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Abstract

Public goods are meant to be universal, but they are inherently place-based. This paper systematically measures spatial access to public goods and quantifies the implications of distance to public facilities for income inequality. First, we map all schools and hospitals across Belgium. We compute the distance to facilities for each of the 20,000 neighborhoods and document large spatial inequalities in access to public facilities. Second, we find that this unequal distribution favors high-income neighborhoods: allocating public goods spending proportionally to our access index increases income inequality compared to measures based solely on disposable income. Third, we show that the positive relationship between income and access can be rationalized by a simple model of public goods allocation with an inequality-neutral social planner. Finally, we provide evidence that access is strongly correlated with educational and health outcomes, emphasizing the need to consider the place-based nature of public goods when measuring inequality.

JEL Classification: D63, H11, H41, R28

Keywords: Inequality, Geography

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Do Public Goods Actually Reduce Inequality?[*]

Micael Castanheira[†] Giovanni Paolo Mariani[‡] Clemence Tricaud[§]

July 2025

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1 Introduction

Public goods are meant to be the great equalizer. Universal access to education and healthcare, financed through progressive taxation, should reduce inequality and provide a foundation for social mobility. This intuitive view underlies much of the modern welfare state and shapes how economists conceive the distributional impact of government spending. Yet, this perspective rests on the assumption that public goods are equally accessible to all citizens, regardless of their income or where they live.

Questioning the validity of this assumption, this paper systematically measures spatial access to public goods across income groups. Using comprehensive Belgian data, we map the geographic allocation of amenities that epitomize public goods and find that they are unequally distributed, favoring the upper income quintiles. Far from equalizing available resources across income groups, this allocation increases inequality by 20 to 50%.

Samuelson (1954) offered a formal definition for "pure public goods." However, theoretical concepts are easily misapplied empirically. Indeed, when assessing the distributive impact of almost all actual public goods—which are inherently place-based—this abstract view of *pure* public goods becomes inappropriate. Children must travel to schools, patients need to get to hospitals, and citizens have to access government offices to fully benefit from most public services. The distance between a household's residence and these facilities thus constitutes an implicit tax that, as we will show, varies dramatically across space and income groups.[1] This geographic component has been a central element in recent episodes of collective dissent. For example, one of the main complaints of the "Yellow Vests" movement in France is the loss of access to public services in peripheral places.[2]

The high granularity of Belgian data allows us to precisely quantify heterogeneous access to public goods across the country. We primarily focus on health and education, since these constitute the two principal public goods expenditures across Europe. In Belgium, they represent 14% of GDP, whereas the total budget for public goods is 23%.[3] Specifically, we geo-localize all schools and hospitals across the country and combine this data with income and population information at the neighborhood level, which constitutes our unit of analysis.[4]

Our study examines the extent of inequality across neighborhoods in terms of *access* to public goods and then quantifies its implications for *income* inequality across neighborhoods. We proceed in three steps. First, we provide a measure of each neighborhood's

[1]As we detail in the next section, a back-of-the-envelope calculation shows that a household living not even thirty minutes away from their child's school faces an implicit tax equivalent to the government's total education spending per student.

[2]See Algan et al. (2020) and Boyer et al. (2020) for the case of France, Cremaschi et al. (2024) for the case of Italy, and Rodríguez-Pose (2018) for a global analysis.

[3]In Section 4.3, we consider additional public goods to map and measure access to public goods that add up to 20.5% of GDP

[4]Formally named "statistical sectors". These neighborhoods correspond to census blocks in the US. There are about 20,000 neighborhoods in Belgium with an average of 683 inhabitants, as detailed in Section 3.2.

access to public goods. In practice, we calculate the travel time needed to access each facility from each neighborhood. Drawing on the Enhanced 2-Step Floating Catchment Area method from the geography literature (Paez et al., 2019), we use this information to determine each neighborhood's catchment area (*i.e.* the radius in which facilities are accessible within a reasonable driving time). We define two measures of access. The uniform index simply counts the number of facilities located within the catchment area. The weighted index further weighs each facility by its distance, so that closer facilities within the catchment area are given a higher weight. We uncover consequential public goods *access* inequalities across neighborhoods that are substantially larger than those for income.

Second, we assess the implications of the unequal allocation of public goods across space for overall *income* inequality. To this end, we convert our access indexes into monetary value and extend the existing measures of average income at the neighborhood level by adding the in-kind transfers that correspond to high or low access to each public good. In other words, we allocate public goods spending to each neighborhood proportionally to our access indexes. We then generate the Lorenz curve and Gini index of this extended income. We perform a wide range of sensitivity analyses: first, we consider solely health and education. Then, we extend our approach to other public goods, and vary the extrapolation methods for the remainder of the public budget. Regardless of the method, public goods increase inequality, compared to the initial data that only considers net disposable income. Specifically, we obtain Gini coefficients between 0.15 and 0.20 for our extended income, against 0.13 for income alone. Hence, the place-based nature of public service delivery actually increases rather than reduces income inequality across space.

Third, we propose a simple model of public goods allocation that can rationalize why the location of public goods systematically favors higher-income neighborhoods. The model combines the insights of Samuelson and Tiebout in a more flexible manner. Tiebout (1956) focuses on local public goods that only benefit the citizens living in the administrative unit where they are provided. We instead assume that neighborhoods may access all the amenities that are within a reasonable distance (*i.e.* in their catchment area). Hence, the number of neighborhoods served by each amenity depends on the distances between them. We then calculate how a government that maximizes a Benthamite social welfare function would allocate amenities across space.[5] We find that, depending on its inequality aversion, the government may either want to accompany or to offset pre-existing income inequalities. That is, we identify the exact conditions under which it allocates public amenities near richer or poorer neighborhoods. We then estimate the elasticity of access with respect to income in our data and observe that it is consistent with inequality aversion being low. In fact, the elasticity of public goods provision with respect to income is close to one after controlling for neighborhood

[5] Another way to rationalize the observed spatial inequality is to assume that households are mobile and that high-income households move closer to public amenities. We believe that our model provides a complementary approach to urban models of spatial sorting, and is also more closely aligned with the Belgian context, where mobility is low.

characteristics. This result aligns well with the Distributional National Accounts (DINA) approach, which imputes public goods proportionally to income (Atkinson et al. 2011; Alvaredo et al. 2018; Piketty et al. 2018). However, this correlation is associated with public goods being spatially more concentrated than income. Hence, the eventual impact on inequality here is higher than in DINA exercises.

Finally, we show that access to public goods is strongly correlated with health and education outcomes, as well as housing prices, even after controlling for other dimensions such as urbanization and income. This suggests that access is directly relevant for welfare, highlighting the importance of considering access when assessing the magnitude of inequalities in a country.

In the next section, we outline how the literature inspires our approach and the ways we complement extant work. For instance, macroeconomic approaches to measuring inequality overlook the place-based component of actual public goods. Conversely, studies in urban and public economics examining the spatial clustering of households and amenities tend to ignore the distributive impact of this allocation on aggregate inequality.

2 Contribution to the Literature

Our work lies at the intersection of public economics, the political economy of public goods provision, the DINA framework, and spatial accessibility analysis in geography and urban economics. By combining insights from each, we develop a unified framework.

As Hussain and Kohn (2024) observe, the formalization of public goods emerged in the 1950s, but the notion originates from the Latin "Res Publica," intended as any good or action that was beneficial for the Roman people. Moreover, "in everyday speech, public goods are understood as collective goods that are provided by the state." Yet, in economics, the main interpretation is that of Samuelson (1954, 1955), who defines "*pure* public goods" as non-rival and non-excludable, hence consumed by all citizens in equal quantity.

From "Pure" Public Goods to Place-Based Provision. Although Samuelson's definition of public goods is foundational, it offers little guidance for understanding how public goods are consumed or allocated in practice—particularly when their provision is local.[6] This gap has profound implications for the measurement of inequality.

The tension between the definition of "pure" public goods and those delivered on the ground has generated a rich literature. The place-based nature of public goods is at the heart of Tiebout's (1956) article "A Pure Theory of Local Expenditures," while Musgrave (1959, p. 268) underlines that "the principle that goods are consumed in equal

[6]The main "pure" public good that comes to mind is nuclear defense. Even the environment and on-the-ground defense have an important spatial dimension. See also Tiebout (1956), Enke (1955), and Margolis (1955) for further discussion of other gaps between Samuelson's definition and concrete public goods.

amounts by all now encounters a spatial limitation." This is also central to Hirschman's (1970) book, *Exit, Voice, and Loyalty*, and is a key element in political economics. In particular, it has been argued that politicians have incentives to target public goods provision to population groups that are more politically involved, which are typically the rich and well-educated (see *e.g.* Ferejohn 1974; Kenneth A. Shepsle 1981; Besley and Burgess 2002; Strömberg 2004, 2008; Genicot et al. 2021).

Public Goods in the DINA Framework. Quite surprisingly, however, the existing literature on inequality measurement has thus far overlooked this spatial dimension. Our first contribution therefore consists of exploiting these insights from the public finance and political economics literature to develop a methodology that allows us to study the distributional effects of the public goods that represent the bulk of government budgets.[7]

The last two decades have witnessed significant progress in measuring income inequality. The DINA approach pioneered by Atkinson et al. (2011), Piketty et al. (2018), and Garbinti et al. (2018) among others, combines micro and macro data to obtain a comprehensive allocation of the components of GDP across the population (see Villanueva et al. 2025 for an extensive survey and Clarke and Kopczuk 2025 for a discussion of income concepts and methodological challenges).

The DINA guidelines (Alvaredo et al., 2018) detail all methodological choices made, and have generated a rich literature that permits direct comparisons across time and countries (see, e.g., Blanchet et al. 2022, Piketty et al. 2019, Bach et al. 2021, Hammar et al. 2021; Decoster et al. 2024, and Guzzardi et al. 2024).

However, these guidelines remain silent on the measurement of the distributive impact of public goods. They contrast two *imputation* methods: public goods are either assumed to be distributed proportionally to post-tax income (their preferred assumption), or on a lump-sum, purely egalitarian basis, in line with the Samuelsonian definition of pure public goods. Auten and Splinter (2024), who question several of the choices made in these guidelines, also rely on these imputation methods: they decide to apply each imputation method to 50% of public expenditures.

Given that public goods account for roughly 25% of national income in developed countries, selecting one or the other imputation method has a substantial impact on eventual inequality estimates. For instance, Riedel and Stichnoth (2024) detail that switching to a lump-sum imputation reduces the measured gap between the top 10% and the bottom 50% by half.

One concrete strategy for quantifying the distributive impact of public goods consists of estimating public goods *consumption* at the household or individual level (see Verbist et al. (2012); Wagstaff et al. (2014); Riedel and Stichnoth (2024), and Gethin (2024) among others). These studies propose, for instance, to impute education proportionally to the number of children and their educational achievements and/or healthcare in

[7]We focus here on public goods, excluding social security and other cash transfers. The latter have been widely studied and their redistributive effects are well documented (see, in particular, Atkinson et al. 2011; Piketty et al. 2018; Bozio et al. 2024).

proportion to incurred medical costs. They find that such consumption patterns are redistributive: in essence, their results align much more with a lump-sum than a proportional imputation of public goods. However, their approach still assumes away the implicit tax of distance—an assumption that is central to their result.

The Importance of Distance. Consider a simple example: imagine two families, each with a single child. One family lives 1 minute away from their child's school. The other, 24 minutes away. The parents must commute to the school twice a day, back and forth, 200 days a year. The difference in commuting time exceeds 90 minutes a day, or 300 hours a year. Using a natural experiment in the U.S., Goldszmidt et al. (2020) estimate that the average opportunity cost of time is on par with median wage. The latter was 21€ an hour in Belgium in 2022. We find that the value of these extra 300 hours is equivalent to total public education spending per student. That is, the implicit tax of the *additional* distance nullifies the entire provision of public education as measured by the consumption approach.

Numerous studies empirically illustrate the detrimental effect of distance for both academic achievement (Dickerson and McIntosh 2013; Falch et al. 2013; Kobus et al. 2015; Tigre et al. 2017) and health outcomes (Ingram et al. 1978; Bertoli and Grembi 2017; Eggerickx et al. 2018; Myers 2024). This is due to the fact that distance plays a central role in household decisions to use a given service or specific facilities (Burgess et al. 2019, 2023).

A Geographically-Grounded Allocation of Public Goods. We develop a novel approach that combines accessibility measures from the geography literature with national accounting principles.

Specifically, we construct an access index that captures proximity, drawing on the spatial accessibility literature in applied geography, especially the work of Luo and Wang (2003) and refinements by Paez et al. (2019). The mapping of public amenities across space is made possible by the recent availability of geo-coded data. Our strategy is thus in line with several recent papers that map local amenities at fine geographical scales, although in different contexts (see, for instance, Miyauchi et al. 2022; Harari 2024, and Abramitzky et al. 2025 for a recent review). Crucially, we use this access measure to allocate public expenditures across space and income groups. This bridges the gap between how services are provided, how they are accessed, and how they should be valued in distributional analyses.

Our approach also aligns with a long-standing body of literature in urban and spatial economics. Classic models show that local amenities affect both housing prices and residential sorting, often reinforcing spatial inequality (Thisse and Wildasin, 1992; Moretti, 2013; Diamond, 2016; Couture et al., 2024). Recent quantitative models integrate amenities into general equilibrium frameworks to evaluate their welfare impacts (Desmet and Rossi-Hansberg 2014; Monte et al. 2018; Fajgelbaum and Gaubert 2020). In these papers, amenities act as a residual in households' location decisions, after accounting for housing prices and wages. Such a setup thus envisions amenities as a bundle that includes both private and public amenities, both of which matter to the households' and firms' location decisions. Our paper instead focuses on the observed allocation of public goods across space, and systematically quantifies inequalities in access and extended income. Moreover, our model of public goods allocation offers a complementary approach to rationalizing the equilibrium allocation of population and amenities. Rather than assuming that households sort across space, we ask under which parameters a social planner would choose to allocate more amenities to richer areas.

One particularly relevant paper to our study is that by Loumeau (2023), who studies school placement in Paris and finds that a more decentralized allocation could have increased welfare by 10%. This result underscores our fundamental argument: access to public goods is unequally distributed, and this unequal spatial allocation may reinforce socioeconomic inequalities. Our paper offers a general method to quantify access and extended income inequalities. We are primarily interested in healthcare and education, but also consider other public goods such as transportation and security. Our method can furthermore be applied in any context where granular data on facility locations and income are available.

3 Public Goods Provision in Belgium: Institutions and Data

3.1 Public goods in Belgium

Belgium's governing institutions are the result of progressive historical evolutions and the coexistence of three linguistic groups: Dutch (about 60% of the population), French (about 40% of the population), and German (less than 1%). Since the 1970s, Belgium is divided into three Communities (attached to each language), three Regions (Flanders and Wallonia, plus a hybrid status for the "Region of Brussels-Capital"), 10 provinces, and 581 municipalities.[8]

Despite this apparent decentralization, the provision of public goods remains highly centralized. Over time, many responsibilities initially borne by provinces have been reallocated upward to the Regions, significantly reducing the role of local governments. Healthcare and education respectively make up the first and second largest shares of the government's budget. Healthcare also epitomizes a public good that remains federal, whereas education is in the hands of the Communities.

Healthcare. As mentioned, healthcare absorbs the largest portion of the public goods budget: health expenditures add up to 8.1% of GDP. Compulsory public health insurance covers 99% of Belgian residents. Citizens are free to choose their insurance, general practitioner (GP), hospital, specialist doctor, etc. As a result of the public provision of healthcare, the proportion of individuals who report unmet medical needs in Belgium

[8] For readability and to avoid going into excessive institutional detail, we use the term "Wallonia" both for the Walloon region and the "Communauté Wallonie-Bruxelles." Flanders merged its community and region in 1980.

is less than half of the EU average (1.0%, compared to 2.2%).[9]

The Federal Minister of Health sets national tariffs for medical procedures, allocates hospital budgets, and regulates the distribution of high-cost medical technologies (e.g., MRI machines, PET scanners, and robotic surgery systems). Regional governments are responsible for enacting and enforcing zoning regulations, while Communities manage health promotion and set language requirements for staff. Budgetary authority, however, remains predominantly centralized.

Despite universal coverage, life expectancy and other health outcomes strongly correlate with socio-economic status and vary significantly across space (as we will see, access to healthcare is actually greater in places where life expectancy is already high). In 2012–16, the life expectancy gap between the most advantaged and most disadvantaged groups was above 9 years for men and just below 7 years for women. Half of these differences are determined by place of residence (Eggerickx et al., 2018). For instance, life expectancy ranges between 83 and 85 years in Flanders, compared to between 78 and 80 for the Walloon provinces of Hainaut, Namur, and Luxembourg.

Education. Education is the second-largest component of the public goods budget, accounting for 6.1% of GDP. Article 24 of the Belgian Constitution guarantees free access to education until age 18. This covers all primary and secondary schools. Importantly, this includes almost all "private" schools. Indeed, while their real estate is mainly financed by Catholic organizations, they are regulated and priced in the same way as public schools.[10]

The Communities and Regions make almost all budgetary and regulatory decisions. This generates differences in budget per student across the country. In particular, Flanders devoted 6,544€ per primary school pupil in 2022, whereas the figure was 5,577€ in Wallonia.

Once again, universal coverage does not translate into equal educational outcomes. OECD PISA assessments reveal highly heterogeneous educational performance both across socio-economic groups and regions. Flanders consistently outperforms Wallonia, although recent scores suggest modest convergence. Within each Community, outcomes remain highly stratified. According to the OECD, "The variance of results in mathematics is strongly associated with the socio-economic status of students, as measured by the PISA index of economic, social and cultural status. [...] Belgium is one of the countries where the relationship between reading performance and socio-economic status (ESCS) is the strongest."[11]

Schools—and hospitals to a lesser extent—are typically accessed locally, creating *de facto* inequality of access. We aim to quantify these spatial differences and understand how the distribution of public amenities interacts with income and geography.

[9] Source: https://iris.who.int/bitstream/handle/10665/376805/9789289059589-eng.pdf

[10] Exceptions to this are the British and American schools, with fees around 45,000€ and 25,000€ per year, respectively, and Montessori schools, with a fee around 6,000€ a year. Such schools primarily cater to temporary residents, mainly diplomats and expatriates.

[11] Source: `https://gpseducation.oecd.org/CountryProfile?primaryCountry=BEL&treshold=10&topic=PI`, accessed in February 2024.

3.2 Data and Descriptive Statistics

We leverage highly granular data on the location of public amenities along with socio-economic data available at the statistical sector level. Statistical sectors are sub-municipal units in Belgium, comparable to census blocks in the U.S. They represent the most disaggregated spatial units for which administrative data are available. Throughout the paper, we refer to statistical sectors as neighborhoods. Unless otherwise specified, all data refer to the year 2018.

Statistical Sector Characteristics: We obtain geographical coordinates, residential population figures, and net average taxable income for each statistical sector from the Belgian Statistical Office (STATBEL). This measure of income captures all net income (from work, assets, and other income sources including pensions, disability benefits, and other in-cash transfers) minus deductible expenses. Due to privacy concerns, income data are not disclosed for the smallest 16% of neighborhoods. Out of a total of 19,794, we thus focus our analysis on the 16,595 neighborhoods for which the income information is available.

Data on age structure comes from the 2021 Census, which records the number of individuals in each five-year age bracket (from 0–4 up to 99+). Neighborhoods' degree of urbanization is based on EUROSTAT data, which classifies each municipality into one of three categories: (1) city, (2) town and suburb, and (3) rural area.[12] To compute distance to the central business district (CBD), we use STATBEL's delineation of Functional Urban Areas (FUAs). These are analogous to U.S. commuting zones, and each FUA comprises a core municipality. We compute the distance between each neighborhood and the core of its FUA, or to the nearest core municipality in case the neighborhood lies outside any defined FUA.

Table 1 provides descriptive statistics at the statistical sector level. On average, statistical sectors have a population of 683 inhabitants, a size of 1.47 km^2, and an average median net taxable income of 35,200 euros in 2018. Figure 1 shows how average income varies across neighborhoods in Belgium.

Taking into account the share of the population each sector represents, income inequality across statistical sectors yields a Gini coefficient of 0.13.[13] Our goal in this paper is to assess how the allocation of public goods across the country impacts this between-neighborhood inequality.

[12] We apply the category of a given municipality to all the statistical sectors that belong to it.

[13] When examining income inequality within the two main Regions, the coefficient remains unchanged for Wallonia, and is marginally lower in Flanders (0.11). The across-neighborhood inequality of 0.13 represents about half of the Gini coefficient computed for Belgium using individual data (0.24 in Decoster et al. 2024). This suggests that slightly more than half of total income inequality arises between neighborhoods, and slightly less than half materializes within them, although Bellù and Liberati (2006) detail the limits of such a decomposition, which must be read as an approximation and not an exact calculation

Table 1: Descriptive Statistics of Neighborhoods (N = 16,595)

	Mean	SD	Min	Max
Total Population	683	745	0	8254
Area (km^2)	1.47	2.59	0.01	44.83
Population Density (1,000 inh./km^2)	1.99	3.49	0.00	46.68
Degree of Urbanization	2.08	0.67	1.00	3.00
Average Net Taxable Income (1,000 €)	35.20	8.42	7.88	163.82
Share $<$ 15 years	0.16	0.05	0.00	0.40
Share 15-64 years	0.65	0.06	0.00	1.00
Share $>$ 65 years	0.19	0.07	0.00	0.94
Distance to CBD (km)	23.85	19.35	0.05	116.18

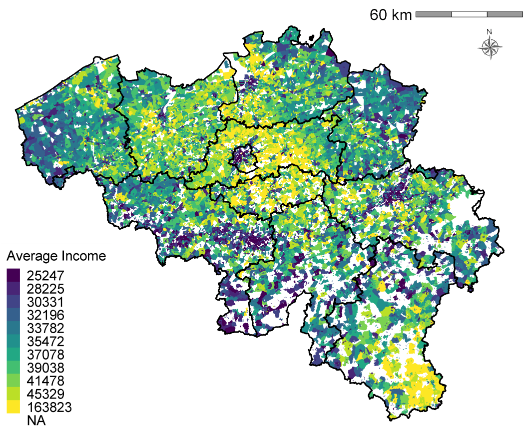


Figure 1: Average Income across Neighborhoods

Public Goods Facilities: We rely on administrative data to geocode and collect information on schools and hospitals. We extracted the address and number of beds of each general and university hospital in the country from the "Federal Public Service for Health, Food Chain Safety, and the Environment" website. We retrieved the addresses of all pre-schools, primary, and secondary schools for each language community separately: for the list of French-speaking schools, we web-scraped the websites of the *Fédération Wallonie-Bruxelles*; for German-speaking schools, those of the Ministry of the German-speaking Community. The list of Flemish schools was downloaded from the Flemish Ministry of Education.

Figure 2 maps the location of hospitals and schools across Belgium. As expected, we observe large clusters in and around the main cities, namely Brussels, Antwerp (north of Brussels), Liège (to the east), Ghent (north-west), and Charleroi and Namur (to the south).

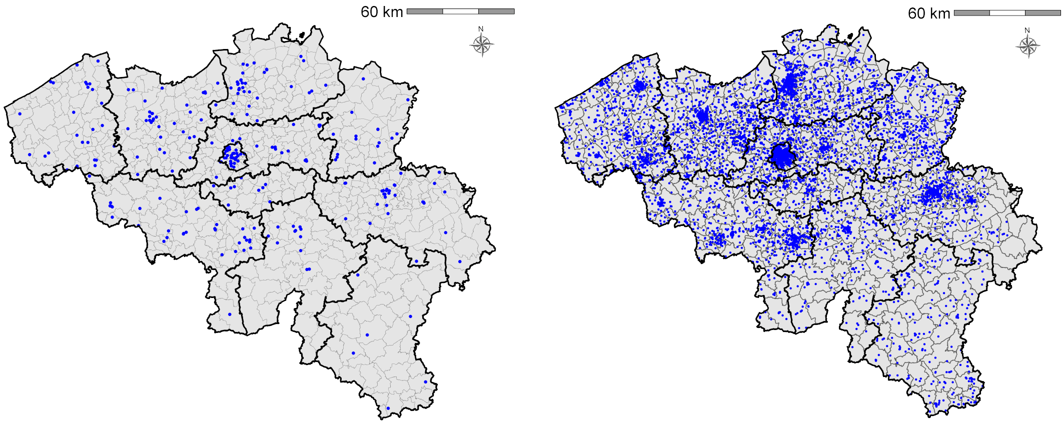


Figure 2: Maps of Hospitals (left) and Schools (right) in Belgium

In Section 4.3, we extend our analysis to incorporate train stations for "public transport" and police stations for "security." We retrieved train station data from the iRail project, an open-source database that provides locations and timetables for Belgian railway stations.[14] We identified the location of police stations using OpenStreetMap (OSM), as no official administrative information was available.

Finally, as detailed in the next section, we rely on the 2019 OSM version of the Belgian road network to calculate driving travel times between each statistical sector and facility.

4 Access and Income Inequality

4.1 Measuring Access

A metric is needed to measure the provision of public goods across neighborhoods. This metric must reveal the number and, ideally, the size of all the amenities accessible to each household, while taking into account distance: the closer an amenity is to a neighborhood, the greater its value.

We draw on a method developed in the applied geography literature by Luo and Wang (2003) and subsequently refined by Paez et al. (2019) — the Enhanced 2-Step Floating Catchment Area (E2SFCA).[15] This entails first calculating the travel times between each neighborhood and each amenity. Formally, define a matrix $\mathbf{T}$ of size $L \times M$, where L is

[14] Train stations are managed by the publicly-owned National Railway Company of Belgium (SNCB/NMBS).

[15] In particular, and as detailed below, we adopt this approach to define the neighborhoods' catchment areas and the weights attached to each facility within the catchment area. We do not apply the second step of their methodology, which aims to build a measure of access at the amenity level (*i.e.* how many users use a given amenity). Our goal is instead to measure access at the neighborhood level (*i.e.* how many amenities residents have access to).

the number of locations and M is the number of said locations that contain at least one amenity. Out of the universe of 19,794 neighborhoods in Belgium, 182 of them contain a hospital, resulting in a healthcare matrix with 3,602,508/2 travel times. Similarly, 4,369 neighborhoods contain a school, resulting in an education matrix with 86,479,986/2 travel times. Each element of $\mathbf{T}$, denoted T_{lm} is the travel time from location l to amenity m. We compute travel times by car, since this is by far the most common means of transportation.[16]

Next, define a second matrix $\mathbf{W}$ that assigns gross weights to each location-and-amenity pair, with W_{lm} being decreasing in travel time T_{lm}. In practice, we use the step-wise function proposed by Paez et al. (2019). For each neighborhood, we compute the travel time to the nearest schools or hospitals.[17] Then, we assign neighborhoods to five equally sized bins, or quintiles: 0.2, 0.4, 0.6, 0.8, and 0.99. This defines five thresholds T_1 to T_5 that correspond to the travel times associated with each quintile. T_5 corresponds to the maximum travel time, which, in the case of Belgium, is equal to 51 minutes for hospitals and 25 minutes for schools. Any facility for which travel time exceeds this threshold is considered outside the neighborhood's *catchment area* and is assigned a weight of zero.

Our first and more easily interpretable access index simply counts the number of beds or schools within the catchment area. We call it the "uniform index" as all amenities inside the catchment area are given the same weight. The second version of our access index, the "weighted index," further takes into account distances within the catchment area. It is calculated as the weighted sum of the beds or schools, where the weights decrease with distance.

Paez et al. (2019) propose estimating the weights inside the catchment area by fitting a Gaussian function with a standard deviation equal to the median of the travel time distribution. The weight attached to each quintile q is equal to the value of the probability distribution function at T_q. Hence, the weight W_{lm} associated with a travel time T_{lm} is given by:

$$W_{lm} = \begin{cases} W_1, & T_{lm} \leq T_1 \\ W_2, & T_1 < T_{lm} \leq T_2 \\ \vdots & \\ W_5, & T_4 < T_{lm} \leq T_5 \\ 0, & T_{lm} > T_5, \end{cases} \tag{1}$$

with $W_1 > W_2 > W_3 > W_4 > W_5 > 0$.

A Gaussian fit captures non-linearities in the cost of distance. Indeed, the cost is likely

[16]Seventy-eight percent of Belgian workers commute to work by car, sometimes in combination with a bike, whereas only 8% use public transport — see the "baromètre de mobilité." produced by Acerta (2025). More generally, T_{lm} captures the opportunity cost of time, which is common to both public and private means of transportation.

[17]We consider the ten nearest schools and the three nearest hospitals, and compute the travel time needed to reach the one farthest of them. This reflects the fact that a person can select one of several facilities at each stage of schooling and or each specialized medical service. Our results are largely insensitive to these thresholds. For instance, they remain qualitatively identical if we simply consider the nearest facility.

similar across walkable distances, but jumps discontinuously once one needs to change modes of transport, from walking to biking, to using a car. Then, beyond a certain distance, the cost is comparably high whether or not one must drive a few extra minutes. As shown in Sections 4.2 and 4.3, our results are very similar whether we rely on these weights or instead consider our uniform access index.

4.2 Access Inequality: Spatial Distribution of Access to Public Goods

We first map the level of access to each public good at the neighborhood level, considering either our uniform access index (the count of hospital beds or of schools within the catchment area) or the weighted access index. Figure 3 classifies each neighborhood's access to healthcare into one of five bins. Figure 4 does the same for education. Lighter (yellow) colors indicate a higher level of access. Darker (deep blue) colors indicate a lower level of access. According to the uniform index, the median neighborhood bin benefits from between 9,627 to 14,484 beds and 143 to 225 schools.[18] Across all neighborhoods, the figures range from 0 to 32,648 beds and 0 to 1,283 schools.

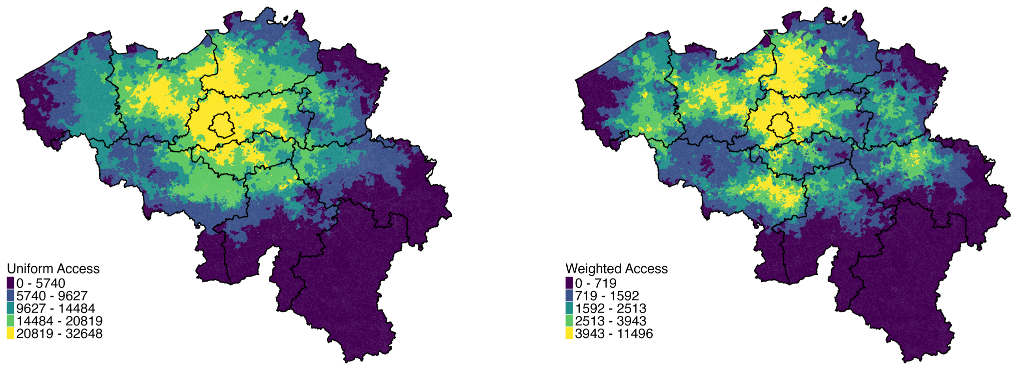


Figure 3: Access to Healthcare. Uniform Index (left) and Weighted Index (right)

As is clear from these maps, most of the best-served neighborhoods are located in Flanders (*i.e.* in the North), whereas most areas of deprivation, in dark blue, are located in Wallonia (*i.e.* in the South). The yellow spot in the center is the Brussels Region, which is surrounded by the provinces of Flemish and Walloon Brabant.

We then compute the Gini coefficients for access inequality. For this computation to be appropriate, we weigh each neighborhood by its share of the total population. We find that access to healthcare and education is highly unequal, with Gini coefficients of 0.28 and 0.41, respectively.[19] The inequality in access to public goods is thus substantially higher than income (0.13). The same is true within each Region for education. Recall that education is provided at the regional level (see Section 3.1): we can therefore obtain

[18] With weighted indices, the figures are respectively between 1,592 to 2,513 beds and 32 to 50 schools.

[19] When using weighted instead of uniform indices, the two Gini coefficients are even higher: 0.37 and 0.46.

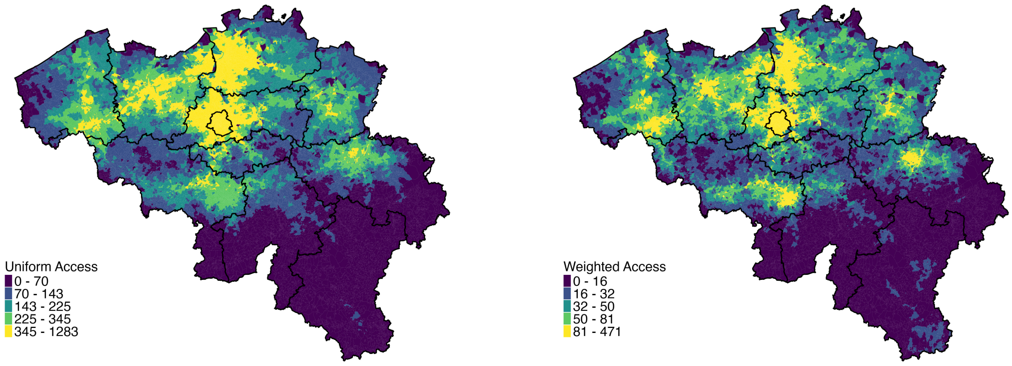


Figure 4: Access to Education. Uniform Index (left) and Weighted Index (right)

the precise budget allocated to education by each region and repeat the same exercise separately for Flanders and Wallonia.[20] The Gini coefficients are respectively 0.35 and 0.33 for education, against 0.11 and 0.13 for income.

4.3 Income inequality: Access-Based Imputation of Public Goods

Such a high level of spatial inequality in public goods provision implies that place of residence can have a substantial impact on the *de facto* in-kind transfer received. We saw, for instance, that the government provides lower access to education and healthcare to citizens in the south of Wallonia than to those residing in Flemish Brabant. In this section, we quantify how this inequality in public goods provision affects what we label *extended income*.

Methodology. Disposable income y^d is commonly defined as gross income minus taxes paid, plus *cash* transfers received from the government. To ensure consistency with national accounts, the sum of each of these individual incomes must add up to net disposable income in the national accounts (line item B.6n, representing 52.6% of the GDP in 2018).[21]

The cash transfers included in disposable income comprise public pensions, unemployment and disability benefits, and child allowances, but exclude reimbursements for healthcare costs, education spending, and other in-kind transfers. Studies attempting to estimate these transfers are based on consumption data.[22] As detailed in Section 2, such measures overlook the implicit tax of accessing public goods. The access indices developed above can instead be used to produce a more direct measure of this implicit tax and the resulting provision of public goods to each neighborhood.

[20]We refrained from doing the same exercise for the Region of Brussels as it contains both Flemish- and French-speaking schools and we do not have information on the share of students attending each of them.

[21]As detailed in Section 3.2, information on income is unavailable for 16% of the neighborhoods due to privacy concerns. We consequently only observe 86.8% of the national accounts aggregate. For this reason, we scale up the net income data for the 16,595 observed neighborhoods by a factor of $1/0.868 = 1.152$.

[22]See Verbist et al. (2012); Wagstaff et al. (2014); Gethin (2024) and references therein.

We define *extended income* as disposable income plus the cash equivalent of the in-kind provision of (or *access to*) public goods. We "extend" disposable income by converting the access index developed above into a monetary value for the entire government budget:

$$y_l^{ext} = y_l^d + \sum_g \frac{access\ index_l(g)/n_l}{\sum_k access\ index_k(g)} \times b(g), \tag{2}$$

where g denotes a specific public good (e.g., health, education...). The conversion works as follows: since access indices are expressed in specific, and different, units (e.g., number of hospital beds or schools), we must rescale them. To this end, we apply the same logic as for Lorenz curves: we calculate the share of the access index at location l out of the sum of indices across all locations $k = 1, ..., L$. This delivers a location-based share that is independent of the initial unit used.

Second, to obtain a cash-equivalent-transfer, the resulting fraction is multiplied by the (national or regional) budget assigned to the public good, $b(g)$.[23] In other words, for each public good g, we attribute the government spending to each neighborhood proportionally to its level of access.

Third and lastly, we measure transfers at the location level, whereas disposable income is a per-household-based measure. Hence, we divide the location total transfer by the number of households in each neighborhood, n_l.[24]

This can be done easily for health and education. In Section 4.1, we've calculated each neighborhood's level of access, and know that the budget for healthcare represents 8.1% of GDP, and that for education, 6.1%, for a total of 14.2%, out of the 23.2% (total budget of the government).[25]

Allocating the remaining part of the government budget, which represents 9% of GDP, is trickier. Indeed, we cannot obtain separate information on both the budget and the geographic allocation of each public good or service (think road repair or park maintenance). Furthermore, for some goods, the relationship between amenities and public goods provision is unclear (How, for example, does the distance to a military base modify the service provided by Defense?). We thus need to decide how to impute these other public goods.

As detailed in Section 2, the literature typically imputes *all* public goods and services either as a lump-sum transfer ($y_l^{ext} = y_l^d + G/N$, with $G = 23.2\%$ of GDP) or as an income-neutral transfer ($y_l^{ext} = y_l^d$). Using a linear combination of the two is also a possibility (Auten and Splinter, 2024).

A conservative approach to incorporating access-based information on public goods

[23] For education, we take into account the regional differences in the amount allocated to students. More precisely, we account for the fact that a Flemish student receives 17% more budget than a French-speaking student. In Brussels, 70% of the schools are French-speaking and 30% Flemish-speaking, implying that, on average, the students of Brussels receive 5% more budget than those in Wallonia.

[24] The results are identical to the third decimal when dividing by the number of individuals instead of households.

[25] 2018 GDP data from the National Bank of Belgium. In line with DINA guidelines, we use the P31 and P32 line items for total spending on public goods and services.

provision is to apply it only to the specific budgets we can allocate geographically, and to continue to rely on these common imputation methods for the remainder. That is:

$$y_l^{ext} \approx y_l^d + \sum_{g=h,s} \frac{access\ index_l(g)/n_l}{\sum_k access\ index_k(g)} \times b(g) + \left(G - \sum_{g=h,s} b(g) \right) \times IM_l, \tag{3}$$

where $g = h, s$ respectively denote healthcare/hospitals and education/schools, G is the total budget of the government, and IM is one of the standard imputation methods: lump-sum or income-neutral.

A less conservative approach is to extrapolate information on those public goods for which we have spatial and budgetary data to the entire government budget. In this case, the approximation becomes:

$$y_l^{ext} \approx y_l^d + \frac{G}{\sum_g b(g)} \times \left(\sum_g \frac{access\ index_l(g)/n_l}{\sum_k access\ index_k(g)} \times b(g) \right). \tag{4}$$

Results.

Figure 5 displays the Lorenz curves obtained using these different approaches.

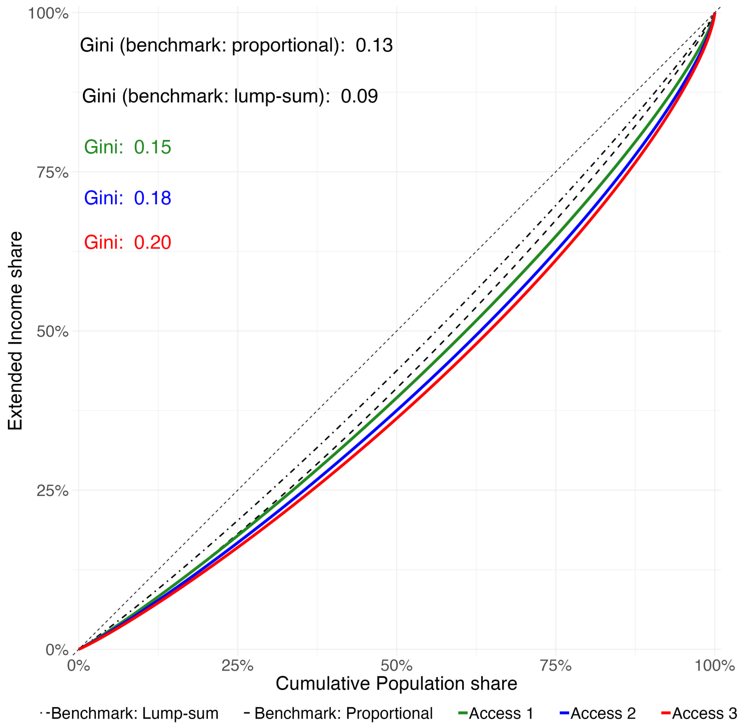
The two initial benchmarks used in the DINA literature are illustrated by the black dashed Lorenz curves. Under the lump-sum imputation method, inequality decreases substantially: the Gini coefficient drops from 0.13 to 0.09. By definition, proportional imputation leaves inequality unchanged, at 0.13: such an imputation scales up each household's income, without redistributive effects.

The colored Lorenz curves depict the measured level of inequality when allocating public spending proportionally to our uniform index (Appendix Figure A.1 shows very similar results when using the weighted index).

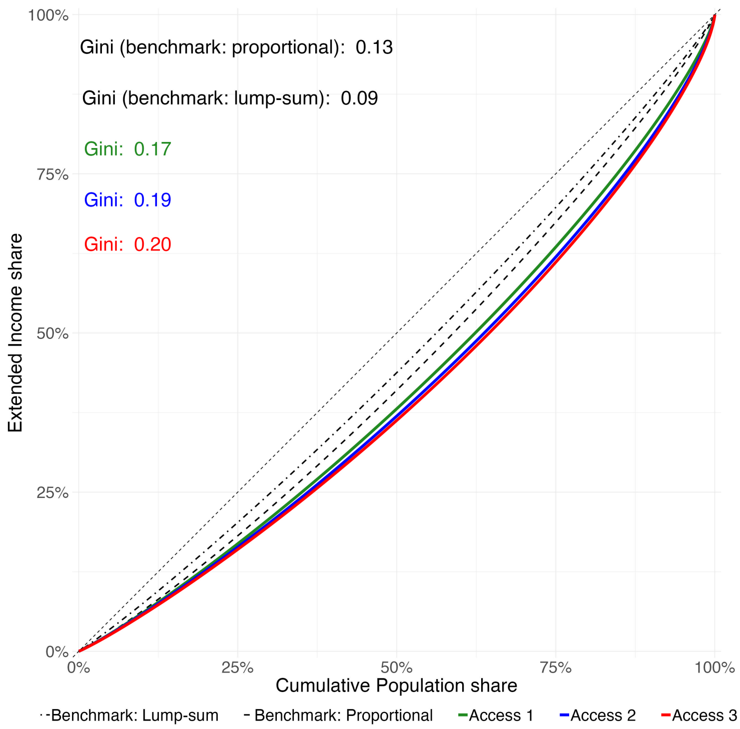
The green Lorenz curves apply the conservative approach in Equation (3). Here, we use only the information on healthcare (8.1% of GDP) and education (6.1%), and impute the rest of the government budget (9%) as either lump sum (panel a) or proportionally (panel b). As is clear from Figure 5, even when using the most conservative approach, which involves the lump-sum imputation of the 9-point residual, the resulting Gini coefficient rises to 0.15. Unsurprisingly, inequality rises further if we impute the residual proportionally: the Gini coefficient is then 0.17.

That is, *measuring* how unequally public goods are provided reveals that income inequality is higher than under either of the two common imputation methods. This seemingly counterintuitive result stems from the uneven spatial distribution of education and healthcare service access, combined with their positive correlation with neighborhood average income, as we will detail in Section 5.

To assess the robustness of these results, we further incorporate the budgets for security and transport. Together with healthcare and education, we can then apply our methodology for 20.5% of the GDP, out of 23.2% for the entire government budget. To compute the access indices for these two additional public goods, we repeat the Section



(a) Residual imputed lump sum



(b) Residual imputed proportionally

Figure 5: Extended Income Inequality with Access-Based Imputation of Public Goods.

Note: The access-based imputation of public goods is performed using the uniform indices. The black dashed Lorenz curves depict the extent of inequality when applying the DINA methodology (*i.e.* when allocating the entire public budget either lump sum or proportionally to income). The green Lorenz curves use only access information on healthcare and education. The blue curves further include access information on security and transport. In both cases, the remainder of the public budget is either allocated lump sum (panel a) or proportionally to income (panel b). The red Lorenz curve attributes the full public budget according to the health and education access indices.

4 procedure, this time with information on the location of police and train stations. The results are displayed in the blue curves: measured inequality increases further, respectively to 0.18 when imputing the remaining 3 points of the public budget lump sum, and to 0.19 when imputing it proportionally.

Finally, the red Lorenz curves present the results of the extrapolation approach detailed in Equation (4), in which we attribute the full public budget according to our indices. The results are the same when we only use information on healthcare and education, or when we also incorporate that on security and public transport: measured inequality increases yet further, yielding a Gini coefficient of 0.20. This figure is no less than 54% higher than that for the inequality of disposable income.

5 A Model of Public Good Allocation

The previous results indicate that public goods facilities are unequally distributed across space and that richer neighborhoods enjoy better access, thereby increasing inequality. How can we make sense of such an association between income and access?

In this section, we develop a model of public goods allocation in which the government allocates amenities across neighborhoods. Our goal is to explore the parameters under which a social planner would choose to allocate more amenities to richer areas, taking as given the spatial distribution of households. While this implicitly shuts down the reverse causality link, whereby high-income citizens move closer to public amenities, such a model has three benefits. First, it is rooted in the reality of the Belgian context, where citizens are typically immobile. Indeed, most workers live and work in the province in which they were born (Acerta, 2025). This is also the logic behind the current allocation of public goods by the government. For instance, the Flemish government aims to provide all necessary public amenities within a 15-minute travel time from each household's place of residence. Second, our model allows us to uncover whether the preference parameters that justify the observed allocation of amenities are somehow "reasonable." Third, it complements a well-established approach in the spatial economics literature, where amenities (whether public or private) are considered fixed, and it is households and firms that are assumed to be mobile (see, for instance, Fajgelbaum and Gaubert 2020). The value of an amenity is thus essentially estimated as a regression residual, like technology in the Solow model.

The economy is composed of L locations indexed by l, each populated with n_l citizens with average income y_l. Let citizen preferences be represented by a Constant Elasticity of Substitution (CES) utility function of private and public goods consumption. Both private and public goods consumption may differ across locations:

$$U(g_l, y_l) = \left(g_l^\eta + \omega \cdot y_l^\eta\right)^{\frac{1}{\eta}}, \text{ with } \omega > 1, \tag{5}$$

where g_l is the total supply of public goods amenities accessible from location l: $g_l = \sum_m W_{lm}\, g_m$, with m denoting a specific amenity and W_{lm} the weight defined in (1).

The parameter ω captures the relative importance of private goods consumption in comparison with public goods consumption. We directly substituted private consumption with disposable income y_l to proxy for individual budget constraints. The elasticity of substitution between the two goods is $0 < \frac{1}{1-\eta} < \infty$. The fact that it must be positive requires that $\eta < 1$. The two goods are complements (substitutes) when $\eta < (>)0$. Note that this utility function can also be expressed as:

$$U(g_l, y_l) = y_l \cdot \left(X_l^\eta + \omega\right)^{\frac{1}{\eta}},$$

where $X_l := g_l / y_l$ denotes the public-to-private goods consumption ratio at location l.

The government must allocate a fixed budget G between the different amenities $g_m \in [0, G]$, subject to the aggregate budget constraint $\sum_m g_m \leq G$. Assume that the government maximizes the following objective function:

$$F(\overrightarrow{g_m}) = \sum_l n_l \cdot [U_l (g_l, y_l)]^\rho - \lambda \left(\sum_m g_m - G\right), \text{ with } g_l := \sum_m W_{lm} g_m. \tag{6}$$

This objective function is a Benthamite social welfare function with *a priori* equal Pareto weights across all individuals, albeit with an additional inequality aversion parameter $\rho \leq 1$. When $\rho = 1$, the government is inequality-neutral and simply maximizes the sum of individual utilities. When $\rho < 1$, as we are about to show, the government *de facto* applies a lower Pareto weight to richer individuals. The Lagrange multiplier of the budget constraint is denoted λ.

The only—but significant—difference with Samuelson (1954) is that public goods need not benefit all citizens equally, since W_{lm} varies with distance (Samuelson implicitly imposes that $W_{lm} = 1, \ \forall l, m$). With $W_{lm} = 0$ beyond some distance, each public amenity typically benefits a different number of citizens.

Differentiating Equation (6) with respect to g_m yields the following first-order condition (FOC):

$$\sum_l W_{lm} n_l \times y_l^{\rho-1} \cdot \left(X_l^\eta + \omega\right)^{\frac{\rho-\eta}{\eta}} \times X_l^{\eta-1} = \lambda / \rho,$$

Comparing two different amenities, m and μ, we obtain:

$$\sum_l \left(W_{lm} - W_{l\mu}\right) \, n_l \times y_l^{\rho-1} \times \left(X_l^\eta + \omega\right)^{\frac{\rho-\eta}{\eta}} \times X_l^{\eta-1} = 0 \tag{7}$$

In line with Samuelson's Law, this implies that if amenity m is, on average, closer to large population centers than amenity μ, it should receive a larger share of the total budget than μ. However, with general functional forms for W, such locational problems are NP-hard. Hence, the literature typically relies on either numerical methods (see, e.g., Loumeau 2023) or the restriction that there are no spillovers across locations: the matrix of W_{lm} becomes a diagonal with $W_{ll} = 1$ and $W_{lm} = 0, \ \forall \ l \neq m$ (see, e.g., the main model in Fajgelbaum and Gaubert 2020).

5.1 Case 1: No Spillovers

The case without spillovers is an extreme version of Tiebout (1956), in which public amenities only benefit the residents of the neighborhood itself, and residents from other neighborhoods have no access. In this case, Equation (7) simplifies into:

$$n_l\, y_l^{\rho-1}\, \left(X_l^\eta+\omega\right)^{\frac{\rho-\eta}{\eta}}\, X_l^{\eta-1} - n_\lambda\, y_\lambda^{\rho-1}\, \left(X_\lambda^\eta+\omega\right)^{\frac{\rho-\eta}{\eta}}\, X_\lambda^{\eta-1} = 0, \text{ or:}$$

$$\frac{\left(X_l^\eta+\omega\right)^{\frac{\rho-\eta}{\eta}}\, X_l^{\eta-1}}{\left(X_\lambda^\eta+\omega\right)^{\frac{\rho-\eta}{\eta}}\, X_\lambda^{\eta-1}} = \frac{n_\lambda\, y_l^{1-\rho}}{n_l\, y_\lambda^{1-\rho}}. \tag{8}$$

With an inequality-neutral government ($\rho \to 1$), we thus have:

Proposition 1. *In the absence of spillovers, all neighborhoods receive a strictly positive supply of public goods. When $\rho \to 1$, the supply in each location l is strictly increasing in the population n_l and in the income y_l at that location. With an equal population size at each location ($n_l = n$, $\forall l$), the ratio $X_l = g_l/y_l$ is constant across locations.*

Proof. *Straightforward from (8).* ■

The first part of Proposition 1 is obviously at odds with the observation that there are many more neighborhoods than public amenities. Yet, it conveys key forces that drive the allocation in more general cases. First, ceteris paribus, X_l is increasing in n_l. Second, in contrast with the *assumption* of pure public goods, an inequality-neutral government would not make public goods equally accessible across population groups: richer places would benefit from more public goods. As shown by the last part of the Proposition, with equally sized neighborhoods, the allocation of public goods would be in line with the assumption made in the DINA guidelines (Alvaredo et al., 2018): the amount of public goods would be proportional to income and thus *public goods would have no redistributive impact*. However, this only holds for equal populations in each neighborhood. If richer neighborhoods are more (respectively less) populated than poorer ones, public goods would increase (respectively decrease) inequality.

Technically, the budget constraint $\sum g_m = G$ imposes that the marginal rate of transformation between different locations is always 1. Hence, at the optimum, the marginal rates of substitution must also be equalized across locations. That is, for $n_l = n_k$, X_l must be equal to X_k. Since $X_l = g_l/y_l$, a doubling of disposable income at location l must be associated with a doubling of public goods supply at l.

This result clearly hinges on government preferences. It is straightforward to check that the Samuelsonian concept of "pure public goods" emerges as another particular case, where inequality aversion ρ is equal to η:

Proposition 2. *In the absence of spillovers, when the population size is equal at each location ($n_l = n$, $\forall l$), and ρ is strictly below 1, the ratio g_l/y_l is strictly decreasing in y_l. In particular, $g_l = g, \forall l$ iff $\rho = \eta$.*

Proof. *Straightforward from (8).* ■

5.2 Case 2: Uniform Spillovers

While highly tractable, the narrowly defined Tiebout setup of Case 1 proves unsatisfactory for at least two reasons. First, it fails to rationalize why a government would concentrate public amenities in a small subset of locations.[26] Second, it fails to capture the fact that each neighborhood can typically access multiple amenities, and each amenity usually serves multiple neighborhoods.

To address the latter issue, we extend the above setup to allow for geographic spillovers. As we are about to show, this automatically resolves the first issue. However, introducing spillovers with a general function W renders the problem NP-hard. To restore analytical tractability, we focus on the case of uniform weights introduced in Section 4. Namely, we assume that amenities (1) equally serve all the citizens inside their catchment area, and (2) neighborhoods located beyond the catchment area have zero access.

Formally, citizens living in any location l within a radius of c minutes (where c stands for *catchment area*) have full access: $W_{lm} = 1$. Those in any location k outside this radius have zero access: $W_{km} = 0$. Hence, each location may access multiple amenities, and each amenity may serve multiple locations: whenever two amenities, m and μ, serve some location l, then $W_{lm} = W_{l\mu} = 1$. If none of the amenities serve location l, then $W_{lm} = W_{l\mu} = 0$. In both cases, $W_{lm} - W_{l\mu} = 0$ in Equation (7).

Such a straightforward extension rationalizes why some locations will not feature any amenity. Indeed, consider a situation where the (potential) amenity in m is better connected than the (potential) amenity in μ. That is, m serves the same locations as μ, plus some additional ones. In this case:

Proposition 3. *If the catchment area of an amenity μ is a strict subset of the catchment area of another amenity m, then $g_\mu = 0$.*

The uniform spillover case delivers the prediction that the number of amenities can be (potentially much) smaller than the number of population centers, even in the absence of economies of scale in the supply of public services. Technically, in the case of Proposition 3, m is better connected than μ. Hence, each term in Equation (7) is either zero or strictly positive. This reveals that the marginal value of g_m is strictly above that of g_μ: the solution entails a corner solution, with $g_\mu = 0$ and $g_m > 0$.

Next, consider two amenities m and μ that are too distant to be accessible by the citizens of their respective neighborhoods, l and λ: $\text{dist}(l, \lambda) = \text{dist}(m, \mu) > c$. This assumes away the possibility that one catchment area is a strict subset of the other. However, neither are the two amenities disconnected: some locations between two cities can be in both amenities' catchment areas. We have:

Proposition 4. *Set the number of amenities to $M = 2$, and locations to be the same: $n_l = n$ and $y_l = y$, $\forall l$. Denote N_m and N_μ the number of locations that only have access to m and μ,*

[26] Note that introducing economies of scale would not resolve this issue, since Inada conditions preclude bringing the supply down to zero in any neighborhood.

and $N_{m+\mu}$ locations that have access to both m and μ. Then, $\frac{1+\omega/X_m^\eta}{1+\omega/X_\mu^\eta} = \left(\frac{N_\mu}{N_m}\right)^{\frac{\eta}{1-\eta}}$.

Proof. See Appendix A.3 ■

While Proposition 4 provides a closed-form solution for the specific case of two amenities and identical locations, the essence of the result is more general. Indeed, in such a model, g_l is automatically equal to g_m in all the locations that belong to the "only m" catchment area. It is also always true that the marginal utility of public goods is decreasing. From the budget constraint, increasing g_m for one amenity requires decreasing g_μ for another, implying a unique, interior, solution.[27]

Note that this allocation is identical to the case of no geographic externalities (Equation (7), with the adaptation that the relevant population ratio becomes N_μ/N_m). We thus obtain the same comparative statics as in Proposition 1 and Proposition 2. In particular, when $\rho \to 1$, the supply of public goods is strictly increasing in the location's population and income.

5.3 Income and Population Elasticities

Together, Propositions 1, 2, and 4 tell us that, after conditioning on population size, public goods provision to a neighborhood should be increasing in income unless the government is sufficiently inequality adverse. In the limit case $\rho \to 1$, the elasticity of g_l with respect to y_l should even be equal to 1. In turn, for any given level of income, provision should increase in population size, although the model does not deliver a sharp prediction about elasticity.

We now assess empirically whether the observed allocation of public goods is close to what an inequality-neutral social planner would choose. To this end, we estimate the elasticities of public goods allocation with respect to both income and population at the neighborhood level. The dependent variables are access to healthcare or education, defined as the number of hospital beds or schools in the catchment area (as delineated in Section 4.1).[28]

As shown in Table 2, both income and population show a strong positive correlation with access. The elasticity of healthcare and education access with respect to income is equal to 0.834 and 0.624 respectively (columns 1 and 3). The point estimates are even larger and reach 1 for both of these public goods once we add controls that can affect the demand and supply of public goods independently from income and population (specifically: age distribution in the neighborhood [5-year age brackets], population density, and distance to the central business district [CBD]). Given that education budgets are managed at the regional level, column 5 further includes region fixed effects. Although we obtain lower point estimates, the elasticity with respect to income remains substantial (0.743).

[27] In contrast, the population that has access to both amenities is immaterial in this comparison, since they benefit independently of which amenity gets these resources.

[28] Here, we provide the results for the uniform indices. See Appendix Table A.1 for the results with our

Table 2: Income and Population Elasticities

Dependent variable	Health Access (log)		Education Access (log)		
	(1)	(2)	(3)	(4)	(5)
Average income (log)	0.834***	1.23***	0.624***	1.15***	0.743***
	(0.040)	(0.043)	(0.033)	(0.031)	(0.026)
Population (log)	0.373***	0.185***	0.446***	0.199***	0.067***
	(0.009)	(0.010)	(0.007)	(0.008)	(0.007)
Controls	No	Yes	No	Yes	Yes
Region Fixed-effects	No	No	No	No	Yes
Observations	16,593	16,593	16,593	16,593	16,593

Note: Heteroskedasticity-robust standard errors in parentheses. ***, **, and * indicate significance at 1, 5, and 10, respectively. In columns 1 and 2 (resp. 3 to 5), the outcome is the log of the health uniform access index (resp. education uniform access index), as defined in Section 4.1. In columns 2, 4 and 6, we include the following set of controls: share of the population in five-year age brackets, log of population density, and log of distance to the central business district. To account for the fact that the education budgets are managed at the regional level, column 5 further includes region fixed effects.

This large positive association between income and access is consistent with a government being close to inequality neutral ($\rho \to 1$) . The regressions clearly reject the null hypothesis that either public good is equally accessible across all income groups (which would require an income elasticity close to zero). They are also consistent with the results presented in Section 4.3, and clarify why inequality rises when we expand our definition of income and allocate the public budget based on access. Indeed, not only are public amenities unequally distributed (Section 4.2), their access is also positively correlated with income.

6 Conclusions. Access is Unequally Distributed, and it Matters

Strikingly, incorporating information on public goods access increases the measurement of inequality. This result contrasts starkly with Samuelson (1954)'s concept of pure public goods.

A natural follow-up question is whether access is relevant to citizens' welfare. As discussed in Sections 1 and 2 when motivating the study, distance indeed seems important: the value of time is high (Goldszmidt et al., 2020), distance to public services can be detrimental to educational achievement and health outcomes (Bertoli and Grembi, 2017; Tigre et al., 2017), and even fuel unrest and populism (Rodríguez-Pose, 2018; Boyer et al., 2020; Cremaschi et al., 2024). In this final section, we provide additional suggestive evidence that access matters in our context.

We first use information on health and education outcomes at the neighborhood level. In this regard, Otavova et al. (2023) provide multiple measures, of which a *health*

weighted indices.

deprivation score and an *education deprivation score*. The former captures poor physical or mental well-being in the Belgian population, including mortality and suicide. The latter captures paucity of educational attainment and skills, with information on early school leavers or the share of adults without qualifications, among others.

Table 3 shows that the deprivation scores are strongly negatively correlated with our access indices, even after controlling for income, population, age, density, and distance to CBD.[29] When we include our full set of controls, we obtain an elasticity of -0.235 for hospitals and -0.245 for schools (columns 3 and 6). This indicates that neighborhoods enjoying 10% higher health (resp. education) access have a 2.4% (resp. 2.5%) lower health (resp. education) deprivation score.[30]

Finally, we repeat the same exercise using housing prices as the dependent variable.[31] If households value access to public goods, this should be reflected in the price of housing. In line with this prediction, we find a positive correlation between housing prices and health or education access at the neighborhood level, with an elasticity of 0.080 and 0.142, respectively (See Appendix Table A.3).[32]

This correlation also shows that the cost of living is higher in neighborhoods closer to public facilities, thus reducing the inequalities in *real* wages. Still, our coefficients indicate that a 10% increase in health (resp. education) access is associated with an increase in house prices of 0.8% (resp. 1.4%). Access is thus far from fully capitalized into housing prices. This suggests that the increase in inequality we document once taking access into account is unlikely to be fully compensated by the differences in housing prices. This is in line with Moretti (2013) who finds that, although the difference in utility between college and high school graduates in the US is smaller when accounting for the cost of living, it remains substantial (about 85% of the inequality in nominal wages).

[29] The results are very similar when we use our weighted instead of uniform access indices, as shown in Appendix Table A.2

[30] We do not include region fixed effects for education, as we did in Table 2, given that the deprivation index is based on the *national* ranking of all Belgian neighborhoods. Though this makes studying within-region variations in deprivation scores inappropriate, we do show the robustness of the results to including region fixed effects when considering housing prices, as next discussed.

[31] We use average housing price per square meter from Domènech-Arumí and Gobbi (2025). The authors exploit highly detailed transaction data from the National Bank of Belgium to predict, using a random forest model, both the market value and the price per square meter of each dwelling in Belgium. These predictions are then aggregated at the neighborhood level. Data are available at WHID – Belgium.

[32] See Appendix Table A.4 for the results using the weighted index. Appendix Table A.5 presents the results obtained for education when including region fixed effects.

Table 3: Access and Deprivation

Dependent variable	Health score (log)			Education score (log)		
	(1)	(2)	(3)	(4)	(5)	(6)
Access index (log)	-0.269***	-0.179***	-0.235***	-0.168***	-0.103***	-0.245***
	(0.013)	(0.013)	(0.015)	(0.009)	(0.009)	(0.010)
Average income (log)		-0.938***	-0.736***		-3.47***	-3.08***
		(0.040)	(0.045)		(0.045)	(0.049)
Population (log)		-0.193***	-0.211***		0.019**	-0.071***
		(0.010)	(0.013)		(0.008)	(0.010)
Controls	No	No	Yes	No	No	Yes
Observations	16,579	16,579	16,579	16,579	16,579	16,579

Note: Heteroskedasticity-robust standard errors in parentheses. ***, **, and * indicate significance at 1, 5, and 10, respectively. In columns 1 to 3 (resp. 4 to 6), the outcome is the log of the health (resp. education) deprivation score, as defined in Otavova et al. (2023), and the main regressor is the log of health (resp.education) uniform access index, as defined in Section 4.1. In columns 3 and 6, we include the following set of controls: share of the population in five-year age brackets, log of population density, and log of distance to the central business district.

Overall, our results challenge the conventional perception of public goods as inherently equalizing. This view underestimates the role of geography in shaping their actual distributional impact. By incorporating spatial access in the measurement of public goods incidence, we demonstrate that access is both unequally distributed and positively associated with local income level. High-income neighborhoods systematically enjoy better access to schools and hospitals, which translates into regressive patterns of effective public goods allocation. Taken together, our results call for a reassessment of how public services are incorporated into distributional accounts. Future research on inequality and redistribution should consider the geography of public goods so as to better understand who truly benefits from the welfare state.

Due to a lack of data, this paper remains silent on the quality of public goods. However, existing research documents clear quality gradients in both education and healthcare facilities with respect to income: poorer neighborhoods often have access to less experienced staff, or lower-performing institutions (see Wagstaff et al. 2014; Aaberge et al. 2019). Since our access measures assume uniform quality across all facilities, our analysis likely provides a lower bound of inequality in public goods allocation.

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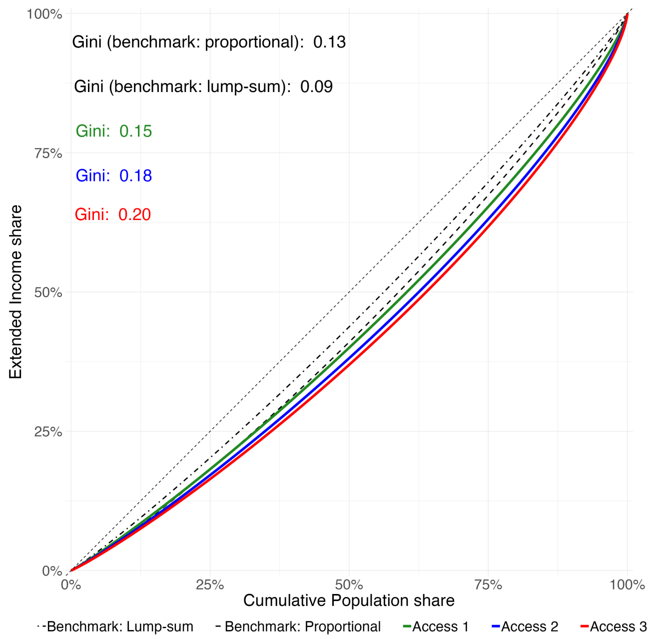
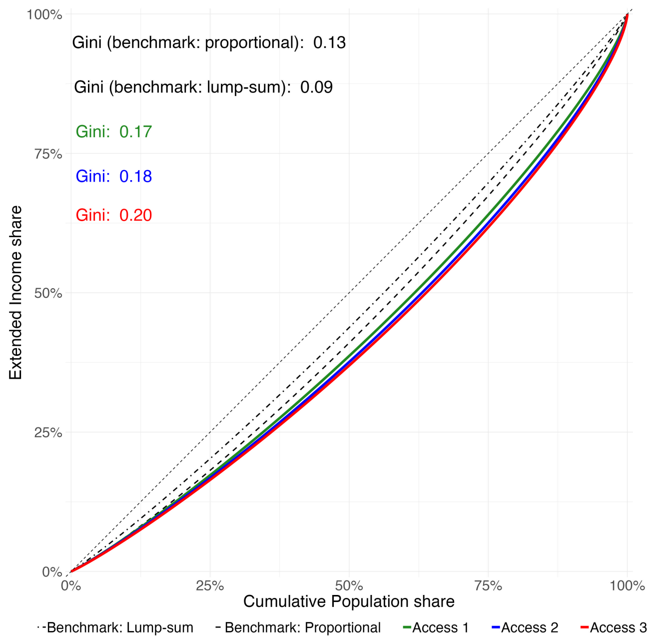
A Appendix

A.1 Additional Figures



(a) Residual imputed lump sum



(b) Residual imputed proportionally

Figure A.1: Extended Income Inequality with Access-Based Imputation of Public Goods (Weighted Indices).

Note: The access-based imputation of public goods is performed using the weighted indices. The black dashed Lorenz curves depict the extent of inequality when applying the DINA methodology (*i.e.* when allocating the entire public budget either lump sum or proportionally to income). The green Lorenz curves use only access information on healthcare and education. The blue curves further include access information on security and transport. In both cases, the remainder of the public budget is either allocated lump sum (panel a) or proportionally to income (panel b). The red Lorenz curve attributes the full public budget according to the health and education access indices.

A.2 Additional Tables

Table A.1: Income and Population Elasticities (Weighted Access Index)

Dependent variable	W. Health Access (log)		W. Education Access (log)		
	(1)	(2)	(3)	(4)	(5)
Average income (log)	0.749***	1.37***	0.205***	0.776***	0.392***
	(0.040)	(0.038)	(0.031)	(0.027)	(0.022)
Population (log)	0.477***	0.195***	0.462***	0.195***	0.070***
	(0.009)	(0.009)	(0.007)	(0.007)	(0.006)
Controls	No	Yes	No	Yes	Yes
Region Fixed-effects	No	No	No	No	Yes
Observations	16,593	16,593	16,593	16,593	16,593

Note: Heteroskedasticity-robust standard errors in parentheses. ***, **, and * indicate significance at 1, 5, and 10, respectively. In columns 1 and 2 (resp. 3 to 5), the outcome is the log of the health weighted access index (resp. education uniform access index), as defined in Section 4.1. In columns 2, 4 and 5, we include the following set of controls: share of the population in five-year age brackets, log of population density, and log of distance to the central business district. To account for the fact that the education budgets are managed at the regional level, columns 5 further includes region fixed effects.

Table A.2: Access and Deprivation (Weighted Access Index)

Dependent variable	Health score (log)			Education score (log)		
	(1)	(2)	(3)	(4)	(5)	(6)
W. Access index (log)	-0.264***	-0.180***	-0.306***	-0.034***	-0.042***	-0.192***
	(0.011)	(0.011)	(0.015)	(0.010)	(0.009)	(0.011)
Average income (log)		-0.953***	-0.607***		-3.52***	-3.21***
		(0.040)	(0.045)		(0.045)	(0.048)
Population (log)		-0.174***	-0.194***		-0.007	-0.083***
		(0.010)	(0.013)		(0.009)	(0.010)
Controls	No	No	Yes	No	No	Yes
Observations	16,579	16,579	16,579	16,579	16,579	16,579

Note: Heteroskedasticity-robust standard errors in parentheses. ***, **, and * indicate significance at 1, 5, and 10, respectively. In columns 1 to 3 (resp. 4 to 6), the outcome is the log of the health (resp. education) deprivation score, as defined in Otavova et al. (2023), and the main regressor is the log of the health (resp.education) weighted access index, as defined in Section 4.1. In columns 3 and 6, we include the following set of controls: share of the population in five-year age brackets, log of population density, and log of distance to the central business district.

Table A.3: Access and Housing Prices (Uniform Access Index)

Dependent variable	Housing price per m^2 (log)					
	Health			Education		
	(1)	(2)	(3)	(4)	(5)	(6)
Access index (log)	0.119***	0.088***	0.080***	0.162***	0.134***	0.142***
	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)
Average income (log)		0.241***	0.325***		0.229***	0.258***
		(0.012)	(0.013)		(0.011)	(0.012)
Population (log)		0.071***	0.067***		0.044***	0.053***
		(0.002)	(0.003)		(0.002)	(0.003)
Controls	No	No	Yes	No	No	Yes
Observations	16,506	16,505	16,505	16,506	16,505	16,505

Note: Heteroskedasticity-robust standard errors in parentheses. ***, **, and * indicate significance at 1, 5, and 10, respectively. The outcome is the log average housing price per square meter from Domènech-Arumí and Gobbi (2025). In columns 1 to 3 (resp. 4 to 6), the main regressor is the log of the health (resp.education) uniform access index, as defined in Section 4.1. In columns 3 and 6, we include the following set of controls: share of the population in five-year age brackets, log of population density, and log of distance to the central business district.

Table A.4: Access and Housing Prices (Weighted Access Index)

Dependent variable	Housing price per m^2 (log)					
	Health			Education		
	(1)	(2)	(3)	(4)	(5)	(6)
W. Access index (log)	0.114***	0.085***	0.086***	0.169***	0.149***	0.164***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Average income (log)		0.251***	0.306***		0.284***	0.295***
		(0.012)	(0.013)		(0.011)	(0.012)
Population (log)		0.063***	0.065***		0.035***	0.049***
		(0.002)	(0.003)		(0.002)	(0.003)
Controls	No	No	Yes	No	No	Yes
Observations	16,506	16,505	16,505	16,506	16,505	16,505

Note: Heteroskedasticity-robust standard errors in parentheses. ***, **, and * indicate significance at 1, 5, and 10, respectively. The outcome is the log average housing price per square meter from Domènech-Arumí and Gobbi (2025). In columns 1 to 3 (resp. 4 to 6), the main regressor is the log of the health (resp. education) weighted access index, as defined in Section 4.1. In columns 3 and 6, we include the following set of controls: share of the population in five-year age brackets, log of population density, and log of distance to the central business district.

Table A.5: Education Access and Housing Prices with Region FEs

Dependent variable	Housing price per m^2 (log)			
	Uniform		Weighted	
	(1)	(2)	(3)	(4)
Education access (log)	0.142***	0.035***	0.164***	0.032***
	(0.004)	(0.003)	(0.003)	(0.003)
Average income (log)	0.258***	0.237***	0.295***	0.250***
	(0.012)	(0.010)	(0.012)	(0.010)
Population (log)	0.053***	0.026***	0.049***	0.026***
	(0.003)	(0.002)	(0.003)	(0.002)
Controls	Yes	Yes	Yes	Yes
Region Fixed-effects	No	Yes	No	Yes
Observations	16,505	16,505	16,505	16,505

Note: Heteroskedasticity-robust standard errors in parentheses. ***, **, and * indicate significance at 1, 5, and 10 percent, respectively. The outcome is the log average housing price per square meter from Domènech-Arumí and Gobbi (2025). In columns 1 and 2 (resp. 3 and 4), the main regressor is the log of the education uniform (resp. weighted) access index, as defined in Section 4.1. We include the following set of controls: share of the population in five-year age brackets, log of population density, and log of distance to the central business district. We further include region fixed effects in columns 2 and 4.

A.3 Model Appendix

Proof of Proposition 4

The FOC in (7) becomes:

$$\sum_{l} \left(W_{lm} - W_{l\mu}\right) n \times \left(1 + \omega / X_l^{\eta}\right)^{\frac{1-\eta}{\eta}} = 0 \tag{A.1}$$

The comparison between the amenities m and μ is therefore between the number of locations each of them serves, and that the other does not:

$$\sum_{l \in C(m) \setminus C(\mu)} \left(1 + \omega / X_l^{\eta}\right)^{\frac{1-\eta}{\eta}} = \sum_{l' \in C(\mu) \setminus C(m)} \left(1 + \omega / X_{l'}^{\eta}\right)^{\frac{1-\eta}{\eta}}, \tag{A.2}$$

where $C(m)$ is the Catchment Area of amenity m: it is the set of all locations l served by m. The population served by m and not by μ is therefore $N_m = n \times \# \left(C(m) \setminus C(\mu)\right)$ where $\#(\cdot)$ denotes the number of locations in the set. Equivalently, let N_μ denote the population served by μ and not by m. With this notation, (A.2) becomes:

$$N_m \left(1 + \omega / X_m^{\eta}\right)^{\frac{1-\eta}{\eta}} = N_\mu \left(1 + \omega / X_\mu^{\eta}\right)^{\frac{1-\eta}{\eta}}, \text{ or: } \frac{\left(1 + \omega / X_m^{\eta}\right)^{\frac{1-\eta}{\eta}}}{\left(1 + \omega / X_\mu^{\eta}\right)^{\frac{1-\eta}{\eta}}} = \frac{N_\mu}{N_m}.$$