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Distances in common: (Un-)Balanced Access to Public Infrastructure in Germany

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Abstract

Public infrastructure shapes everyday opportunities, yet little is known about how balanced access to work, social reproduction, and leisure as public commons is distributed across households. Existing studies typically assess single services or regional averages, overlooking the relational nature of accessibility of public commons and differences in households' ability to privately substitute for missing public commons.

We use German SOEP microdata to construct the relative distance for the three public commons and map households into a ternary space that captures their compositional accessibility. We also develop a Private Substitution Index that identifies the extent to which households rely on private substitutes to offset gaps in public infrastructure. Together, these measures reveal how households position themselves when facing infrastructural trade-offs.

Most households exhibit relatively balanced access, but this average masks clear patterns: some live close to work and far from the other public commons, others show the opposite tilt. Urban–rural differences are substantial, while East–West differences are modest. Private substitution capacity rises steeply with income, driven by remote-work feasibility and living-space advantages, whereas public substitution in social reproduction remains limited.

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These findings show that balanced access to public commons is highly uneven and cannot be understood through single amenities or regional summaries. Policies aimed at spatial justice must consider both positional trade-offs and unequal capacities for private substitution.

1 Introduction

Access to public infrastructure, such as schools, childcare, and healthcare services, is a key foundation for social cohesion and territorial justice. Despite the balanced provision of public services being a main objective of German policy, the unbalanced accessibility between regions and social groups persists in Germany (Aretz et al., 2024; Albrech et al., 2015; Wüstemann et al., 2017).

Research on inequality has traditionally focused on the distribution of private resources such as income and wealth. Public resources in the form of infrastructure and services have received comparatively little attention. Yet, these public resources are fundamental to structuring everyday life. Public infrastructure affects not only material well-being but also the capacity for participation in the spheres of work, social reproduction, and leisure. Understanding how access and potential substitution to these domains is distributed is essential for identifying new forms of spatial and social inequality.

This study adopts a distributional perspective on public infrastructure by analyzing the availability and private substitution of public commons on the household level. We categorize these core services into work, leisure and social reproduction based on which we assess the spatial balance of these domains in everyday life. We evaluate how equally each household can access all three domains within its immediate environment, rather than measuring regional service density. We combine publicly provided services and private facilities that serve a public purpose. Such private entities with a public purpose are banks, shops and restaurants as they are considered as essential to everyday life (Bentham et al., 2013). Our focus goes beyond the general accessibility of the public commons as we highlight the balanced accessibility of the different dimensions of public commons. We emphasize the accessibility as a spatial concept of supply and not as the *de facto* possibility to access, and finally demand, a facility or service. We contrast the supply side of the public commons with a demand-sided private substitution index, in which we synthesize the ability to compensate for missing public commons through private means such as size of living space, ability to work from home and private external care of children and elderly. We move on from the pure provision and availability of resources towards an integrated understanding of public commons as a heterogeneous formation of social capital. This highlights that access to public commons must be understood as a relational outcome rather than a fixed geographic fact (Bebbington and Perreault, 1999).

We address two questions. First, we explore how patterns of accessibility vary across socio-economic groups, particularly by income and region. Second, we investigate whether limited access to public commons is compensated through private substitutes. Private substitutes are acquired in the market with a clear focus on rivalrous and ex-

cludable consumption. These private substitutes can include private care for children or elders, or private green space in the form of a garden. Our approach incorporates such contextual factors, aiming to distinguish between public commons and private substitutes.

Methodologically, we combine distributional analysis with spatial and socio-economic disaggregation using data from the German Socio-Economic Panel (GSOEP). Our analysis centers on distances from home to selected proxies for work, social reproduction, and leisure. We map these compositional distances to capture spatial trade-offs and imbalances at the household level in ternary plots. This allows us to investigate whether a household's location supports a balanced distribution across the three domains or whether structural characteristics result in prioritization of one domain at the cost of the other two domains.

Our results suggest that access to the three domains is heterogeneous across the population. Some households maintain relatively balanced access across all three dimensions. The majority of households face an imbalance that reflects spatial constraints and the differing capacities to compensate public commons with private substitutes. While the access to public commons remains balanced across socio-economic factors, the ability to substitute depends highly on socio-economic aspects. Especially a high net-equivalent income is the driving factor for households to privately substitute for the lack of public commons. Our findings highlight the need for a policy perspective that addresses accessibility as a relational and household-specific issue. It is important to stress the implications for spatial justice and the future of welfare infrastructure in an increasingly heterogeneous society.

To analyze the balanced access to public commons in a tripartite structure for Germany, we first review existing research on the regional distribution of public services. We embed the conceptual framework of our analysis into the wide range of literature of the provision of public commons and the possibility of private substitutes. We move on with an overview of our methods and data, leading with descriptive statistics into our results section. We conclude the paper by discussing the positional trade-off between the different public commons a household faces based on socio-economic characteristics and the ability to compensate for public commons with private substitutes.

2 The Distribution of Public Commons in Germany

The availability and accessibility of public infrastructure have long been considered crucial to welfare state functioning and spatial cohesion. Public services such as education, childcare, healthcare, and green spaces are typically provided under the principle of universality. However, their distribution varies considerably across space and population

groups. This variation contributes to what has been termed infrastructural or territorial inequality (Pandey et al., 2022; Pandey et al., 2025). The focus of this territorial inequality lies on the fact that an individual's ability to access essential services depends on their place of residence.

Territorial inequalities arise not merely because some regions sit closer to essential services than others, but because the local environment shapes how infrastructures can be transformed into real, usable opportunities. Public commons gain meaning only when people can effectively convert them into actions that enhance their well-being, and this conversion capacity varies widely across places (Grillitsch et al., 2025). Social embeddedness further modulates access: spatial proximity does not guarantee equal use if information channels, support networks, or informal entry points favour certain groups. Economic dynamics reinforce these divides (Weber and Schulz, 2025), reshaping local opportunity structures in ways that public policy struggles to counterbalance. Capability constraints, social barriers, and agglomeration pressures illuminate why infrastructures may be evenly planned on paper yet unevenly effective in practice (Wessel, 2022).

In the German context, several studies have documented persistent regional inequality in public commons. Childcare availability remains significantly higher in East Germany compared to the West (Mätzke, 2019; Vitt, 2025). A substantial share of rural households lack access to childcare within walking distance (Neumeier, 2019). Access to public commons like childcare or access to general practitioners correlates with socio-economic characteristics like unemployment rate (Neumeier, 2017; A. Pennerstorfer and D. Pennerstorfer, 2021; Aretz et al., 2024). Socio-economic characteristics also intersect with spatial inequalities. Households with lower income levels tend to reside further away from essential services (Riedel et al., 2020), and urban green spaces (Wüstemann et al., 2017). Evidence shows further that social-spatial inequality has been increasing recently due to lower status areas falling further behind (Kadi et al., 2022).

Existing approaches often map infrastructural inequality based on aggregated indicators of regional service density or typologies of service-rich and service-poor clusters (Sonnenburg, 2022; Fink et al., 2019; Albrech et al., 2015). These cluster approaches offer important insights into macro-level disparities but obscure intra-regional inequalities and the lived experience of accessibility at the household level. This resonates with Grillitsch et al. (2025), who conceptualize regional 'opportunity spaces' as unevenly distributed, shaping the scope of agency individuals and households have to overcome structural constraints. Households with similar incomes experience very different accessibility profiles depending on their specific location within a city or region (Groh-Samberg et al., 2020).

Patterns of regional inequality in Germany are complex and defy a simple urban–rural or East–West divide. Germany is shaped by persistent core cities, which remain strong (Heider et al., 2024; Bentlage et al., 2021) and increasing (Heidinger et al., 2025) employ-

ment hubs as centers of commuting patterns (Patuelli et al., 2010). People with more complex jobs accept higher commute distances, if they find better fitting and paying jobs (Dauth and Haller, 2016). This development coexists with a suburbanization driven by increasing housing costs and rents (Siedentop, 2024), with people wanting to increase their space and live in a greener environment (Bauer et al., 2022). Within this context, poverty rates are especially high in fast-growing, high-cost cities, where low-income households are disproportionately concentrated in neighborhoods with inadequate public infrastructure (Gohla and Hennicke, 2023).

3 Conceptual Approach

A balanced and equitable provision of infrastructure across the territory is a central objective of German policy. The Federal Spatial Planning Act (*Raumordnungsgesetz* 2008) stipulates that "in the overall territory of the Federal Republic of Germany and in its subregions, balanced social, infrastructural, economic, ecological, and cultural conditions are to be pursued. [...] These tasks are to be fulfilled equally in metropolitan as well as rural areas, and in structurally weak as well as structurally strong regions." Based on this political objection, we treat the local provision of basic services as a core function of the welfare state. This supply-side perspective allows us to abstract from heterogeneity in households' needs. The abstraction of household needs implies the premise that households will not be required to move under changing life circumstances, when these services, like child or elderly care, will be actively required. The necessary public commodities should be provided in the first place. Consistent with this supply-side perspective, we weight the different public commodities equally and intentionally do not consider household-specific priorities.

We analyze the relative distance to all three spheres, not the absolute distance to the public commons. This prevents us from having outliers (households living very remotely) as we scale their absolute distance to a relative position in a ternary space. We abstract from the preference of households to live close to all public commons and focus on the unbalanced distribution of the public commons. If an unequal provision of the commodities is given, the preference of a household for a specific public commodity comes at the cost of the other commodities. This trade-off leads to an unbalanced positioning of households, allowing us to focus on socio-economic restrictions and structural dependencies.

We focus on the "part of the economy that creates and distributes goods and services consumed by all (regardless of income and status) because they support everyday life" (Bentham et al., 2013). The essential infrastructure includes utilities, food, banking, retail, health services, education and other social services. The essential infrastructure

is not necessarily provided solely through the state but, like in the case of supermarkets and banks, through private entities which may have a focus on profits and profitability. Independent of the nature of the provision, the essential infrastructure provides a public purpose. Due to zoning regulations in Germany, the state has an impact on the provision of privately owned infrastructure as it can actively design zoning for commercial businesses. We therefore combine all essential infrastructure under the umbrella term of public commons to highlight their public purpose.

We group services into three dimensions, *social reproduction*, *leisure*, and *work*. Following Fraser (2016) *Social Reproduction*, is the non-market provisioning and care activities that sustain and renew people (and the labour force) and social bonds on a daily and generational basis, building the foundation of production. It comprises processes, activities, and institutions such as care for elders and children, housework, education and training, health care, and the community. We combine public childcare, schools, doctors, banks, and shops to form the social-reproduction dimension.

Leisure is the portion of socially available time remaining after the production and reproduction of labor-power. It encompasses rest, sociability, cultural and political participation, play, and self-development (Veal, 2019). We classify restaurants, youth centers, public green spaces, sports facilities, and facilities for older people as leisure infrastructure. We consider only paid work as *work* in the sense of a public common that work generates a labor income. Unpaid work, voluntary engagement and other forms of work lie in the other two dimensions.

In addition to the relative distribution of public commons, we analyze the distribution of private substitutes. Private substitutes reflect a household's ability to compensate for gaps in the provision of public commons. Some public commons are close to public goods and difficult to supply privately, but many services can, in principle, be delivered through public and/or private channels. Hence, the scope and responsibility of public provision are continually contested and reconfigured. Childcare is illustrative: only in the past two decades has it become widely institutionalized as a public responsibility in West Germany, shifting from predominantly female-based, unpaid labor to formal state provision. At the same time, it remains possible for high-income households to access private daycare, private schools, or even private staff like nannies or tutors to substitute privately for public commons.

These private substitutes must be incorporated into the analysis, as the access and use of such private substitutes can cancel out the distance to the public commons. While public services are designed for universal access, households differ markedly in their capacity to substitute for, or privately compensate, deficiencies in public provision. This capacity for substitution depends on the wealth and income level of a household (Nobis and Kuhnimhof, 2018; Holm et al., 2021; Goebel et al., 2024). For rich households, a

lack of public service can be privately substituted and compensated for. Households with higher incomes are able to mitigate limited public provision through private alternatives, such as private childcare, private healthcare services, or compensating public green space with private gardens. Conversely, households without such resources are more dependent on the proximity and quality of public services. Rising competition for central urban space reduces the ability of lower-income households to compensate for locational disadvantages, reinforcing uneven substitution capacities (Wessel, 2022). Differences in the ability or inability to compensate amplify underlying inequalities, creating what has been referred to as multidimensional deprivation (Atkinson, 2003; Parks, 2004). Table 1 maps selected public service domains to potential forms of private compensation.

Table 1: Public Commons and Private Substitution Mechanisms

Category	**Public Commons**	**Private Substitute**
Work	Distance to workplace	Home office
Social Reproduction	Childcare	Family-based care, babysitting services, private daycare
	Schools	Private schools, private tutoring
	Health care	Private health insurance, out-of-pocket services
	Elderly care	Family-based care, private nursing homes, live-in caregivers
Leisure	Parks / Green Spaces / Playgrounds	Private gardens, private recreational areas
	Sports facilities	Private gyms, private memberships

4 Data

Our analysis is based on the German Socio-Economic Panel (GSOEP) (SOEP-Core v38.1, 2023), a longitudinal household survey that has been conducted annually since 1984. It provides comprehensive microdata on individuals and households in Germany. We exclude the migration and refugee sample (M1-M5) from the analysis as the distance variables are not included in that sample. We restrict the sample to individuals in employment, as we otherwise cannot observe the distance to work. Overall, our sample contains over 16 260 observations.

Our analysis is based on the available distance variables as presented in Table 2. The variables are recorded every 5 years, with the most recent survey wave from 2019. Our analysis is based on a variety of distance variables, which are all encoded as discrete

ordinal categories. $\mathbf{L}_i$ encompasses the leisure variables and $\mathbf{SR}_i$ the social reproduction variables. The variables in $\mathbf{L}_i$ and $\mathbf{SR}_i$ represent durations in minutes on foot, recorded on a discrete ordinal scale ("Less than 10min", "10-20 min", "Greater than 20 min", "None In The Area/ Not Reachable On Foot"). Distance to work ($\mathbf{W}_i$) is given in minutes without clarification of the means of transportation. We translate the commute time to work into the same discrete ordinal categories.

Table 2: Distance to Services and Facilities by Foot – Percentage Share of Households

Facility	**< 10 min**	**10–20 min**	**> 20 min**	**NA**
Work	31.3	28.9	39.8	
Social Reproduction				
Shops	60.4	23.9	7.0	8.8
Banks	55.0	26.6	8.7	9.7
General practitioner	45.1	26.5	11.8	16.7
Kindergarten	61.5	25.5	6.8	6.2
Primary school	53.1	28.6	9.0	9.3
Secondary school	22.6	25.7	17.4	34.3
Leisure				
Restaurants	64.8	23.4	6.0	5.8
Youth center	39.2	31.0	11.4	18.5
Facility for elderly	39.2	28.3	12.4	20.1
Public green spaces	69.2	19.7	4.8	6.3
Sport facilities	52.6	31.4	10.0	6.1
Public transport	89.8	8.6	0.8	0.8

Note: Shares within each facility sum to 100. **Data:** Authors' calculations based on SOEP-Core v38.1 (2023), weighted.

5 Method

We conceptualize individual behavior in terms of temporal distances to core spheres of everyday life: leisure, social reproduction, and work. The different individual public commons are weighted by the root mean square (RMS) to balance their different distances across the multi-dimensional availability of public commons. The Private Substitution Index (PSI) captures for each household its ability to substitute public commons with goods and services that are acquired in the market.

5.1 Ternary Plots

Ternary plots allow the visual expression of the compositional distances to the three necessities, work, leisure and social reproduction, at the same time. We are able to express

the *balance* between those three factors rather than focusing on single aspects and individual trade-offs due to the three-dimensional nature of the plots. Ternary plots do not present absolute access levels as the relative distances must be normalized to one. Each point represents a household, with its distance to a specific dimension. By construction, higher values on any axis represent greater distance from the corresponding domain relative to the other dimensions, reflecting an unbalanced accessibility. A household positioning itself toward a vertex indicates comparatively better access to that specific public common. Such a positioning closer to a specific public common comes by definition at the cost of moving relatively farther away from the other two public commons. Two households can lie at the simplex center, implying equal relative distance to all three, while differing in absolute travel times (e.g., 5 vs. 20 minutes to each).

Let each observation i be characterized by three sets of variables:

- $\mathbf{L}_i = \{l_{i1}, l_{i2}, ..., l_{im}\}$ for leisure,
- $\mathbf{S}_i = \{s_{i1}, s_{i2}, ..., s_{in}\}$ for social reproduction,
- $\mathbf{W}_i = \{w_i\}$ for work.

For each of these three dimensions, we calculate the root mean square distance. We normalize these three distances to $(\tilde{d}_i^{\text{leisure}}, \tilde{d}_i^{\text{sr}}, \tilde{d}_i^{\text{work}})$ so that we can display the balance in distances in a ternary plot.

Leisure consists of four components. It combines the distance on foot to restaurants, to youth meeting place, to public park/space and to sporting facilities. The leisure distance d_i^{leisure} is computed as the RMS distance from the place of living as the fixed reference point:

$$d_i^{\text{leisure}} = \sqrt{\frac{1}{m}\sum_{j=1}^{m} l_{ij}^2}$$

As social reproduction, we classify the distance on foot to shops, to banks, to doctors, to kindergarten, to primary school, to grammar school and to elderly facilities.

$$d_i^{\text{sr}} = \sqrt{\frac{1}{n}\sum_{j=1}^{n} s_{ij}^2}.$$

Work consists of only one component, the distance to work itself. The three dimensions consist, therefore, of an unequal number of components. The use of RMS prevents the number of components from having an impact on the overall distance of each of these

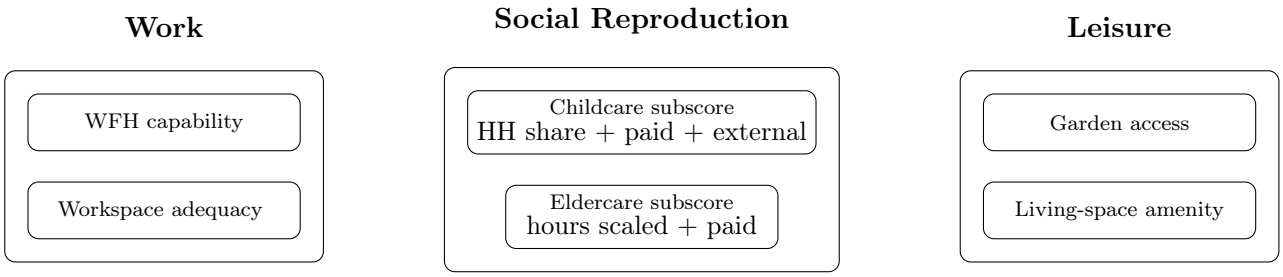


Figure 1: Structure of the Private Substitution Index (PSI).

Note: The figure shows the set-up of the Private Substitution Index for each specific public common area.

three dimensions. To analyze the relative contribution of each distance component, all distances are jointly normalized to lie on the 2-simplex. The normalization factor ϕ is derived individually for each household as$\phi_i = d_i^{\text{leisure}} + d_i^{\text{sr}} + d_i^{\text{work}}$. It holds that:

$$\tilde{d}_i^{\text{leisure}} = \frac{d_i^{\text{leisure}}}{\phi_i},$$
$$\tilde{d}_i^{\text{sr}} = \frac{d_i^{\text{sr}}}{\phi_i},$$
$$\tilde{d}_i^{\text{work}} = \frac{d_i^{\text{work}}}{\phi_i}$$

This transformation guarantees that for each observation i, the normalized distances sum to unity:

$$\tilde{d}_i^{\text{leisure}} + \tilde{d}_i^{\text{sr}} + \tilde{d}_i^{\text{work}} = 1$$

The result is a compositional vector suitable for visualization and further analysis in the ternary coordinate system.

5.2 Private Substitution Index

The household-level Private Substitution Index (PSI) captures the capacity to compensate for missing public services along the three domains of work, social reproduction and leisure (see Figure 1). Each domain is equally weighted, contributing one-third to the overall index. This mirrors the equal weight that is applied to the three dimensions of public commons.

Work domain

The ability to compensate for the time to commute to work depends on two aspects: first, if the nature of the job allows for work from home. Many jobs do not allow for work from home due to the need of specific machinery or in-person interaction with patients or customers. Second, a person's living space must be suitable to allow working from home. The place of living must have an adequate size that allows for work time without impacting the necessary space for living. Only if both criteria are strictly fulfilled, private compensation of the work domain is reached.

We calculate for each household the relative space available based on the household characteristics. The relative space available is the ratio of the available square meters over the equivalized square meters which this household is expected to have (Meyer-Ehlers, 1971). Only if this relation is strictly larger than one, we consider a household as able to compensate for commuting to the workplace with working from home. This captures the employee-side of working from home as a necessary criterion without considering job-specific requirements, which may restrict working from home.

The job-specific requirements that restrict working from home depend on the individual job description. We match the individual jobs in the survey with the 'working-from-home'-index based on the ISCO-08 classification (Alipour et al., 2023). This share of ability to work from home is labeled *ho*. The household-level of working from home is the share of work hours that could be completed from home over all household members. This household measure to work from home is limited between zero for households whose job description does not allow for working from home and one for households that are able to work completely from home, based on their job description.

$$\psi_{\text{work}} = \begin{cases} \frac{\text{ho}\cdot\text{work hours}}{\text{work hours}} & \text{if } \dfrac{\text{actual square meters}}{\text{equivalized square meters}} > 1, \\ 0 & \text{if } \dfrac{\text{actual square meters}}{\text{equivalized square meters}} \leq 1. \end{cases}$$

Social Reproduction domain

The ability to compensate for public commons in the sphere of social reproduction is a multi-dimensional problem, as the willingness and ability for substitution can depend on time and income. A poor household might require access to support in the provision of care in order to work additional jobs, has to give up a job because affordable care is not provided, or can simply not afford external support. A rich household can either decide to provide all care without external support or actually acquire external support on the market. The ability to substitute depends on several factors, like financial situation, so-

cial values and the availability of a personal support net at the location of residence. The substitution is a combination of ability and preference, whose outcome can be observed in the actual use of private substitutes.

In our analysis, we combine the use of social reproduction substitutes regarding the care of children and of elders. The care needs for children are determined as an age-dependent factor for the most care-intensive child in a household. Due to data limitations, the care needs of elderly persons cannot be observed. We imply the multiple burdens in care, which are known to affect women disproportionately compared to men (Samtleben, 2019), as existing but through the private substitution as resolved.

We first compute a daily *childcare need* from children's ages. For the most care-intensive child, 16 waking hours are assumed, for which the age-appropriate alone time is subtracted (Stahmer and Leipert, 2003; Zick and Bryant, 1996). This implies that care can and must be provided for more than one child at a time. We further subtract the time a child is taken care of through public commons. We consider the share over the awake time as the use ratio of private substitutes in cases where private substitutes are used. If private substitutes are not used, we set the index to zero. Private substitutes include care by parents or paid and unpaid private external care.

$$care_{child} = \begin{cases} \frac{16-\text{alone}-\text{public}}{16} & \text{if private substitute has been used,} \\ \\ 0 & \text{if private substitute has not been used} \end{cases}$$

Due to a lack of available information regarding the overall care needs of the elderly person and any information on care hours provided by public institutions, we only include the use of a private care service as a substitution measure.

$$care_{elder} = \begin{cases} 1 & \text{if private substitute has been used,} \\ \\ 0 & \text{if private substitute has not been used} \end{cases}$$

We combine the two forms of care, similar to the availability of public commons in the form of the root mean square, so that

$$\psi_{\text{social reproduction}} = \sqrt{\frac{1}{2}\left(care_{child}{}^2 + care_{elder}{}^2\right)}$$

Leisure domain

Leisure can be substituted in two distinct ways: first, through the existence of private green space in the form of a garden, and second, through excessive space for living.

Both aspects ensure that households have enough space for personal development and recreation, implying personal space as the relevant criterion. Both forms are considered equally important, so that here the root mean square of both aspects is calculated again, expressing the balanced nature of both aspects. The existence of a garden is encoded in the form of a dummy variable, while space differs in regard to an individual household's needs. Similar to the ability to work from home, we use the equivalized square meters as a reference to calculate the excessive space for living.

$$\psi_{\text{leisure}} == \sqrt{\frac{1}{2}\left(\text{Garden}^2 + \left(\frac{\text{actual square meters- equivalized square meters}}{\text{equivalized square meters}}\right)^2\right)}$$

Overall index

The PSI is the RMS of the three domains:

$$\Psi = \sqrt{\frac{1}{3}\left({\psi_{\text{work}}}^2 + {\psi_{\text{social reproduction}}}^2 + {\psi_{\text{leisure}}}^2\right)}$$

The social reproduction index is excluded from the overall PSI if households do not have any care needs. This ensures that the PSI remains comparable across households and does not penalize households without any care responsibilities.

6 Descriptives

The average distance to public commons differs based on geographic characteristics of a household. The majority of households have public commons available within a 10-minute walking distance, particularly public green spaces (69.8%), restaurants (64.8%) and kindergartens (61.5%). By contrast, access to secondary schools (Gymnasium) is more limited, with only 22.6% of households reporting proximity within 10 minutes, and over one third of the households (34.3%) indicate that such facilities are either unavailable or not within walking distance. General practitioners are accessible within 10 minutes for 45.1% of households, while 16.7% reported they are not available or too far to walk to. Similarly, access to facilities for the elderly and youth centers showed notable gaps, with 18.5% and 20.1% of households, respectively, reporting a lack of access. Shops (60.4%) and banks (55.0%) are frequently within walking distance. A non-negligible share of around 10% of households report that shops and banks are not reachable on foot. Breaking the analysis into East and West Germany, the contrasts in walkable access become more evident. Households in West Germany are more likely to live within 10 minutes of most amenities and less likely to report any services being not reachable

on foot. The largest gaps for those two regions favor the West for kindergartens (+14 pp within 10 min), banks (+7), primary schools (+11), restaurants (+13), and sports facilities (+11). Correspondingly, "not reachable on foot" is markedly higher in the East—especially for banks (+7 pp), youth centers (+7), primary schools (+7), shops (+5), and restaurants (+6). Gymnasiums are an outlier where walkable access is poor on both sides (33–36% not reachable). Distance to work is almost identical across East and West (see A.4 and A.5).

The share of households that report access to all public commons within walking distance, as well as full access to all public commons, differs by income (Table 3). Close access to work decreases with income. 54.9% of households in the 1st quintile have work close by, compared to 43.3% of households in the fifth quintile. Overall access is the lowest for the middle of the distribution with only 2.7% of households. The pattern is particularly pronounced for social reproduction-related commons, with just 8.2% of households in the middle quintile reporting full access compared to 12.4% in the second quintile. Households within the first quintile of living space in equalized square meters, have overall better access to public commons than households in the top quintile: 58.2% vs. 44.6% for work, 20% vs. 14.7% for leisure and 14.7% to 9.1% for reproduction commons. We further observe higher access for tenants than owners. Households with children have slightly better access to both social reproduction commons (18.4%) and public commons overall (4.8%) than households without children. Similarly, single households have better access than couple households across all categories, particularly in leisure and social reproduction (17.2% vs. 16.3% and 13.6% vs. 11.1%, respectively). Marked differences appear between urban and rural areas. Urban households are substantially more likely to report full access, especially for social reproduction-related commons (14.6% vs. 6.3%) and leisure (18.8% vs. 11.7%). Only 2.6% of rural households report access to all services, compared to 4.8% in urban areas. East German households are somewhat less likely to report full access than their West German counterparts across most public commons, particularly for leisure (11.2% vs. 17.7%). However, the gap in overall access remains modest (3.2% vs. 4.3%).

7 Results

Ternary plots are a convenient way to express a three-dimensional perspective. We provide a brief introduction to assist with the reading of the plots. For this purpose, we concentrate on the mean value of each domain (Figure 2). Ternary plots graphically present the position of a point among three different scales in a two-dimensional space. Each scale goes from zero to one, with zero indicating smaller distance and one a higher distance. In our case, the bottom axis presents the normalized distance to work, the

Table 3: Share of households having access to all services in the respective category within walking distance

	Access within walking distance				
	Work	Leisure	Reproduction	Overall	N
1st income quint	54.9	16.7	13	4.3	2067
2nd income quint	49.3	16.1	12.4	5.1	2063
3rd income quint	45.6	13.5	8.2	2.7	2064
4th income quint	43.4	18.3	13	3.8	2066
5th income quint	43.3	20.5	14.3	5.2	2067
1st sqm quint	57.8	20.0	14.6	5.9	2120
5th sqm quint	44	15.3	10	3.3	2066
Tenant	52	18.1	13.6	4.4	5152
Owner	44	14.1	10.1	3.8	5175
No child in HH	48.5	15.9	11.9	3.9	6288
Child in HH	48.2	18.4	12.3	4.8	4039
Couple HH	47.0	16.3	11.1	4.0	8146
Single HH	51.2	17.2	13.6	4.5	2181
Urban	49.3	18.8	14.6	4.8	6662
Rural	46.2	11.7	6.3	2.6	3367
West Germany	47.8	17.7	12.6	4.3	8126
East Germany	51.6	11.2	9.3	3.2	2201

Note: "Access within walking distance" refers to all services being available in under 10 minutes. **Data:** Author's own calculations based on SOEP-Core v38.1 (2023), weighted.

left axis the normalized distance to leisure and the right axis the normalized distance to social reproduction.

Consider the leisure axis as an example, the mean value over all households is 0.302. The solid reference lines mark the sample means. Points located above the leisure-mean are accepting a longer commute to leisure compared to the rest of the sample and vice versa. Everyone on the line itself has the same relative distance to leisure but different valuations of work and social reproduction. The corresponding means for social reproduction and work are 0.350 and 0.348, respectively. In the overlay across panels, the intersection of the three mean isopleths yields the triplet of average distances. The mean household is located quite central in the ternary plot, which translates to a balanced distance to all three domains. The mean household is slightly closer to leisure than to work and social reproduction.

The distribution of households across the space becomes more visible in the ternary space (Figure 3a). Points mark individual observations, and isopleths indicate the local

Figure 2: Ternary plots with mean distances to work, leisure, and social reproduction

(a) Leisure (b) Social reproduction (c) Work

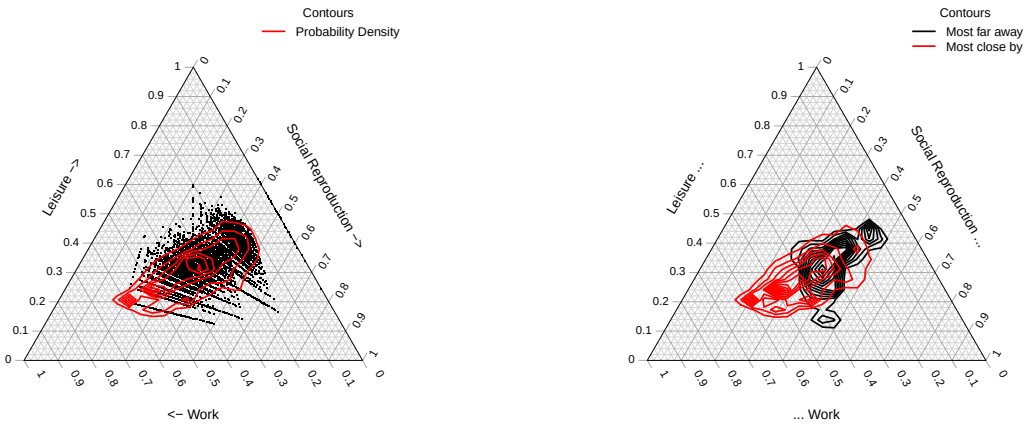
Note: The figure presents the mean household distance to leisure (0.302), social reproduction (0.350), and work (0.348) in ternary plots. The black line indicates the mean position. The orange area indicates a household position that is relatively farther from the respective sphere than the mean household. **Data:** Author's calculations based on SOEP-Core v38.1 (2023).

density over households. The mass of the distribution lies near the center, implying that most households have a relatively balanced position across work, social reproduction, and leisure. We observe a bean-shaped density as households have a slight tilt toward leisure. Clearly visible are the data artifacts with balanced access within a single domain with the peaks outside of the bulk, highlighting a more unbalanced distribution across the public commons.

To understand the preference of (un-)balanced access to public commons beyond a purely relative aspect, we separate households into two groups based on their absolute distance to public commons. We define close by as a distance of less than 20 minutes commute. A household is defined as mostly close by if the majority of the three public commons has a majority of their components mostly close by. Households are defined as far away when the majority of the three public commons has a majority of their components mostly far away. Each of the three domains is equally weighted. 13,335 observations of our sample are mostly close, 2,079 are mostly far away.

We observe that the absolute availability of services also leads to a different relative distribution (see Figure 3b; red = mostly close; black = mostly far). Households cluster relatively nearer to social reproduction (0.2) and leisure (0.2) and farther from work (0.6) when the household is defined as close by. This incorporates another data artifact where the majority of components in leisure and social reproduction are close by, setting the household to a 'close by' household. The distance to the dimension work is in these cases of less relevance where it is located. This artifact strengthens the aspect of balanced access to public commons when components are considered individually. When we consider the distribution of the relative distances, the relative distance to work is

Figure 3: Ternary Plots by absolute distance to public commons



(a) All households

(b) Mostly Far / Mostly close

Note: The figure presents the distribution of the households in the ternary space. The isopleth lines present the probability density of households at a certain spot. The points present individual households. **Data:** Author's own calculations based on SOEP-Core v38.1 (2023).

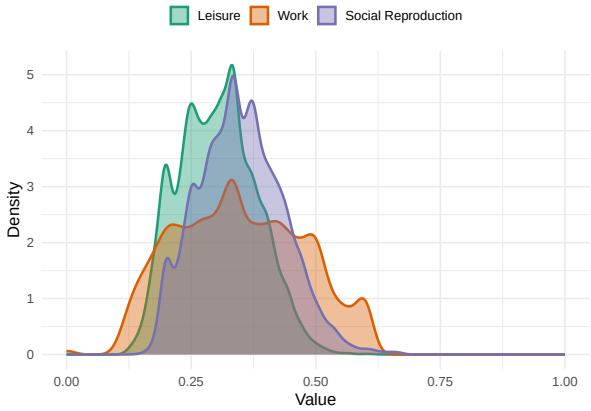
comparatively spread out, between 0.15 and 0.65. Leisure and social reproduction both peak around 0.3, with leisure having a wider spread than social reproduction (Figure 10).

Households with public commons mostly far away tend to cluster near the center of the simplex, indicating a balanced disadvantage across domains. We observe another peak close to work (0.15) at the expense of social reproduction (0.4) and leisure (0.45). These households are located close to work at the cost of access to social reproduction and leisure. Here, the widespread of relative distances is in the distance to leisure. Work is less spread than before. The spread in social reproduction remains stable compared to earlier analyses. For households with most public commons far away, we see a different preference compared to all households. Households with most of the public commons far away locate themselves closer to work compared to households that have shorter absolute distances.

Figure 4 presents the density distribution of the normalized distance to work, social reproduction and leisure. We observe a concentration of similar relative distances for households in the domain of leisure and social reproduction. The distance to work is spread wider across all households. Overall, households prefer a slightly smaller distance to leisure compared to social reproduction. Both dimensions peak at around 0.33,

indicating a balanced access to public commons.[1]

Figure 4: Density Plot of Leisure, Work and Social Reproduction Distances



Note: The figure presents the density distribution of the normalized distances to work, leisure and social reproduction.
Data: Author's own calculations based on SOEP-Core v38.1 (2023).

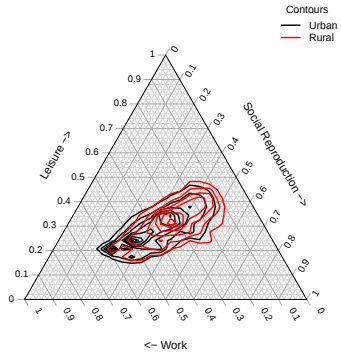
In Figure 5, we present the ternary position of households by region, East/West and income. While the bean-shape remains unchanged, we see different results of the trade-off between work and leisure by each group.

Urban households locate themselves closer to leisure and social reproduction compared to rural households (Figure 5a). Urban households exhibit a bimodal distribution in ternary space, with a concentration in the center and one at the lower left, which is a position close to social reproduction and leisure, while further away from work. Such a distribution is consistent with the structure of German cities, where we see a strong heterogeneity between inner-city neighborhoods (closer to social reproduction and leisure) and suburban locations, which are further away from work hubs in the large cities (Heidinger et al., 2025). Rural households display a single mode on a broader plateau, indicating a more balanced access to public commons. Mean positions underscore these contrasts: urban households are relatively closer to social reproduction and leisure, while being further away from work (Urban: $W = 0.372$, $L = 0.294$, $SR = 0.334$) than rural households (Rural: $W = 0.302$, $L = 0.319$, $SR = 0.379$) (see also Table 7).

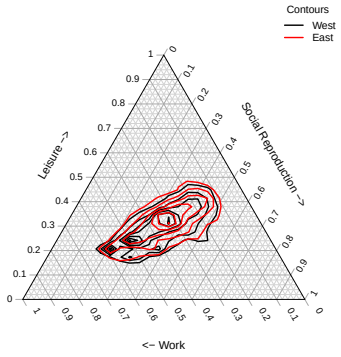
Germany has a historic and distinct structure of public commons in West and East Germany, with disparities particularly evident in areas such as childcare (Mätzke, 2019) or well-paying jobs (Gohla and Hennicke, 2023). However, regional disparities are more defined by an urban/rural difference than the East/West divide, with growing East German cities and stagnating rural areas (Gohla and Hennicke, 2023). We also find only

[1]Minor peaks across all three dimensions are at values 0.2, 0.25, 0.5 and 0.6. These are specific data artifacts where we see specific combinations of access. These artifacts are driven by households that have balanced access to public commons within each of the three domains.

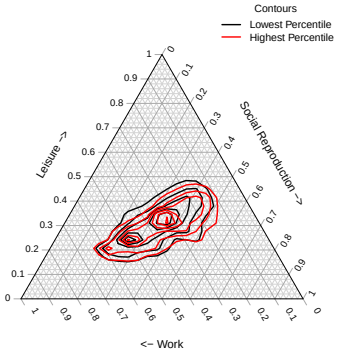
Figure 5: Ternary distributions by subgroup



(a) Urban vs. Rural



(b) West vs. East



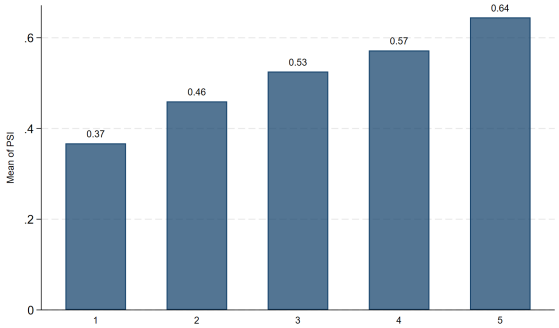
(c) Top Percentile vs. Bottom Percentile

Note: Each panel shows the household distribution in ternary space for the indicated subgroup. Isopleths denote density; points are individual households; shading highlights local peaks. **Data:** Author's calculations based on SOEP-Core v38.1 (2023).

modest regional differences regarding the balanced accessibility. West German households are relatively farther from work and closer to leisure and social reproduction than those in East Germany (West: $W = 0.354$, $L = 0.298$, $SR = 0.347$; East: $W = 0.333$, $L = 0.315$, $SR = 0.351$).

Figure 5c further presents the relative position of households with equivalised household income in the top percentile and bottom percentile. The distribution is very similar, with a slight shift of the top income households to the bottom right, indicating a higher relative distance to social reproduction and a closer position to work.

Figure 6: Distribution of Private Substitution Index and Index Blocks by Income Quintile



(a) Private Substitution Index by Income Quintiles

(b) Index Blocks by Income Quintiles

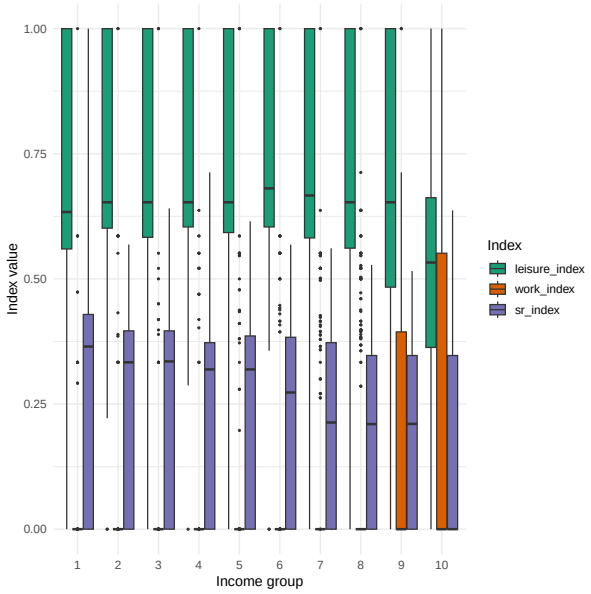
Note: The figure presents (a) the average private substitution index over income quintiles and (b) the average of the sub-indices of income quintiles **Data:** Authors' own calculations based SOEP-Core v38.1 (2023))

The unbalanced access to public commons can be substituted unevenly across the socio-economic capacity of a household (see Figure 6a). The index rises monotonically with income; the mean of the top quintile is over 40% higher than the mean of the bottom quintile. Figure 6b decomposes the index into its three domains and shows that the gradient is driven primarily by the *work* and *leisure* components. Work-from-home (WFH) capability and equivalized living space increase with income, which lifts both the leisure and work components. By contrast, the reproduction component exhibits a comparatively flatter profile across quintiles; it even slightly decreases with income. It shows that while we observe only small positional differences by income, high-income households are more flexible in choosing their living place as they can compensate for missing facilities, particularly in work and leisure.

The normalized substitution index over income groups reveals that this income effect is prevalent only for the richest income deciles (Figure 7). We observe a relative increase in work from home, accompanied by a decrease in social reproduction substitution. While we cannot determine any substantial differences in the distribution of the PSI by characteristics such as urban/rural and East/West, there are substantial differences by income

(see A.12 and A.11). For both households with and without care-responsibilities, working from home only becomes possible with higher incomes.

Figure 7: Boxplots of Private Substitution Sub-Indices by Income Deciles



Note: The figure presents boxplots of the normalized substitution index for work, leisure and social reproduction by income deciles. **Data:** Authors' own calculations based SOEP-Core v38.1 (2023))

8 Discussion

We observe an overall balanced distribution of public commons of work, social reproduction and leisure in Germany. The balanced distribution has small differences between East and West Germany, as well as between rural and urban areas. We observe a cluster of households that face a trade-off between closeness to work and social reproduction/leisure. This result is robust for socio-economic factors like net-equivalence income. The ability to substitute public commons with private substitutes paints a slightly different picture. For the PSI, we see that high-income households can particularly compensate for work and leisure by a) having jobs with a high work-from-home capability; b) having more than optimal living space to work from home and enjoy leisure activities and c) have access to a private garden.

Our results strengthen three mechanisms that have been described in the literature. First, people who move to urban areas especially do this to reduce the relative distance to work, while people who move to the suburbs are looking for more space and greener surroundings (Bauer et al., 2022). We observe this at the two outer ends of the bean-shape. Second, persons with a higher education and more complex jobs commute

the longest (Dauth and Haller, 2018) as households accept longer commutes to access better fitting jobs, if wages compensate for it (Dauth and Haller, 2016), which might explain the concentration of households at a position relatively far from work. Third, employment hubs are reachable by car or public transport, as transport systems still follow a radial structure around city centers (Bentlage et al., 2021), whereas many social reproduction or leisure amenities are effectively place-based and require living nearby, which might explain the trade-off between work and social reproduction/leisure. This underlines Bentlage et al. (2021) finding that relocation for better access to social infrastructure is one of the main drivers for deconcentration from centers. Taken together, the second cluster reflects households prioritizing everyday provisioning (schools, care, shops, green space) over immediate proximity to jobs, with commuting used to bridge the gap to employment.

This observed locational trade-off many households face, abstracts from social components like informal networks, asymmetric information flows and structural discrimination that further shape access to public commons beyond mere proximity. These structural components reinforce the negative impacts of an unbalanced distribution of public commons with implications for well-being (Grillitsch et al., 2025). While public decision-making and policies play an influential in the balanced provisioning of public services, location choices by private businesses are found to reinforce geographical inequalities, a dynamic even strong public institutions and policies struggle to counteract (Wessel, 2022). Thus, even where a territorially balanced provision of public commons is in place, social constraints and differing capabilities may still result in unequal access (Grillitsch et al., 2025). Our analysis highlights the necessity of balanced access to public commons as a basic provision, even when private substitutes are available and social components define how much use a household can make of the public commons.

Our analysis focuses on the distance on foot to basic/social needs, and the general commute time to work. It neglects the ability and private substitutes households have to complete the commute. The unbalanced distribution of cars across households and access to public transport can mirror the socio-economic position of a household. The number of cars in a household increase with income levels (Nobis and Kuhnimhof, 2018), making public commons accessible that were not reachable by foot. Suburban houses with a garden have less access to public transport compared to the city center, but peripheral parts of the city might be cut off from a well-functioning public transport network as well. The ability to substitute accessibility by foot with other means of transportation is currently neglected in this paper. The focus remains on the balanced access to public commons by foot as a means of transportation, which remains free of charge without the emission of greenhouse gases.

9 Conclusion

We take a distributional view of access to the public commons of work, social reproduction, and leisure. We arrive at three main results by using ternary distances and a Private Substitution Index. First, the average household lies near the center of the simplex, indicating broadly balanced relative distances across the three public commons. Second, this balanced access conceals a positional trade-off: many households live closer to work at the expense of social reproduction and leisure, or vice versa. These trade-offs vary systematically across space: urban households are relatively nearer to social reproduction and leisure but farther from work, while rural households show the opposite tilt. West Germany exhibits better walkable access for most public commons than East Germany, though the distance to work is similar. Third, the capacity to privately substitute for missing public commons rises monotonically with income. The ability to substitute is driven primarily by the ability of remote work, adequate living space and private green space. The ability to privately substitute for public commons in the dimension of social reproduction is flatter as here the high costs of private care limit the accessibility to a small share of households.

Methodologically, we combine RMS-based aggregation of multiple public commons into three life-spheres, ternary mapping of relative distances and a PSI that operationalizes the ability to privately substitute public commons. These tools reveal patterns and trade-offs that density maps or single-amenity metrics would miss. The form and intensity of these trade-offs depends on socio-economic and regional characteristics of a household like urbanity and income. The balanced access to public commons is a welfare-state objective, requiring balanced planning of all public commons rather than single-component expansion.

Policies must recognize that private substitution is unequally distributed, so it cannot replace public provision without equity costs. The distributional aspect of accessing public commons and their ability to substitute privately for the lack of such public commons must be the guiding principle of spatial development.

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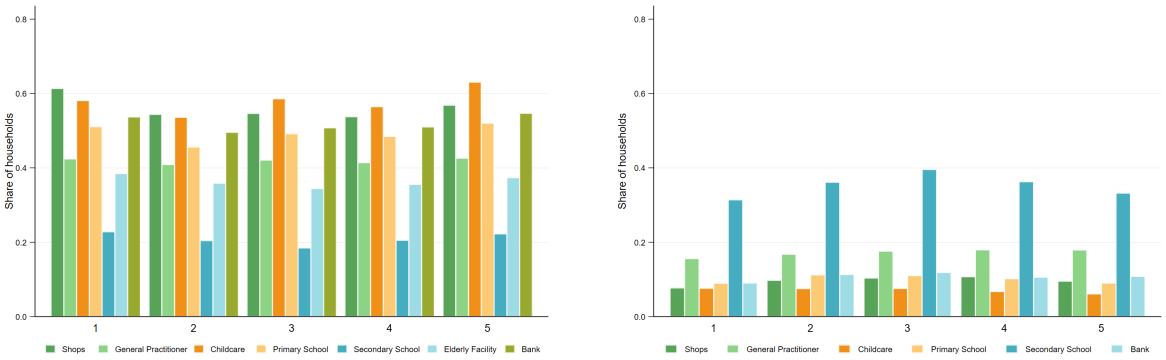
A Appendix A

Table 4: Distance to Services and Facilities by Foot – Percentage Share of Households in East Germany

Facility	**< 10 min**	**10–20 min**	**> 20 min**	**NA**
Work	30.5	29.2	40.3	
Social Reproduction				
Shops	61.2	18.9	6.9	13.0
Banks	45.9	26.9	11.7	15.6
General practitioner	38.7	27.0	16.6	17.7
Kindergarten	49.4	30.0	10.9	9.7
Primary school	44.1	28.0	12.8	15.1
Secondary school	21.2	23.5	19.2	36.0
Leisure				
Restaurants	54.0	25.5	9.6	10.9
Youth center	31.9	27.9	14.6	25.6
Facility for elderly	36.3	24.5	16.2	23.0
Public green spaces	65.1	19.4	7.8	7.8
Sport facilities	43.7	29.8	15.9	10.6
Public transport	87.0	11.4	0.8	0.7

Note: Shares within each facility sum to 100. **Data:** Authors' calculations based on SOEP-Core v38.1 (2023), weighted.

Figure 8: Share of households having services nearby/not available by income quintile - Social Reproduction Services



(a) Within 10 min walking distance

(b) Not available

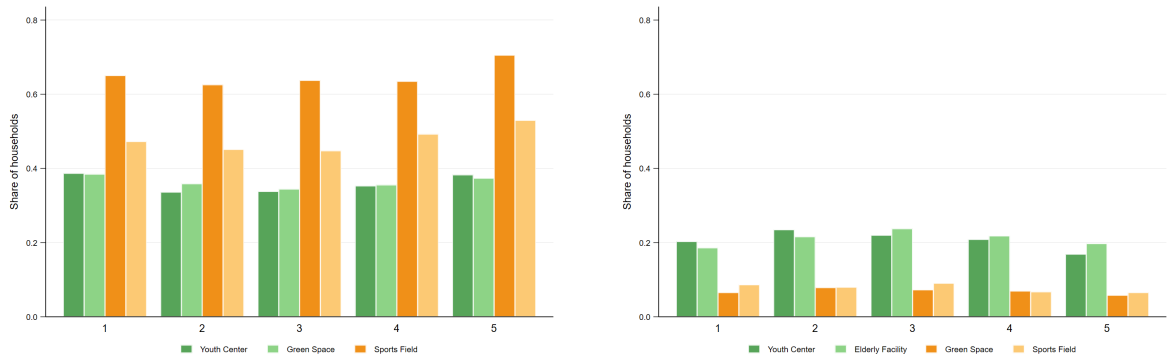
Note: The figure presents (a) the share of households by income quintile having the respective service (shops, general practitioner, childcare, primary school, secondary school, elderly facility, bank) within 10 minutes of walking distance (b) the share of households having no access to the respective service. **Data:** Authors' own calculations based SOEP-Core v38.1 (2023))

Table 5: Distance to Services and Facilities by Foot – Percentage Share of Households in West Germany

Facility	**< 10 min**	**10–20 min**	**> 20 min**	**NA**
Work	31.5	28.8	39.7	
Social Reproduction				
Shops	60.2	24.9	7.0	7.9
Banks	56.9	26.5	8.1	8.4
General practitioner	46.4	26.4	10.8	16.5
Kindergarten	63.9	24.6	5.9	5.5
Primary school	54.9	28.8	8.3	8.1
Secondary school	22.9	26.1	17.1	33.9
Leisure				
Restaurants	67.0	23.0	5.3	4.7
Youth center	40.6	31.7	10.7	17.0
Facility for elderly	39.8	29.1	11.6	19.5
Public green spaces	70.0	19.8	4.2	6.0
Sport facilities	54.4	31.7	8.8	5.1
Public transport	90.4	8.0	0.8	0.9

Note: Shares within each facility sum to 100. **Data:** Authors' calculations based on SOEP-Core v38.1 (2023), weighted.

Figure 9: Share of households having services nearby/not available by income quintile - Leisure



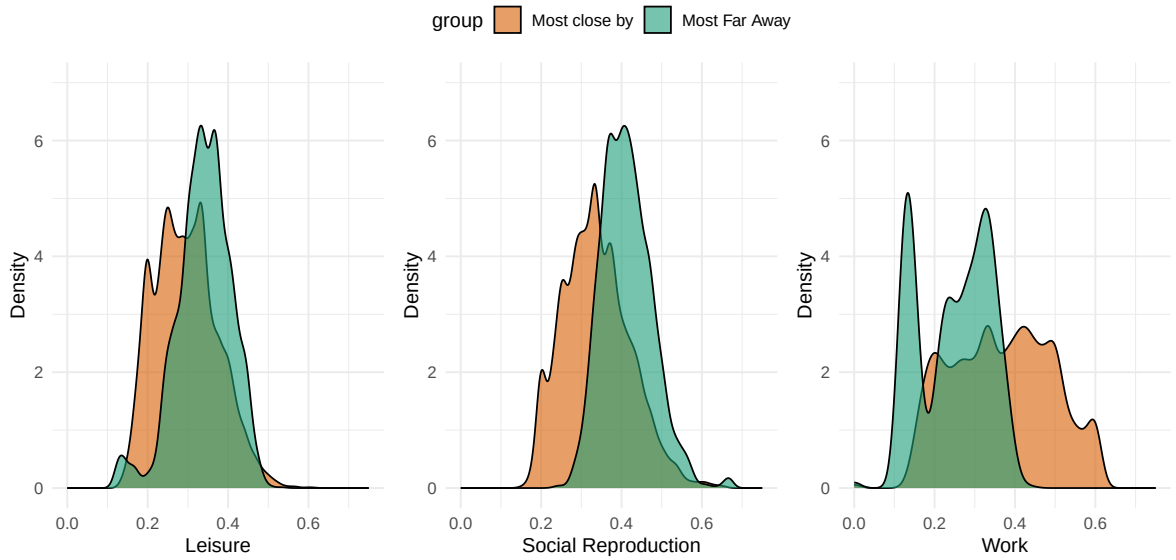
(a) Within 10 min walking distance

(b) Not available

Note: The figure presents (a) the share of households by income quintile having the respective service (youth center, green spaces, sport facility) within 10 minutes of walking distance (b) the share of households having no access to the respective service **Data:** Authors' own calculations based SOEP-Core v38.1 (2023))

B Appendix B

Figure 10: Density Plots of Distance to Work, Leisure and Social Reproduction



Note: . **Data:** Author's calculations based on SOEP-Core v38.1 (2023).

C Appendix C

Table 6: Median Distance to Facilities

Group / Level	Work	Leisure	Social Reproduction	N
Income Quintile 1	2.0	1.5	1.7	1982
Income Quintile 2	2.0	1.7	1.8	1909
Income Quintile 3	2.5	1.5	1.8	1792
Income Quintile 4	2.5	1.5	1.8	1816
Income Quintile 5	2.0	1.5	1.7	2828
PRI Quintile 1	2.5	1.5	1.6	3252
PRI Quintile 5	2.0	1.7	1.9	3252
No child in HH	2.5	1.5	1.8	9424
Child in HH	2.5	1.5	1.7	6836
Car in HH	2.5	1.5	1.9	14 638
No car in HH	2.5	1.3	1.4	1620
Owner-occupied	2.5	1.5	1.6	7547
Rented	2.5	1.8	2.0	8713
SQM Quintile 1	2.5	1.5	1.6	3253
SQM Quintile 5	2.0	1.8	2.0	3251
Urban	2.5	1.5	1.6	10 399
Rural	2.0	1.8	2.1	5499
West Germany	2.5	1.5	1.7	12 902
East Germany	2.5	1.8	2.0	3358
Male	2.5	1.5	1.7	8109
Female	2.5	1.5	1.8	8147

Note: The table presents the median distance to work, social reproduction and leisure facilities of individuals. The distance is given in minutes by foot for social reproduction and leisure. 1 is under 10 minutes; 2 is between 10 to 20 minutes; 3 is more than 20 minutes and 4 is not available or not reachable by foot. Leisure and Social Reproduction measure is taken as average across all subcategories as defined in Table 2. **Data:** Authors' calculations based on (SOEP-Core v38.1, 2023) (unweighted).

D Appendix D

Table 7: Average normalized distance to public services (access within walking distance)

Group	Work (%)	Leisure (%)	SR (%)	N
Income Quintile 1	0.352	0.306	0.342	1982
Income Quintile 2	0.341	0.307	0.352	1909
Income Quintile 3	0.352	0.299	0.350	1792
Income Quintile 4	0.360	0.295	0.345	1816
Income Quintile 5	0.347	0.302	0.351	2828
No child in HH	0.350	0.303	0.347	6315
Child in HH	0.349	0.301	0.350	4047
Couple HH	0.345	0.303	0.352	8172
Single HH	0.369	0.296	0.335	2190
Single HH (woman)	0.364	0.299	0.337	1063
Single HH (man)	0.373	0.294	0.333	1124
Urban	0.372	0.294	0.334	6687
Rural	0.302	0.319	0.379	3377
West Germany	0.354	0.298	0.347	8159
East Germany	0.333	0.315	0.351	2203
Social housing (yes)	0.376	0.298	0.326	235
Social housing (no)	0.371	0.296	0.332	4920
Car in HH (yes)	0.343	0.303	0.354	9104
Car in HH (no)	0.400	0.291	0.309	1256

Note: Shares sum to 1 within row by construction. Data correspond to "(a) Access within walking distance." **Data:** Authors' calculations based on (SOEP-Core v38.1, 2023) unweighted.

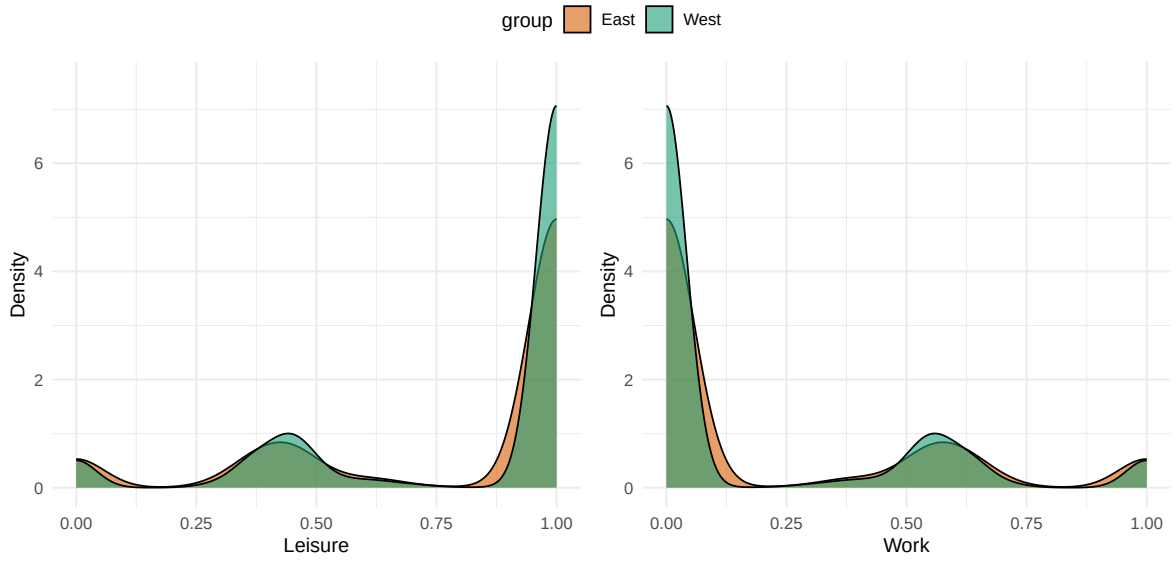
E Appendix E

Table 8: List of Variables

Variable description	Variable name
Restaurants	hlf0137
Youth meeting place	hlf0143
Park	hlf0145
Sport	hlf0146
Shops	hlf0136
Banks	hlf0138
Doctors	hlf0139
Kindergarten	hlf0140
Primary school	hlf0141
Grammar school	hlf0142
Elderly facility	hlf0142
Employment status	plb0022_h
Actual working time	plb0186_v3
Current job	pgisco08
Living space in sqm	hgsize
Garden	hgeqpgar
Childcare	pli0044_h
External childcare	kc_care_h
Hours in public childcare	kd_hrs_h
Hours elderly care	pli0046

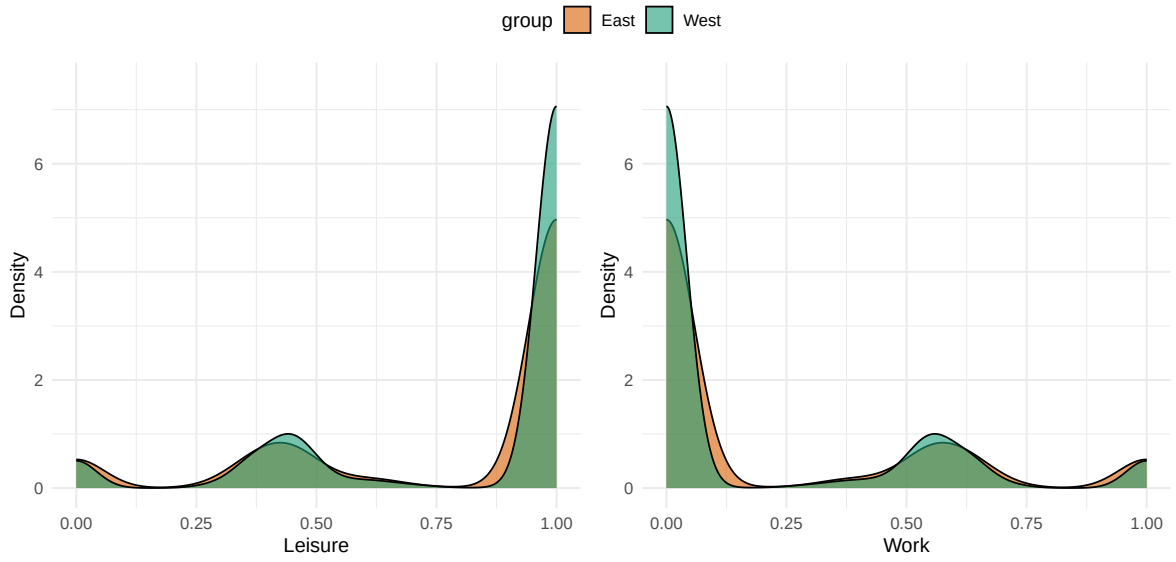
F Appendix F

Figure 11: Density Plots of Private Substitution Index for East and West Households



Note: This density plot shows the distribution of the private substitution index for East and West Germany. **Data:** Author's calculations based on SOEP-Core v38.1 (2023).

Figure 12: Density Plots of Private Substitution Index for Urban and Rural Households



Note: This density plot shows the distribution of the private substitution index for Urban and Rural Germany. **Data:** Author's calculations based on SOEP-Core v38.1 (2023).

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