwellings and the built environment could also influence residents' expectations regarding size of living space.

CRediT authorship contribution statement

Simon Hein: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Conceptualization. **Tobias Kuhnimhof:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

None.

Acknowledgements

This study forms part of Simon Hein's doctoral research and has not received any external funding or grants.

Appendix

Table A1
Basic socio-economic statistics of a sample including all observations with valid EDO responses (left); and, a sample after filtering out cases for which not all control variables were captured due to missing or implausible responses (right). Source: SOEP v39, authors' calculations.

	Sample with all obs. (age $\geq$ 18) and basic information available (n = 120,902)							Sample after filtering out obs. with missing responses (n = 94,856)						
	n	Mean (or distribution)	SD	Min	Pctl. 25	Pctl. 75	Max	n	Mean (or distribution)	SD	Min	Pctl. 25	Pctl. 75	Max
EDO frequency														
… Daily	1,972	2 %						1,297	2 %					
… Weekly	26,246	22 %						18,578	20 %					
… Monthly	37,814	31 %						29,772	30 %					
… Less frequently	41,591	35 %						36,323	38 %					
… Never	13,279	11 %						8,886	11 %					
Sex														
… Female	58,790	49 %						44,439	48 %					
… Male	62,112	51 %						50,417	52 %					
Age		50	18	18	34	60	103		53	17	18	39	64	102
Household size		2.4	1.2	1.0	2.0	4.0	16.0		2.4	1	1	2	4	13
Employment status														
… Employed	69,792	56 %						50,274	53 %					
… Not employed	51,110	44 %						44,582	47 %					
Household income		2,485	3,449	35	1,540	3,500	1700,000		2439	1,659	72	1,680	3,500	200,000
Migration background														
… No	90,353	83 %						55,113	86 %					
… Yes	30,549	17 %						39,743	14 %					
Educational attainment														
… General elementary	16,224	15 %						11,121	14 %					
… Middle vocational	57,418	53 %						49,052	54 %					
… Vocational	7,164	6 %						5,220	5 %					
… Higher vocational	7,546	7 %						7,028	7 %					

(*continued on next page*)

Table A1 (*continued*)

	Sample with all obs. (age ≥ 18) and basic information available (n = 120,902)							Sample after filtering out obs. with missing responses (n = 94,856)						
	n	Mean (or distribution)	SD	Min	Pctl. 25	Pctl. 75	Max	n	Mean (or distribution)	SD	Min	Pctl. 25	Pctl. 75	Max
… Higher education	25,990	18 %						20,944	18 %					
… Inadequate	6,560	2 %						1,491	1 %					
Population at place of residence														
… 2,000 or fewer	8,734	7 %						8,115	8 %					
… 2,000 to 5,000	11,209	9 %						9,479	9 %					
… 5,000 to 20,000	30,474	25 %						24,202	25 %					
… 20,000 to 50,000	22,234	18 %						16,938	18 %					
… 50,000 to 100,000	11,043	9 %						8,146	9 %					
… 100,000 to 500,000	19,710	17 %						14,848	16 %					
… 500,000 or more	17,498	16 %						13,128	16 %					

Table A2
Goodness of fit of FE-OLS estimation for various combinations of built-environment control variables.

Variables included	Base	Model.1	Model.2	Model.3	Model.4	Model.5	Model.6	Model.7	Model.8	Model.9	**Model.10**	Model.11	Model.12	Model.13	Model.14	Model.15
Size of living space	x	x	x	x	x	x	x	x	x	x	**x**	x	x	x	x	x
Socioeconomics	x	x	x	x	x	x	x	x	x	x	**x**	x	x	x	x	x
Walking distance to restaurant or bar		x				x	x	x				x	x	x		x
Residence in city centre			x			x			x	x		x	x		x	x
Population at place of residence [10,000] (log)				x			x		x		**x**	x		x	x	x
Access to private terrace/ balcony and/ or garden					x			x		x	**x**		x	x	x	x
Num.Obs.	64,219	64,219	64,219	64,219	64,219	64,219	64,219	64,219	64,219	64,219	**64,219**	64,219	64,219	64,219	64,219	64,219
AIC	18,748.6	18,748.9	18,746.2	18,743.8	18,736.7	18,746.8	18,744.8	18,737.7	18,743.1	18,735.6	**18,762.9**	18,744.3	18,736.8	18,735.7	18,734.6	18,735.8
ΔAIC.Base	-	0.3	−2.4	−4.8	−11.9	−1.8	−3.8	−10.9	−5.5	−13	**−14.3**	−4.3	−11.8	−12.9	−14	−12.8

Table A3
Results of the FE-OLS panel data models, *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

	τ = 15 m²		τ = 20 m²		τ = 25 m²		τ = 30 m²		τ = 35 m²		τ = 40 m²		τ = 45 m²	
	Coefs.	s.e.	Coefs.	s.e.	Coefs.	s.e.	Coefs.	s.e.	Coefs.	s.e.	Coefs.	s.e.	Coefs.	s.e.
Equivalised living space														
Square metres below τ	0.028*	0.014	0.014**	0.005	0.007*	0.003	0.003*	0.001	0.002***	0.001	0.001***	0.000	0.001**	0.000
Square metres above τ	−0.000	0.000	−0.000	0.000	−0.000	0.000	−0.000	0.000	−0.000	0.000	−0.000	0.000	−0.000	0.000
Access to private terrace/balcony and/or garden														
No terrace/balcony, no garden (ref.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Terrace/balcony, no garden	−0.011	0.010	−0.011	0.010	−0.010	0.010	−0.010	0.010	−0.010	0.010	−0.010	0.010	−0.010	0.010
Garden, no terrace/balcony	−0.013	0.007	−0.013	0.007	−0.013	0.007	−0.012	0.007	−0.012	0.007	−0.012	0.007	−0.012	0.007
Terrace/balcony and garden	−0.029***	0.008	−0.029***	0.008	−0.029***	0.008	−0.028***	0.008	−0.028***	0.008	−0.028***	0.008	−0.028***	0.008
Population at place of residence [10,000] (log)	0.007*	0.003	0.007*	0.003	0.007*	0.003	0.007*	0.003	0.007*	0.003	0.006*	0.003	0.006*	0.003
Household type *(ref.: single household)*														
Single Parent	−0.066***	0.010	−0.065***	0.010	−0.065***	0.010	−0.065***	0.010	−0.065***	0.010	−0.066***	0.010	−0.066***	0.010
Couple	−0.003	0.012	−0.003	0.012	−0.003	0.012	−0.003	0.012	−0.003	0.012	−0.003	0.012	−0.004	0.012
Couple with Children	−0.062***	0.010	−0.062***	0.010	−0.062***	0.010	−0.063***	0.010	−0.063***	0.010	−0.064***	0.010	−0.064***	0.010

(*continued on next page*)

Table A3 (*continued*)

	$\tau = 15$ m²		$\tau = 20$ m²		$\tau = 25$ m²		$\tau = 30$ m²		$\tau = 35$ m²		$\tau = 40$ m²		$\tau = 45$ m²	
	Coefs.	s.e.	Coefs.	s.e.	Coefs.	s.e.	Coefs.	s.e.	Coefs.	s.e.	Coefs.	s.e.	Coefs.	s.e.
Other	−0.042*	0.017	−0.043*	0.017	−0.043*	0.017	−0.044*	0.017	−0.044**	0.017	−0.044**	0.017	−0.045**	0.017
Marital status *(ref.: not married)*	−0.135***	0.014	−0.135***	0.014	−0.135***	0.014	−0.135***	0.014	−0.135***	0.014	−0.134***	0.014	−0.134***	0.014
Income after housing costs [€500 s]	0.008**	0.003	0.008**	0.003	0.008**	0.003	0.008**	0.003	0.008**	0.003	0.008**	0.003	0.008**	0.003
Employed *(ref.: not employed)*	0.006	0.004	0.006	0.004	0.006	0.004	0.006	0.004	0.006	0.004	0.006	0.004	0.006	0.004
Recently moved *(ref.: not moved)*	0.043***	0.012	0.043***	0.012	0.043***	0.012	0.043***	0.012	0.043***	0.012	0.043***	0.012	0.043***	0.012
Num.Obs.	64,219		64,219		64,219		64,219		64,219		64,219		64,219	
AIC	18,763.3		18,763.4		18,762.9		18,768.6		18,768.0		18,768.0		18,769.1	
RMSE	0.27		0.27		0.27		0.27		0.27		0.27		0.27	

Table A4
Additional dynamic panel data models fitted via ML-SEM (robustness checks), *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

	Persons, who never eat or drink out included in sample				Persons without kitchens included; and, Persons residing in retirement homes/student dormitories included in sample			
	$\tau = 20$ m²		$\tau = 25$ m²		$\tau = 20$ m²		$\tau = 25$ m²	
	Coefs.	s.e.	Coefs.	s.e.	Coefs.	s.e.	Coefs.	s.e.
Equivalised living space								
Square metres below τ	0.010*	0.005	0.005*	0.002	0.015**	0.005	0.007*	0.003
Square metres above τ	−0.000	0.000	−0.000	0.000	−0.000	0.000	0.000	0.000
EDO frequency (t-1)	0.162***	0.007	0.160***	0.007	0.157***	0.007	0.157	0.007
Access to private terrace/balcony and/or garden								
No terrace/balcony, no garden (ref.)	-	-	-	-	-	-	-	-
Terrace/balcony, no garden	−0.005	0.007	−0.007	0.007	−0.010	0.008	−0.010	0.008
Garden, no terrace/balcony	−0.010	0.008	−0.011	0.008	−0.018	0.010	−0.016	0.009
Terrace/balcony and garden	−0.027***	0.008	−0.027***	0.008	−0.034***	0.009	−0.031***	0.009
Population at place of residence [10,000] (log)	0.006*	0.002	0.006*	0.002	0.005*	0.003	0.005*	0.003
Household type *(ref.: single household)*								
Single Parent	−0.047***	0.010	−0.047	0.010	−0.053***	0.012	−0.052***	0.011
Couple	−0.002	0.008	−0.002	0.008	−0.004	0.009	−0.004	0.009
Couple with Children	−0.048***	0.010	−0.049***	0.009	−0.051***	0.010	−0.052***	0.010
Other	−0.045**	0.014	−0.048***	0.014	−0.048**	0.016	−0.049**	0.016
Marital status *(ref.: not married)*	−0.113***	0.006	−0.114***	0.006	−0.120***	0.007	−0.120***	0.007
Income after housing costs [€500 s]	0.006***	0.001	0.006***	0.001	0.006***	0.001	0.006***	0.001
Employed *(ref.: not employed)*	0.009	0.004	0.010	0.004	0.008	0.005	0.008	0.005
Recently moved *(ref.: not moved)*	0.040**	0.012	0.036**	0.012	0.037**	0.013	0.039**	0.013
Num.Obs.	74,351		74,351		65,151		65,151	
Chi^2	903.565		900.405		859.021		861.608	
RMSEA	0.007		0.007		0.007		0.007	
	90 % CI [0.006, 0.007]		90 % CI [0.006, 0.007]		90 % CI [0.006, 0.007]]		90 % CI [0.006, 0.007]	
p(RMSEA < 0.05)	1		1		1		1	
SRMR	0.007		0.007		0.007		0.007	

Data availability

The authors do not have permission to share data.

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