The Spatial Impacts of Population Ageing*

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Abstract

Rich countries are ageing and will all soon lose population. This paper examines the impact of this major demographic shift on welfare and inequality by taking into account its wide spatial heterogeneity. Using administrative data on population, housing markets, and local public finance in France, I reveal a new trade-off related to population ageing: an increase in housing costs and in local tax revenues. I build and calibrate a quantitative spatial model in which households differ in terms of skill, age, and family size. I then use this model to run counterfactual experiments based on demographic forecasts. The results show small positive impacts on welfare albeit with an increase in spatial inequalities.

Keywords: Population ageing, Quantitative spatial model, Household sorting, Welfare

JEL: J11, J14, R13, R23

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1. Introduction

In rich countries, population ageing raises many challenges: productivity and overall economic slow down (Maestas et al., 2023; Kotschy and Bloom, 2023), healthcare supply (Kallestrup-Lamb et al., 2024), pension system funding Giuponni and Seibold (2024), monetary and fiscal policies (Bodnár and Nerlich, 2022). This paper studies this major macroeconomic shift through the lens of spatial analysis.

My main contribution is to estimate effects on welfare and inequality implied by population ageing using an extended quantitative spatial model featuring age-, skill-, and family-size heterogeneity. Households have heterogeneous location preferences and enjoy different levels of income and different types of public good. In this setting, any change in the local demographic composition affects three key local equilibrium variables: rents, labour productivity, and public good provision. I calibrate this framework with exhaustive administrative data at the local government level, including in particular municipal balance sheets. Using demographic forecasts from 2030 to 2070, I show that ageing is associated with a small effect on utilitarian welfare but with a large effect on inter-generational and inter-regional inequalities.

France is an interesting case-study to analyse demographic changes for several reasons. First, its demographic characteristics are similar to the European average: similar retirement age (64 on average), similar ageing trajectory, similar mobility rates (4% around 60, slightly lower in France than on average – see Angelini and Laferrère, 2012). Second, the French economy is spatially homogenous in terms of income with great heterogeneity in terms of amenities. Households aged more than 60 represent around 30% of French population in 2019 and this share is expected to reach up to 40% by 2050. At the same time, non-retired population is expected to decrease, leading to an overall decrease in population. With a migration rate of 4% at retirement age and a homeownership rate of 80%, French retired households are relatively not mobile as compared to the active population and thus "age-in-place", like most European elderly (Fernández-Carro, 2014).

Finally, precise data on public finances are available at the very local level, namely the

inter-municipal cooperation unit level, the smallest integrated fiscal unit (IMCU). There are 1252 IMCU, allowing for very granular data as compared to the literature to better grasp on the local effects. I assemble data on the universe of household's location choice from the full count 2019 Census. I also use the universe of tax-paying dwellings to measure household-level housing consumption. On the local public good perspective, I use data on tax collection at the municipal and at the inter-municipal level and I map them with the effective tax rates paid by households. I am also able to target municipal spendings towards specific demographic groups.

I motivate the general equilibrium analysis with four stylized facts. First, I document the mobility preferences of older households through low mobility and a strong desire to age in place. The residential mobility rate is 4% at retirement age and is monotonically decreasing with age. Additionally, 80% of households above 60 are owners. Second, I show that ageing has been a spatially unequal process over the past 50 years. The most populated areas aged "from the top" (higher share of pensioners with an increase in population) while the least populated areas aged "from the bottom" (higher share of pensioners with a decrease in population), amplifying their loss of attractiveness. Third, I show that retired households are net contributors to the local public good. Pensioners consume more housing and enjoy more income so they contribute a larger share to local public finance than their share in the population. At the same time, they are targeted by a smaller fraction of the public good. Using detailed budgetary data, I show that that only 4% of targetable spendings funds are targeted to old-age.[1] Fourth, using a lagged-population instrumental variable strategy, I show that the elasticity of rent with respect to population is the same along the age distribution. It departs from the finding in Germany or in the United States where ageing is associated with a decrease in rents.

With those evidence at hand, I set a quantitative spatial model featuring heterogeneous

[1]Transfers to pensioners are mainly national. The pension system is national (around 40% of total transfers and 14% of GDP). Healthcare supply is provided locally but funded by the central government. The main locally managed spendings targeted to old-age is a personal care allowance (APA), decided at the *département* level, a larger level of aggregation than the IMCU.

households. The model also encompasses a competitive labour market for the active households, a competitive housing market, and local governments which collect taxes and supply type-specific local public goods. Households differ in skills, household size, and age. They also have different preferences for migration, housing consumption and benefit from type-specific public good (for instance, families enjoy the supply of elementary schools whereas pensioners do not). Households sort by trading-off type-specific income, tax-inclusive housing cost, and local quality-of-life. Taking advantage from the model, I decompose the exogenous residual, augmented with an endogenous public good measure. I show that local public goods represent a larger driver of quality-of-life for pensioners than for active households, especially because of healthcare supply.

Counterfactual analysis investigate the change in location choice and in turn welfare variations following the forecasted changes in demographic composition from 2030 to 2070. These changes are characterized by an increase in the share of pensioners and a drop in fertility. Ageing is associated with a slight increase in aggregate utilitarian welfare (0.08 % in 2030, 1 % in 2050, 0.85 % in 2070). Welfare variation decompositions show that the positive effect of amenities is negligible. Welfare variations are mostly explained by the decrease in overall population: as population decreases, demand for housing and rent decrease, offsetting the negative effect on wages (less agglomeration economies and local demand). Under counterfactual policies targeting the housing market (increase in housing sector productivity and decrease in property tax rate), the welfare effects are amplified. Younger households experience the strongest decrease in welfare, even in the long-run. Pensioners experience the largest increase in welfare. Indeed, they are not affected by labour productivity decrease and, because they are fully homeowners, housing cost represents a lower share of their consumption bundle. The small welfare effect however goes with an increase in spatial inequalities measured by inter-quantile ratios, generalized entropy indices, and Gini index. Specifically, inequality decomposition suggests that within-age inequality trumps the within-area inequalities. I extend the model by parametrizing inter-generational transfers with housing units

owned by pensioners and rented to young households. As the share of young households decrease over time, pensioners experience a decrease in welfare. Indeed, pensioners income depends positively on the share of young households in population. As young population shrinks and pensioners share increase, their income decrease and in turn their welfare. It also goes with an increasing in inequalities, driven by the drop in pensioners' welfare.

Contribution to the literature This paper contributes to several strands of the literature.

First, it advances the quantitative spatial modelling literature (surveyed in Redding and Rossi-Hansberg (2017) and Allen and Arkolakis (2025)). I build on this framework to model between-region migration in a static spatial equilibrium setting, following Morten and Oliveira (2024). I extend these approaches by introducing multiple dimensions of heterogeneity—age group, skill level, and family composition—as in Brülhart et al. (2022), Ahlfeldt et al. (2020), and Ahlfeldt et al. (2025). In addition, while Fajgelbaum and Gaubert (2020) and Jannin and Sotura (2020) model non-targeted endogenous public provision, this paper is among the first to explicitly model type-specific, targeted local public spending. These features enable the joint analysis of interregional and intergenerational inequalities within a unified spatial framework.

Second, it relates to the literature on demographic change, particularly population ageing, in a spatial context. Early contributions include Graves and Knapp (1988), who model retirees' location choices within a Rosen–Roback framework. A growing body of work has examined how demographic composition affects local economic outcomes. Moreno-Maldonado and Santamaria (2024) show that fertility decisions shape within-city sorting, while Giannone et al. (2024); Kim (2023); Suzuki (2023) study the implications of ageing for local labour markets, regional growth, and demographic dynamics. Komissarova (2022) documents age-specific sorting patterns in the United States, and Angelini and Laferrère (2012) provide evidence of low migration rates among European seniors. In a closely related context, Badilla Maroto

et al. (2024) estimate the effects of pensioner inflows on rents, population, and local GDP across French regions, while Ahlfeldt et al. (2025) analyse life-cycle location choices using detailed Copenhagen data.

Third, this paper connects to the literature on the macroeconomic and aggregate impacts of ageing. Mankiw and Weil (1989) and Poterba (2001) first investigated the effect of the increase in old-age population on housing cost. I find conflicting results where ageing is actually associated with an increase in housing cost as opposed to their findings. Ageing is also associated, both with reduced-form and structural approaches, with effects on regional finance (Tani and Uemura, 2023), regional GDP (Maestas et al., 2023), and labour force outcomes (Maestas and Zissimopoulos, 2010). I add to this array of evidence with findings on French data.

Roadmap First, I motivate the analysis with descriptive evidence (Section 2). I set the model in Section 3, bring it to the data (4) and use it to run different counterfactual analyses (Section 5). Section 6 provides extensions and Section 7 concludes.

2. Motivating evidence

I introduce the data used in the analysis. Then, I present several descriptive evidence to ground my analysis and to support the modelling choice made later.

Data and context

The analysis focuses on France. As of 2019, around 28% of the French population is aged 60+ and this share is expected to reach around 38% in 2070 (see Figure B3). This demographic trend is slightly stronger than the European one.

France is an ideal context to study ageing impact in a spatial setting. First, data are widely available at a fine grained level (municipality) for a relatively long period (at least since

the late 1960s). Second, the institutional context, as noted in Badilla Maroto et al. (2024), allows free migration of households – up to the moving costs. Interestingly, the pay-as-you-go pension system is administered by the national government such that the pension levels are independent of the region of residence. Pensions depend only on the previous income, the recovery rate (the share of past income earned in retirement), and potential personal retirement plans. It notably implies that retired households do not need to use their (housing) capital to fund their pension, as in life-cycle theory. Workers need to reach a minimum statutory retirement age to benefit from a pension. Hence, retirement age concentrates around the same age. On average, workers retire at 62. I set the age threshold for being a pensioner at 60 throughout the whole analysis.[2] Moreover, I define ageing as the increase in the share of 60-80 in total population aged less than 80.

I combine several administrative and historical datasets. Population data come from the exhaustive census (1968, 1975, 1982, 1990, 1999, 2013, and 2019). They contain information on current and past location at the municipality level. Since 2011, 1/12 of the French population is part of a yearly panel dataset (*Échantillon Démographique Permanent*, EDP), combined with fiscal and administrative data, providing details on income by sources and household composition. Income is taken from two sources. Wage income is from *Données annuelles de déclarations sociales*, an exhaustive employer-employee dataset containing the wage of all workers. Following standard practice, I keep full-time, private sector (excluding finance and primary sectors), non-annex workers. Pension levels are computed from the EDP. On the housing market perspective, I mainly rely on the *Fichiers des Logements Localisés à la Commune* (FILOCOM). It consists in the universe of dwellings located in France, identified at the municipality level, notably with the floorspace and the housing composition. Contemporaneous rent data come from *Carte des Loyers*, a project compiling rental postings from the major online realtors. Finally, local public finance data come from two sources. Information on taxes, bases, and amount collected are from the *Recensement*

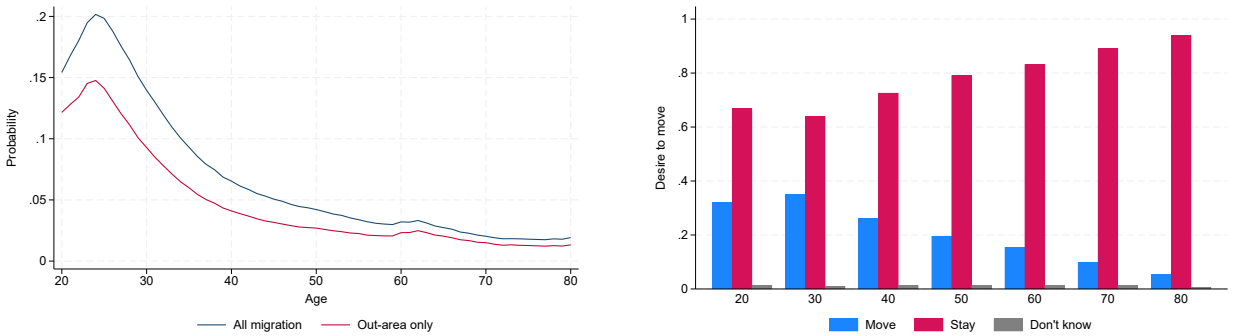
[2] I indifferently use the terms "pensioners", "retired workers", or "seniors".

des éléments d'imposition (REI), which contain the universe of locally applied taxes. On the spending side, I rely on the *Balance comptable des collectivités*. It provides, for all entities populated by more than 3,500 inhabitants, a mapping to specific spending items (e.g, education, old age, libraries).

The analysis is conducted at the inter-municipal cooperation unit level (*Établissement Public de Coopération Intercomunnal*, EPCI). It is the smallest integrated cooperation level in France. Since 2010, all municipalities have to be part of an EPCI (see Tricaud (2025) for further details). They share part of their fiscal capacity and pool some or all spendings (notably the waste collection). On average, an EPCI contains 29 municipalities (minimum is 1 and maximum is 164) and 59,000 inhabitants (min. is 4,621 and max. is 2,165,631). I focus on households aged from 20 to 80. Indeed, the migration pattern of households aged more than 80 is driven by moves to retirement houses, which is outside the scope of this analysis. Appendix A.1 provides extensive description of the data and the cleaning process.

Fact 1: Households age in place

Mobility preferences are heterogenous across households, in particular along the age distribution. Figure 1 shows the cross-sectional migration probability (defined as the share of households with a different address a year prior) of households in 2019 at all age between 20 and 80. I distinguish between "all migration" (all moves, even within the same city or even the same building) and "out-area migration", which take place outside of the inter-municipal cooperation unit of origin. Conditional on moving, a large majority of households move out of their area of origin. Central to my analysis, the moving probability decreases sharply with age, only to slightly increase around retirement age. This clearly states a strong preference of households to age in place. This finding is corroborated in the *Enquête Logement*, a representative survey of French households. To the question "Do you want to change of housing unit?", a majority of households answer "No", and the share is monotically increasing with age, to reach 90% at 80.



(a) Moving probability

(b) Expressed desire to stay

Data: EDP 2011-2020 and Enquête Logement 2020. Left panel: The probability is computed as the share of households with a different address a year prior. Out-area are moves that happens outside of the EPCI of origin. Right panel: Share of "Yes" to the question: "Do you want to change of housing unit?"

Figure 1: Low mobility preferences along the age distribution

What would have population been absent household migration? I compute a hypothetical population change, assuming no retired internal migration, since 1968. Following Giannone et al. (2024), the counterfactual population at time t is:

$$R_t^c = R_t \times \prod_x (1 + \texttt{Net retired migration rate}_x)$$

where x corresponds to the all past censuses, including current census t. As the analysis start in 1968, $x = 0$ and $R_{1968}^c = R_{1968}$. Figure 2 plots the results for the top and bottom decile in terms of 1968 population density. Population is normalized to 1968 and expressed in log, so the y axis can be interpreted as percentage change with respect to 1968. Absent retired migration, top decile areas population would have grown the same. It suggests a desire to stay in place as already suggested in Fact 1. Strikingly, the growth path for bottom decile areas would have been different absent retired migration. Indeed, absent retired migration, their population would have grown by a larger magnitude, indicating that over the years, households located in denser areas, leading to potential congestion. Contrary to the findings in Giannone et al. (2024), least dense areas did not depopulate, their population increased, but less than top decile areas.

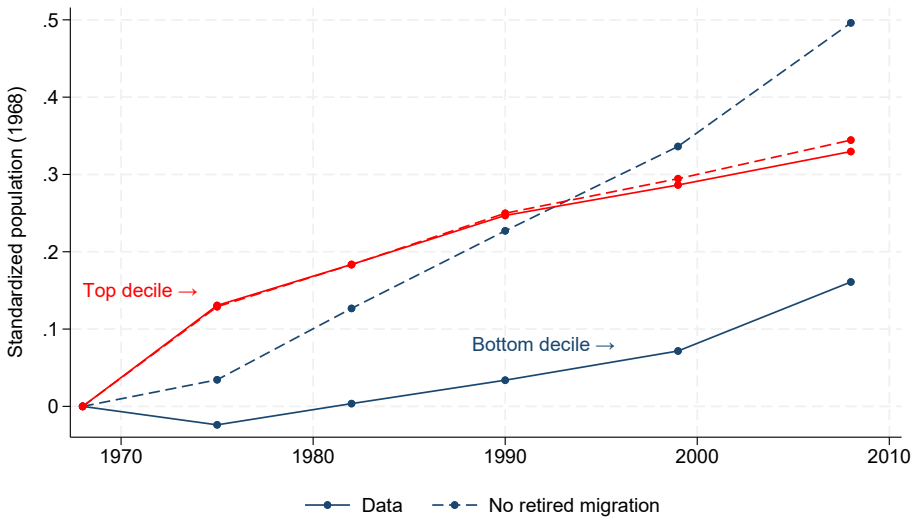


Figure 2: Counterfactual population change

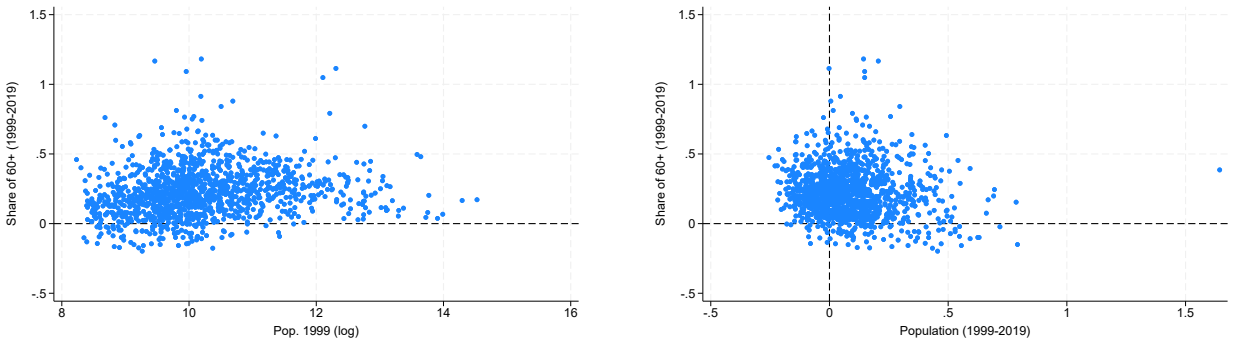
Data: Recensement Permanent 1968 to 2008. Observed (plain line) and counterfactual (dotted line) change in population. Log population standardized in 1968. Lecture: In 2008 and in the bottom decile area, population grew by 15% with respect to 1968. Absent migration of pensioners, it would have grown by 50%.

Fact 2: Ageing is a spatially heterogenous process

Despite a low mobility rate, have all areas "aged" the same during the past decades? First, I plot the change in the share of 60+ in each EPCI over the (log) total population in 1999 (Fig. 3). A striking absence of pattern emerges: ageing is not associated with city size. Moreover, at the exception of few of them, all areas aged over the period. The change magnitude spans from -20% (indicating a "rejuvinating" of the area) in Nozay (Loire-Atlantique) to 118% (a more than doubling in the share of seniors) in Jalle-Eau-Bourde (Nouvelle-Aquitaine). On Figure B4, I map these changes along with the change between 1975 and 1999. Ageing areas are mainly located around the Paris region, in the Alps, the Atlantic Ocean and Mediterranean Sea coastlines.

From Figure 3 a second pattern emerges: ageing is not necessarily associated with a decrease in population. Indeed, some areas aged but saw their population increased over the same period (top right quarter of the right panel), either because of high fertility and/or positive in-migration. A sizeable share of areas aged and lost population (top left quarter), due to

a drop in fertility and/or out-migration and lack of attractiveness. Most areas that did not age also gained population (bottom right quarter). Depending on the ageing pattern, those areas might face different economic outcomes. Demographers coined the term ageing "from the top" and ageing "from the bottom" (Preston et al., 1989) to distinguish two types of ageing. The former refers to a situation in which the top of the age pyramid widens (increase in life expectancy, in-migration of seniors) and the latter refers to a situation in which the bottom of the pyramid narrows (low fertility, out-migration of workers). Due to data constraint, I adapt the definition, and define an area that ages from the bottom as an area where the share of seniors (60-80) increased and the share of active (20-59) increased as well. Reversely, an area that ages from the top is an area where the share of 60+ increased and the share of active decreased. Figure B5 maps the typology. With the exception of Paris and Nice, most populated areas age from the top. Areas known for their low attractiveness (the "empty diagonal", *diagonale du vide*, from the Belgian border to the West Pyrenees) are indeed ageing from the bottom. One could expect different local outcomes depending the ageing type. An ageing areas with a growing active population might exhibit an increase in rent whereas an ageing-from-the-bottom area might exhibit a drop in rent and in local public good due to its lack of attractiveness.



(a) Ageing by area size

(b) Ageing by change in pop.

Data: Recensement Permanent 1999, 2019. Change in the share of 60-80 in total population aged less than 80 between 1999 and 2019. Left panel: The x-axis is the log total population in 1999. Right panel: The x-axis is the change in total population between 1999 and 2019. Each dot is an EPCI.

Figure 3: Ageing patterns between 1999 and 2019

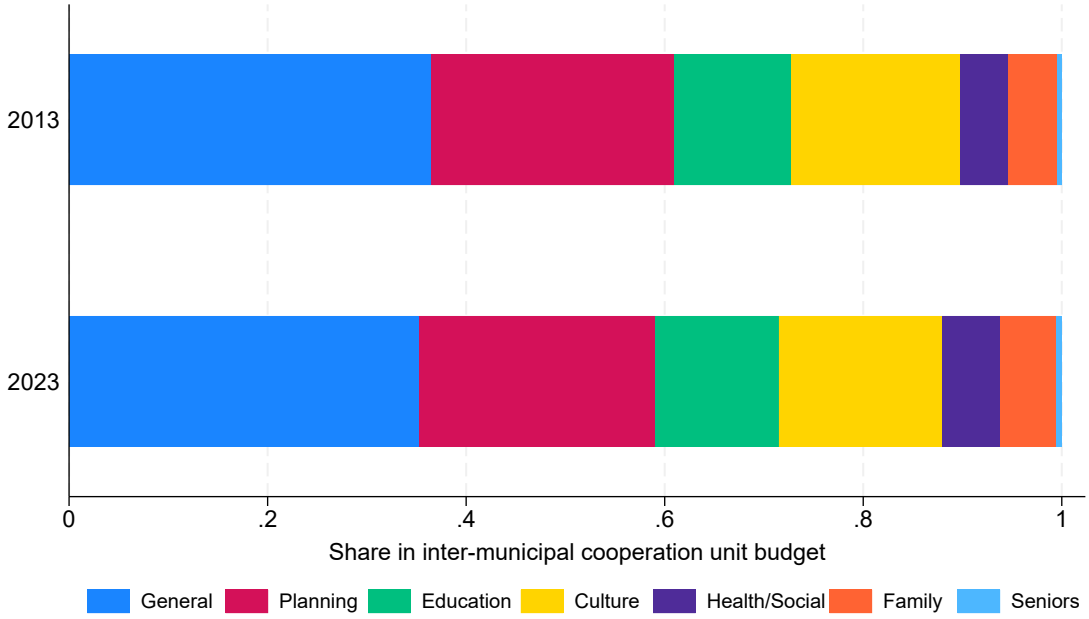
Fact 3: Pensioners are net contributors to local public good

Local attractiveness is partly driven by local public good access in the Tiebout (1956) and Rosen (1974)-Roback (1982) spirit. Local public good are mainly funded by local governments through local tax collections and national government transfers. When making a location choice, households make a real income *vs.* quality-of-life trade-off: they are willing to earn less in real income (income over local price index – mainly housing cost) if the local quality-of-life increases. Pensioners are not attached to a location in terms of income and only compare tax-inclusive housing cost and quality-of-life.

To what extent do they benefit from local public good provision? Are they net contributors to local public good? First, I show that only a small share of local public spendings is targeted *specifically* to retired households. The French Ministry of Finance distinguishes 10 main spending items for local governments (municipalities and EPCI): general services (including security and salubrity), planning (including environmental, transport, and economic support), culture/leisure/sport, education, health/social (including family and old-age support). All households benefit from general services, planning, culture/leisure/sport and general health/social. Only families benefit from education and family support. Only pensioners benefit from old-age support. The majority of municipal spendings benefits to everyone (road quality, public libraries), but only a marginal share is targeted to pensioners specifically (less than 0.8% of overall spendings, 4% of targeted spendings). Indeed, most old-age targeted spendings, such as pensions, healthcare supply, retirement benefits, are managed by higher administrative levels. It ensures the stability of the system and the uniformity in access to healthcare and resources, as the sole pensions represent around 25% of total governmental spendings.

Turning to the fiscal revenue, I am able to compute, for each municipality and EPCI, the share of locally levied property taxes[3] paid by households whose head is aged between 20 and

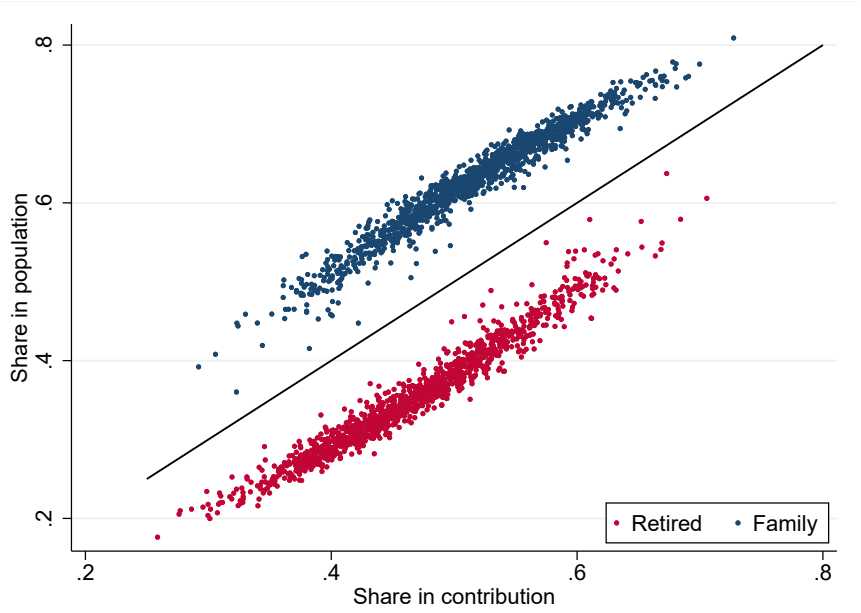
[3]In 2019, owners would pay a property and a housing tax, both depending mostly on the floorspace. The housing tax, paid by both renters and owners, is progressively removed until 2023. On Figure B6 I show a similar result for the housing tax.



Data: Balance comptable des collectivités 2013 and 2023, retreated by OFGL. Item description in Appendix A.1. Data are aggregated as the sum of municipal and EPCI spendings.

Figure 4: Share of local government spendings per item

60 ("family") and households whose head is aged more than 60 ("retired"). I then compare these shares to their shares in local population. Figure 5 shows the results. Pensioners systemically contribute more to the local tax revenue than their share in the population. Reversely, families contribute systematically less. This is partly explained by two facts: retired households are, on average, more owners and mechanically pay more property tax, and because retired households consume, on average, larger floorspace. These two evidence show that, on the one hand, pensioners receive relatively less public good than their active counterparts, and, on the other hand, pay relatively more local taxes given their share in the population. Hence, ageing should be associated, *ceteris paribus*, with higher local public good quality and in turn, higher in-migration rate, especially from active and family households.



Data: FILOCOM 2019. Each dot is an EPCI. The black line is the 45° line. If a dot lies on the 45° line, then the share in population is equal to the share in contribution to local tax revenue.

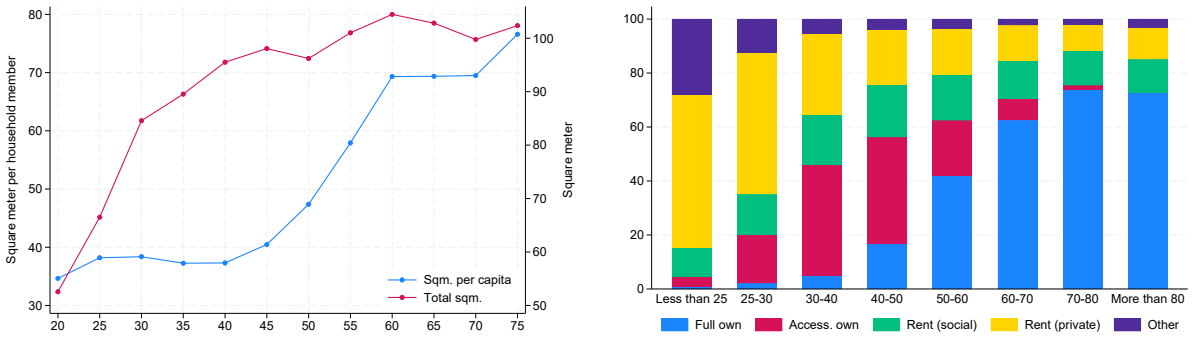
Figure 5: Share in population and in contribution to the property tax by demographic group

Fact 4: Ageing is associated with higher local housing cost

On top of population and local public good provision, ageing also has an impact on housing cost. First, I show that retired households consume more housing in absolute value and per capita than their younger counterparts (Figure 6). Households do not downsize when they age, as opposite to the United States (Poterba, 2001), the United Kingdown (Banks et al., 2010) or to a lesser extent, Germany (Hiller and Lerbs, 2016). On top of that, the ownership rate monotonically increases with age, to reach a maximum at 75 where around 70% of households own their dwellings.

Understanding the relation between the share of retired households and housing cost boils down to compute the rent elasticity with respect to age-specific population. The standard framework from Saiz (2010) states the following relation between local rents r_d and local demand Q_d:

$$r_d = \overline{h}_d Q_d^{\beta}$$



(a) Floorspace consumption

(b) Ownership status

Data: SRCV 2019. Left panel: Each point is the survey-weighted average of the age bin. Blue line is the average housing consumption per household member (left axis). Red line is the average total housing consumption (right axis). Right panel: Ownership status by age. Full owners do not pay mortgage whereas Accessing owners do. Renters are either in the social or the private park (including retirement home). Other includes living in a community, co-living with parents or families, and individuals hosted for free.

Figure 6: Housing consumption along the age distribution

where $\overline{h}_d$ is an exogenous housing productivity shifter and β is the demand elasticity of rent. Assuming that households aged θ consume a fixed share α^θ of her income w_d^θ, we obtain the following function:

$$r_d = \overline{h}_d \left(\sum_\theta \alpha^\theta w_d^\theta R_d^\theta \right)^\beta$$

It comes directly that age-specific demand elasticity β^θ is:

$$\beta^\theta = \beta \frac{\alpha^\theta w_d^\theta R_d^\theta}{\sum_\theta \alpha^\theta w_d^\theta R_d^\theta} < \beta \tag{1}$$

Hence, if the population aged θ increases by 1%, rent increases by β% weighted by the market share of that population, *ceteris paribus*. By construction, $\sum_\theta \beta^\theta = \beta$.

Because β^θ is the elasticity of rent with respect to age-specific population, it can be estimated as such:

$$\log r_d = \log R_d^\theta + \gamma X_d' + e_d^\theta \quad \forall \theta \tag{2}$$

where X_d' is a vector of local covariates (average wage, latitude, longitude, and whether the area ages from the bottom, the top, or if it does not age). Equation (2) relates the effect

of a specific demographic group on rent. However, population level might also be affected by factors such as favourable fiscal policies or negative labour market outcomes that in turn affect rents. To account for these potential confounders, I rely on an instrumental variable strategy that exploits past population stocks and exogenous variation in population growth across areas. The identifying assumption is that past population affects current rent only through the realized population. In practice, I interact lagged local population with the predicted national cohort survival rate. This falls into the shift-share instrument family, where the endogenous share is the lagged population and the exogenous shift is the national survival rate. I relegate all the details on instrument building and first stage estimates in Appendix B.2. It turns that rent elasticity with respect to population is U-shaped, contrary to prior beliefs (Breidenbach et al., 2024; Hiller and Lerbs, 2016; Poterba, 2001). The elasticity of rent for population aged 75 is in the same range as the elasticity of rent for population aged 35, around 0.12. Summing all elasticities give 1.42, which is lower – but within a credible range – than the elasticity of 1.92 found in Chapelle et al. (2023). This can be explained by households' absence of downsizing when ageing and high ownership rate in France. Due to the pay-as-you-go pension scheme, households do not have extra capital need when retiring.

3. Quantitative Spatial Model

To better account for general equilibrium effect, I develop a quantitative spatial model of inter-regional location choice. I augment the canonical model by adding different household types, indexed by θ. There is a fixed number of areas indexed by d. Areas are populated by a fixed measure of households R of types θ such that $R = \sum_\theta R^\theta = \sum_\theta \sum_d R^\theta_d$. Households are mobile in space but migration is costly. Heterogeneity in household type affects location choice, and in turn the general equilibrium, across four dimensions: preference for housing, income level, migration cost, and quality of life. The model is static and captures the effects

of one-off migration.

3.1. Demand for location

Households derive utility from consumption of a freely traded good, c, which acts as the numéraire, a non-traded good, h. Housing units come at price r_d and are locally taxed *ad valorem* at rate τ_d^θ if owned. It is also considered as a necessary good, with a type-specific vital minimum $\underline{h}^\theta$. Active households earn an income w_d^θ by inelastically supplying a unit of labour. Retired households earn an income w^θ, which is location-independent. Households also enjoy a local amenity vector $a_d = A_d \xi_d^\theta$. Hence, the indirect utility derived from locating in d, for a household of type θ, originating from o, is:

$$V_d^\theta(w_d^\theta, r_d, \tau_d^\theta; \underline{h}^\theta) = v_d^\theta(w_d^\theta, r_d, \tau_d^\theta; \underline{h}^\theta)\frac{\xi_d^\theta}{\mu_{od}^\theta}$$

ξ_d^θ captures idiosyncratic preference shocks for locations and μ_{od}^θ is a type-specific symmetric migration cost. The shock is Fréchet distributed with parameter κ^θ and is i.i.d. across locations and within types. v is increasing in income and decreasing in rents, property taxes, and minimum housing consumption.

Following the standard derivation (Monte et al., 2018), I can derive the share of households choosing to locate in d conditional on living in o:

$$\pi_{od}^\theta = \frac{R_{od}^\theta}{R_o^\theta} = \frac{\left(v_d^\theta/\mu_{od}^\theta\right)^{\kappa^\theta}}{\sum_{d'}\left(v_{d'}^\theta/\mu_{od'}^\theta\right)^{\kappa^\theta}} \tag{3}$$

3.2. Labour market

Active households supply units of labour to a representative firm that only takes labour as input. Profit maximization yields that wage equals productivity. Households differ in skill (which explained income differences). Individual productivity depends on an exogenous

factor $\overline{\varphi}_d$ and an endogenous factor dependent on employment density (Combes et al., 2008):

$$w_d^\theta = \overline{\varphi}_d^\theta \left(\frac{R_d^{act}}{T_d} \right)^{\phi^\theta}$$

The ability of a worker to benefit from local employment density depends on its type.[4]

3.3. Housing market

To keep the model tractable I assume housing services are supplied by some absentee landlord that does not consume nor live within the economy. First order condition of its profit maximization program yields:

$$HS_d = \overline{h}_d r_d^\eta$$

η controls the housing supply elasticity with respect to price. $\overline{h}$ captures all exogenous factors influencing housing supply (geographical constraints, soil quality, etc.). Demand for housing is expressed as:

$$HD_d = \sum_\theta R_d^\theta h_d^\theta (w_d^\theta, r_d, \tau_d^\theta; \underline{h}^\theta)$$

where h_d^θ is the Marshallian demand for housing stemming from the households' utility maximization program. Market clearing condition on the housing market pins down the equilibrium rent equation:

$$r_d = \left[\frac{\sum_\theta (1-\alpha) R_d^\theta w_d^\theta + \alpha R_d^\theta \underline{h}^\theta}{\overline{H}_d (1+\tau_d)} \right]^{\frac{1}{1+\eta}} \tag{4}$$

Rent increases with population and income, but also as the survival quantity of housing increases. It decreases with housing sector productivity and taxes.

[4] A large strand of literature (see Davis and Dingel (2019) for instance) elicits a skill-biased return to agglomeration.

3.4. Local quality of life

One innovation of the paper is to allow for type-specific endogenous public good provision. I detail in Appendix A.2 how taxes are collected. Renters do not pay taxes whereas owners (either full and accessing) do. The tax base is legally defined as half the housing cost (CGI, art. 1388 quinquies (II)). Each area receives a transfer from the national government g_d.[5] The tax revenue is then:

$$G_d = \sum_{\theta \in \texttt{owners}} R_d^\theta \frac{r_d h_d^\theta}{2} \tau_d^\theta + g_d$$

Finally, the government can decide to spend fiscal revenues in three main ways: for general purpose (road maintenance, sport and culture, public libraries, for instance), for families and children (kindergarten, elementary schools), and specifically for retirees. I denote the share of each item ι such that $1 = \iota^G + \iota^F + \iota^R$, respectively. The general purpose expenditure benefits to all inhabitants and the type-specific expenditure benefits only the type considered.

Amenities are composed of an exogenous component $\overline{A}_d^\theta$ and an endogenous component. The latter component is supplied by local government (local public good) and is a function of tax revenue G_d:

$$A_d^\theta = \overline{A}_d^\theta \left((\iota^G + \iota^\theta) G_d \right)^\Omega \tag{5}$$

Ω captures the elasticity of amenity with respect to public good provision.

3.5. Equilibrium

Given structural parameters $\{\alpha^\theta, \kappa^\theta, \mu^\theta, \phi^\theta, \eta, \iota^\theta, \Omega\}$, structural variables $\{T, \overline{\varphi}, \overline{A}\}$, and an initial endowment in population R, a general equilibrium of the model is defined as labour market clearing, residential market clearing, and housing market clearing.

[5] In practice, this transfer includes the perfect monetary compensation for the removal of housing tax started in 2019 and achieved in 2022.

3.6. Welfare

Because of frictional mobility, expected welfare is not equalized between locations. Welfare is defined as the population-weighted average of all origin indirect utilities, weighted by mobility cost:

$$\overline{U}^{\theta} \propto \sum_{o} \frac{R_o^{\theta}}{R^{\theta}} \left[\sum_{d} \left(\frac{v_d^{\theta}}{\mu_{od}^{\theta}} \right)^{\kappa^{\theta}} \right]^{1/\kappa^{\theta}} \tag{6}$$

Welfare change is the comparison between the baseline welfare and a counterfactual welfare. This definition of welfare is interesting as it allows to compute location-type-specific welfare measure, measured as the quantity between brackets: the sum of attainable indirect utilities corrected with mobility cost.

4. Quantification

I bring the model to the data using the source described in Section 2. In particular, I present how I defined the types θ. Based on those types, I describe how housing cost is borne by households in their utility maximization program. Finally, I present how key parameters are calibrated or estimated.

Household types So far, I remain relatively agnostic on the household type, apart from age. I follow Brülhart et al. (2022) or Ahlfeldt et al. (slides) and distinguish households based on (i) age (ii) family composition and (iii) skills, leading to 12 categories. Table 1 summarizes the different household types. Age is split in three: young (20-29), family (30-59), and retired (60-79). Family composition is split in two: with or without children. Finally, skills depend on the diploma: low skilled completed high school and high skilled completed a higher education degree. I show in Appendix A.4 that these three dimensions combined, instead of age only, are a good proxy for the homeownership status. Homeowners - no matter they are accessing owners or full owners – pay taxes whereas renters do not. I make the assumption that accessing homeowners pay the rent r, as a proxy for mortgage,

and not the full owners. The typology is based on Figure A2.

Table 1: Description of households types

θ	Age	Skill	Size	Owner. status	Tax	$\underline{h}^\theta$	Housing cost	Share
$y,1$	20-30	LS	NoCh	Renter	✗	28	rh	5.64%
$y,2$	20-30	HS	NoCh	Renter	✗	25	rh	4.81%
$y,3$	20-30	LS	Ch	Renter	✗	59	rh	5.30%
$y,4$	20-30	HS	Ch	Renter	✗	60	rh	2.87%
$f,1$	30-60	LS	NoCh	Renter	✗	28	rh	16.2%
$f,2$	30-60	HS	NoCh	Acc. owner	✓	43	$(1+\tau)rh$	7.29%
$f,3$	30-60	LS	Ch	Renter	✗	65	rh	22.4%
$f,4$	30-60	HS	Ch	Acc. owner	✓	70	$(1+\tau)rh$	11.3%
$r,1$	60-85	LS	NoCh	Owner	✓	54	τrh	21.9%
$r,2$	60-85	HS	NoCh	Owner	✓	62	τrh	1.70%
$r,3$	60-85	LS	Ch	Owner	✓	65	τrh	0.052%
$r,4$	60-85	HS	Ch	Owner	✓	72	τrh	0.0946%

NOTES: Population from RP 2019. Skill corresponds to the classification in appendix. Size is NoCh if no children in the households, Ch otherwise. Tax is ✓ if the household pays the property tax. $\underline{h}$ corresponds to the 10th percentile of floorspace consumption (FILOCOM). Share is the share of each type in the estimating sample.

Effective housing cost Depending on the types defined above, each household pays a different housing cost. Local tax applies only on accessing and full owners. Full owners do not pay rent. I assume furthermore that accessing owners and renters face the same housing price r_d. Hence, housing cost writes: rh for renters, $(1+\tau)rh$ for accessing owners, and τrh for full owners. The underlying assumption is that even when moving households do not change their homeownership status. This is supported by the very low permeability between status conditional on moving, at any age (Figure B10).

Endogenous variables Wages are the monthly labour income for private sector workers, working full time, in a non-auxiliary position. I winsorize the first and last percentile of the distribution to avoid outlier. Rents are computed as the average monthly cost for a square meter. Pensions are the national average pension level for each type. Population is computed as the number of *households* of each type in the Census.

Calibrated parameters From the 2019 *Statistiques sur les revenus et les conditions de vie des ménages* (SRCV), a nationwide representative survey on households income and life condition, I calibrate $\alpha = 0.2$ based on the average share of income spent in housing. I also calibrate the Stone-Geary parameters $\underline{h}^{\theta}$ as the 10th percentile of the housing consumption distribution for each type. I set $\phi = \{0.03, 0.06\}$ – the productivity density elasticity – for unskilled and skilled workers respectively (to fall within the standard estimation of 0.04 made by Combes et al. (2008)). Chapelle et al. (2023) find $\eta = 0.5$ for the medium run (1999 to 2019) housing supply elasticity in France. This is slightly higher than the short run elasticity of 0.38 found by Lerbs (2014) using German data. This is in line with Han and Baum-Snow (2024) in the United States.

The set of ι, which captures each item of municipal spendings, is computed for each municipality and each inter-municipal cooperation unit. From the local accounting data, I drop debt reimbursement, mortgages, salaries and keep "investment" spendings. Appendix A.3 provides more details on how the ι are computed. Non-retired households without children get a share ι^G, non-retired households with children get a share $\iota^G + \iota^F$. Retired households without children get a share $\iota^G + \iota^R$. Retired households with children get the full share of public spendings. Finally, Ω, the elasticity of quality of life with respect to public good spending is set to $\Omega = 0.04$ as Fajgelbaum et al. (2019) on United States data.

Estimated parameters Remain to estimate the migration parameters ρ^{θ} and κ^{θ}. Equation (3) sets the base for a gravity equation, which I estimate by Pseudo-Poisson Maximum

Likelihood to account for the large number of 0 flows (Head and Mayer, 2014):[6]

$$\pi_{od}^{\theta} = \gamma_o + \gamma_d + \kappa^{\theta} \log \mu_{od}^{\theta} + \varepsilon_{od}^{\theta} \tag{7}$$

I parametrize $\mu_{od}^{\theta} = \exp(-\rho^{\theta} \texttt{distance}_{od})$ as the migration bilateral resistance parameter. Estimating the previous equation separately for each age group jointly identifies $\kappa\rho$. Table 2 summarizes the result for all household types. The bilateral resistance term has a stronger effect as individuals get older.

The literature does not readily provide clear equivalent for ρ nor κ, especially for retired households. Because the idiosyncratic shock is Fréchet-distributed, the real income is Fréchet distributed. By definition, the log of a Fréchet distribution is Gumbell distributed, with shape parameter $\tilde{\kappa} = 1/\kappa$. The variance of a Gumbell-distributed random variable X is $\mathbb{V}(X) = \frac{\pi^2}{6\kappa^2}$. Using $X = \log \frac{w_d^{\theta}}{(1+\tau_d) r_d^{1-\alpha}}$, I back-out the κ^{θ} parameters.

Table 2: Migration parameters

	$y,1$	$y,2$	$y,3$	$y,4$	$f,1$	$f,2$	$f,3$	$f,4$	$r,1$	$r,2$	$r,3$	$r,4$
$\rho\kappa \times 100$	2.7	1.2	4	3	6.9	2.5	4	2.6	9	5.2	9.8	4.5
$\rho \times 100$	0.4	0.2	0.6	0.4	1.1	0.3	0.6	0.3	3.2	1.1	3	0.9
κ	6.24	7.57	6.66	7.52	6.48	8.59	7.20	9.10	2.79	4.68	3.33	5.06

Table 3 summarizes the parameters and variables used in the estimation.

5. Counterfactual analysis

How does expected population ageing going to shape cities and economic activity? I simulate different ageing scenarios based on INSEE predictions. As the model is a closed-economy model, I change the total population in the economy for each age group $\overline{R}^{\theta}$. To do so, I follow the central predictions made by INSEE for 2030 (C1), 2050 (C2), and 2070 (C3).

[6] I actually estimate this equation at three different levels of aggregation: *départements* (95x95), commuting zones (274x274), and EPCI level (1252x1252).

Table 3: Parameters used in the estimation

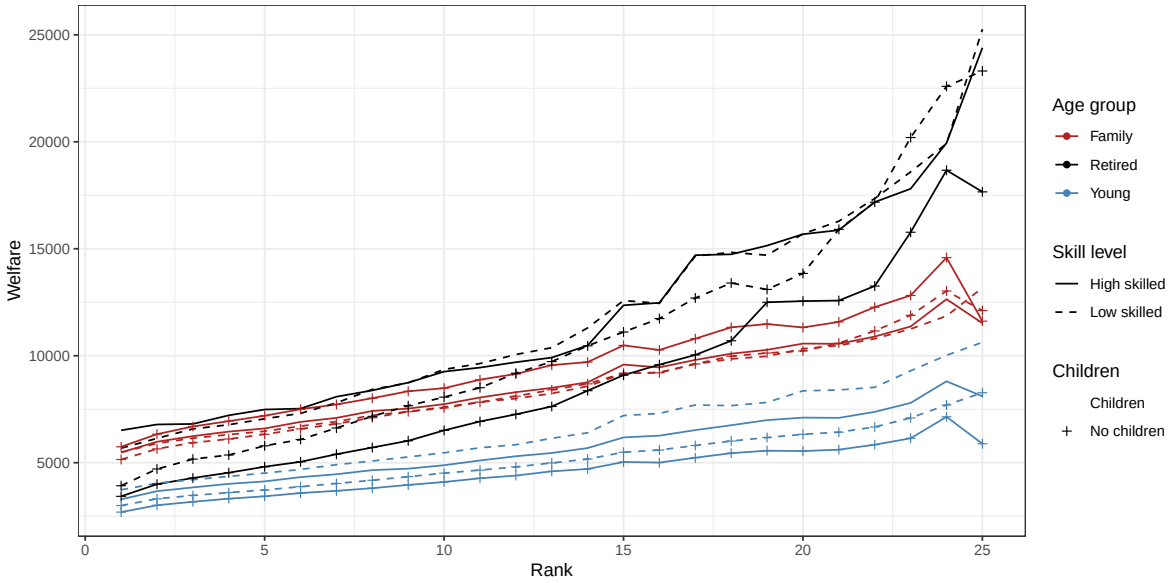
Par.	Description	Source	Value
Structural parameters			
α	Share of housing cons. in budget	SRCV 2019	0.25
η	Housing supply elasticity	Chapelle et al. (2023)	0.5
ϕ^θ	Agglomeration (productivity)	Ahlfeldt et al. (2019)	§4
Ω	Agglomeration (public good)	Couture et al. (2023)	0.05
ι	Share of municipal budget	BCC 2019	A1
$\kappa^\theta \rho^\theta$	Migration resistance	PPML	Tab. 2
κ^θ	Variance of real income	Model moment	Tab. 2
Exogenous variables			
g_d	Transfer from central government	BCC 2019	
$\underline{h}^\theta$	Minimum housing cons.	SRCV 2019	Tab. 1
T	Land area	IGN	
`dist`	Distance	Geodesic distance	

In Section 6, I also estimate the 2030 ageing scenario without mobility cost (C4) and with three different policies: a 10% pension increase (C5), a 10% increase in the exogenous housing supply productivity (C6), a 10% decrease in the property tax rate (C7). These "policies" do not have a specific real life counterparts. However, they appear to be helpful to highlight the main mechanisms of the model. I also implement an alternative parametrization of the model to allow for multi-ownership and the presence of secondary homes (C8).

Table 4: INSEE prevision for national population change

	2030	2050	2070
Young	1.039	0.912	0.9534
Family	0.9445	0.9263	0.899
Retired	1.123	1.141	1.161

Source: INSEE Omphale. Variation with respect to 2019 observed population.



Welfare is the sum of achievable indirect utilities from any location, weighted by population, averaged by 2019 population quantile bin, as defined in (6).

Figure 7: Baseline welfare

5.1. Baseline and model fit

The model fit is satisfying, as presented in Appendix D.1. The R^2 of the regressions between the targeted endogenous variables and the ones actually observed is comprised between 0.85 and 1 for all variables. I also compare observed and predicted non-targeted variables (population and local fiscal revenues), laying comparable results. Figure 7 shows the distribution of welfare $\overline{U}_o^\theta$ (as defined in Equation (6)) along the baseline population distribution percentile (as observed in 2019). Households with the higher welfare are high-skilled retirees and most family types. Younger households exhibit the lower welfare. In line with the standard spatial economics conclusions, welfare is higher in more populated areas due to higher public good provision and higher wages (Diamond and Gaubert, 2022). On top of the standard urban wage premium, retired households also strongly benefit from living in top areas.

5.2. Quality-of-life decomposition

The structural estimation provides a measure of $A_d^\theta = \overline{A}_d^\theta f(R_d^\theta)$, an age- and location-specific measure of quality of life. It captures the attractiveness of each area for a given type. In the spirit of Ang et al. (2024), I regress the quality-of-life vector on observable local characteristics and decompose the variance. Local characteristics are derived from three sources: the *Base permanente des équipements* (BPE), a declarative survey sent to each municipality to survey its equipments, both public and private; the average monthly temperatures observed at the EPCI level in 2019; and measures of natural amenities. Appendix A.1 describes the local measures used in the subsequent analysis.

Explained variance What is the share of variance in quality of life explained by those equipments? First, I group those equipments in different bundles depending on their targets. INSEE defines four bundles depending on the age they are targeted to: daily life (which are accessible by all), young, families, and pensioners. I regress for each class the quality-of-life measure on the count of each equipments in the bundle daily life and the bundle targeted for the age class. As shown in Table 5, local services explain between 40 and 48% of the variance of quality of life for active households, and up to 65% for pensioners. The unexplained part of local quality of life is certainly due to climate and natural amenities, as suggested by the higher R2 when adding those variables to the regression. The higher values for pensioners validate the importance of local quality-of-life in their sorting behaviour as opposed to other local economic variables (also captured in the structural residuals).

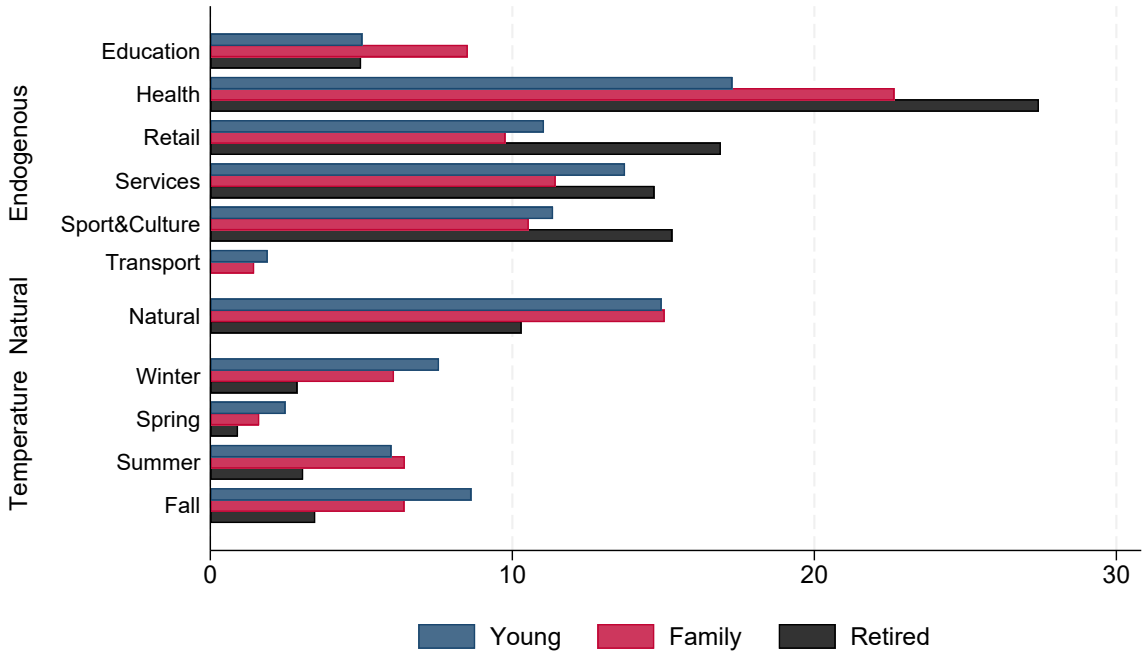
Variance decomposition What is the contribution of each amenity to the R2? To answer this question, I decompose the R2 *à la* Shapley-Shorrocks to measure the relative importance of each amenity to the variation in model-based quality-of-life measures. The decomposition needs to run 2^k estimation for k regressors. To keep the decomposition computationnaly tractable, I rely on an aggregation developed by INSEE in its definition of *bassins de vie*,

Table 5: Share of variance explained by observables

Decomposition	Young	Family	Retired
Endogenous	45.5	47.7	65.0
Temp. + Natural amenities	29.5	27.4	22.0
Endog. + Temp. + Natural	59.0	60.0	70.3

Data: structural residuals, IGN, Copernicus, CLC, BPE. Each cell is an R2 from a different regression of the amenity component on the observables. Endogenous includes all local services in the BPE and listed by INSEE in the {bassins de vie} definition. Temperature is the monthly average temperature in 2019. Natural amenities include distance to the sea, presence of a seashore, share of forests, diversity of landscapes, average and maximum altitude, altitude differentials, presence of waterbodies and presence of water courses.

defined around the accessibility to basic services. Those services are classified in 5 categories: services, retail, education, social and health, sports, leisure and culture. I also group temperature in 4 seasonal groups and natural amenities within one group. Unsurprisingly, healthcare access explains the larger share of the R2, followed by services (such as post offices), education matters more for families than for the other age classes (Figure 8).



Data: BPE 2019, Copernicus, IGN, and structural estimation. Contribution of each bundle of services to the R2 of the regression of local quality of life on explained amenities.

Figure 8: R2 decomposition *à la* Shapley-Shorrocks

5.3. Ageing scenarios

The main set of counterfactual exercises consist in using the INSEE previsions for population in 2030, 2050, and 2070. In practical terms, I change the total quantity of households in the population, $\overline{R}^{\theta}$. In particular, retired population is expected to increase by 12.3% by 2030, 14.1% in 2050, and 16.1% in 2070, with respect to 2019. In the same time, the total population of family and young is going to remain constant then decrease, as shown in Table 4. I present in the main text the results in terms of welfare. Each scenario is decomposed into the change in terms of rent, population, and wages on Figures D18 to D20 in the Appendix. First, we notice that demographic change is expected to have a small effect on welfare. The effect is slightly positive over the short to the long-run (2070), especially for the pensioners. Aggregate welfare change (measured in a utilitarian way as the population-weighted sum of all area-type specific welfare) is 0.08 % in 2030, 1 % in 2050, and 0.85 % in 2070. Second, welfare effects are heterogenous across areas. The least populated regions and the top quantile (Paris) experience relatively strong decrease in welfare. In the sample, the areas experiencing the highest welfare gains are Lille, Lyon, and Aix-Marseille. Third, welfare effects are also heterogeneous across types. Pensioners are the "winners" of ageing, low-skilled workers experience only a moderate welfare loss, and high-skilled exhibit the strongest welfare losses. Family composition does not seem to matter. Over the long run, welfare effects are slightly positive, driven by the aforementioned cities and the increase in pensioner's welfare, who now represent a third of the sample.

Two counter-acting force are at play: due the relative decrease in active population (both young and family households), wages are decreasing, as they depend positively on working age population. Rents, which also depend positively on population, decrease as housing demand decreases. Because pensioners do not earn a market wage, they only benefit from the lower housing cost. The higher pressure imposed by pensioners on the housing market is not strong enough to lead to increasing rents over the long run. This confirms the demographic patterns observed in Fact 2. As all areas are expected to age from the bottom (longer life

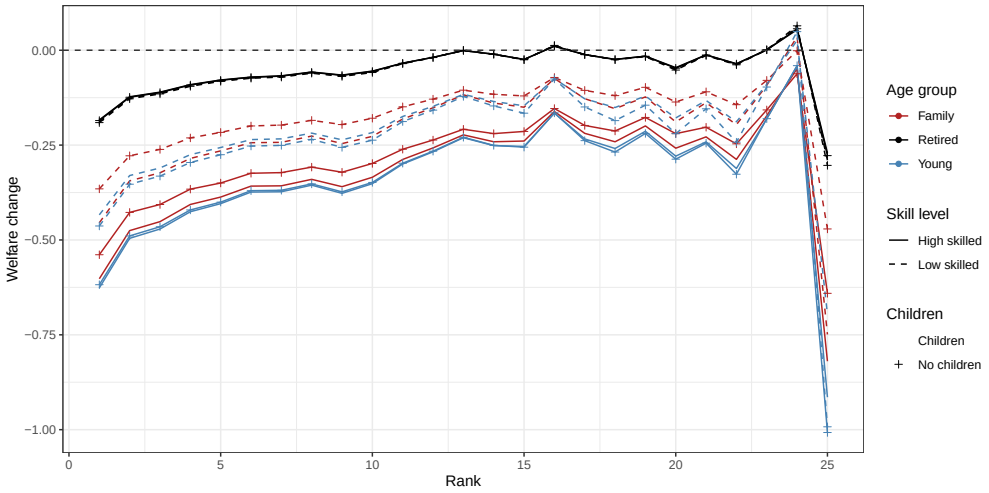
expectancy and low fertility), rents and wages are decreasing. It also suggests that the observed correlation between ageing and housing cost is going to reverse over the long run. Generally, population tends to continue to flow from more rural, less dense, to more urban, denser, areas. Such patterns are observed in the Paris area (Paris and the surrounding suburbs) as presented in Appendix D.3.

While the welfare effects are small, the impacts on spatial and regional inequalities are large. Inequalities can be measured through a number of indicators (Cowell, 2011): Atkinson's index, generalized entropy index, Gini, and inter-decile and inter-quartile ratios. In particular, I measure the Atkinson index with parameter $e = 0.5$ and $e = 2$, indicating a moderate and strong inequality aversion. I use generalized entropy indices with parameter $\tau = \{0, 1, 2\}$, respectively the mean log deviation, the Theil's index, and the half of the coefficient of variation. In particular, $\tau = 0$ weights more the bottom, $\tau = 1$ applies equal weights, and $\tau = 2$ puts more weight on the top of the distribution.

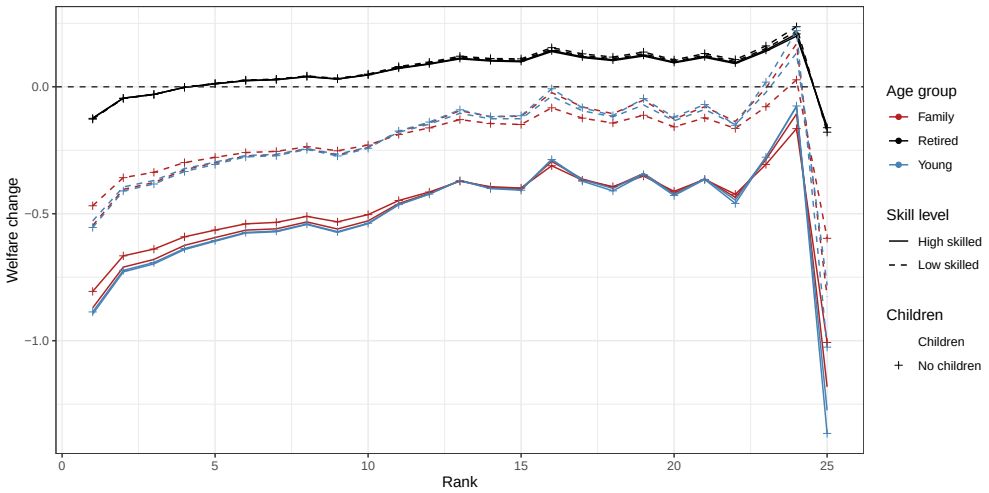
Figure 10 summarizes the percentage variation of the inequality indicators in 2030. A similar pattern albeit a slightly stronger magnitude is observed for 2050 and 2070. All inequality measures are increasing. The generalized entropy indices increase, indicating a rise in inequalities along the whole welfare distribution.

Generalized entropy indices can be decomposed in a within component and a between component as they are additively separable (Shorrocks, 1980; Shorrocks and Wan, 2005). The within-group component is the inequality that would remain had welfare been equalized in all groups but the within-group inequality remained the same. The between-group component is the inequality that would remain if all units in each group had a welfare equal to the average welfare of the group. I perform the decomposition for $GE(0)$, $GE(1)$, and $GE(2)$ in 2030, 2050, and 2070. Results are similar across entropy indices and counterfactuals. Below, I present the Theil's index $GE(1)$ in 2030 decomposition in Table 6.

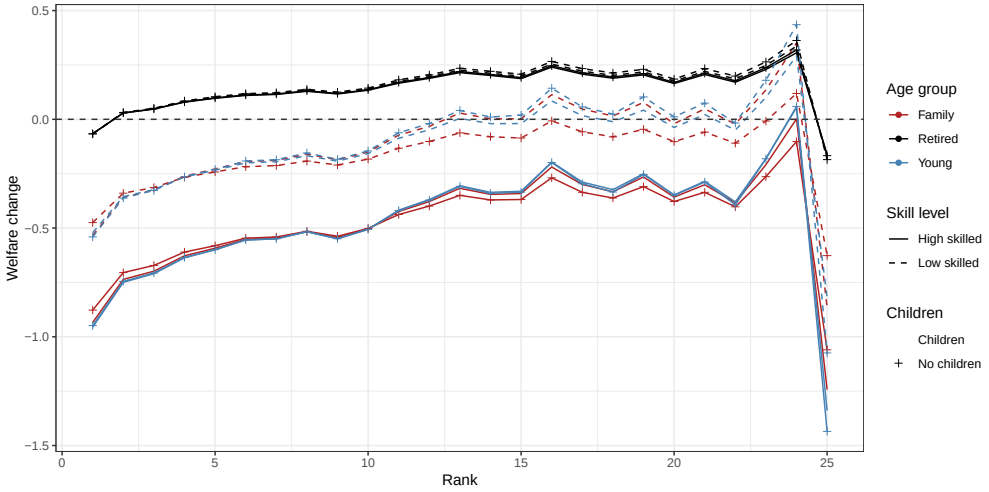
70% of overall inequality is attributable to within-type inequality and 30% to between-type inequality. If inequalities between types were eliminated but inequality within types



(a) 2030

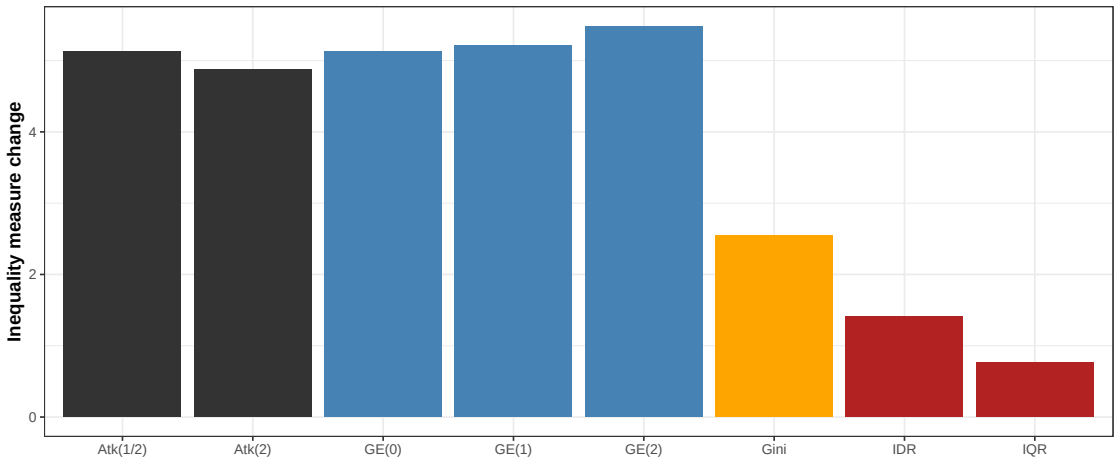


(b) 2050



(c) 2070

Figure 9: Counterfactual change in welfare (ageing scenarios)



Population forecast in 2030. Inequality indicators are measured across areas for all types. Variation in percentage change. Atkinson's index for $e = 1/2$ and $e = 2$. Generalized entropy index for $\tau = \{0, 1, 2\}$. IDR and IQR stands for inter-decile and inter-quantile ratio.

Figure 10: Counterfactual change in inequality measures (2030)

remained the same, the overall inequality would be reduced by 29.84%. Similar magnitudes are for the decomposition by age only. Skill and composition contributions are close to nil. Interestingly, if we were to eliminate the inequalities between age groups, the inequality index would drop by a quarter. If we were to eliminated the inequalities between areas, the inequality index would drop by half. Hence, any policy targeted at reducing inequalities between areas would have a larger effect than policies targetting within-age group inequalities. The contributions remained relatively stable across time, although within-inequality components slightly increased.

6. Extensions

6.1. Additional counterfactual exercises

Demographic change is (in the model) exogenous to the policy-maker. Its welfare effect is small but positive and its inequality impact is negative. Which policies can be implemented to reconcile to two? I simulate several "policies" that I combine with the short-run ageing scenario (2030). In particular, I manipulate one-by-one the model fundamental variables:

Table 6: Within- and between-inequality decomposition of the Theil's index in 2030

Group	Within	Between
Type	70.16% (0.43%)	29.84% (-1.00%)
Skill	99.98% (0.02%)	0.02% (-50.00%)
Composition	99.93% (-0.06%)	0.07% (600.00%)
Age	76.83% (0.05%)	23.17% (-0.17%)
Area	44.17% (0.41%)	55.83% (-0.32%)

Each line is a different decomposition depending on the grouping variable. Type is the product of skill, family composition and age. The percentage change with respect to the baseline decomposition is between parenthesis.

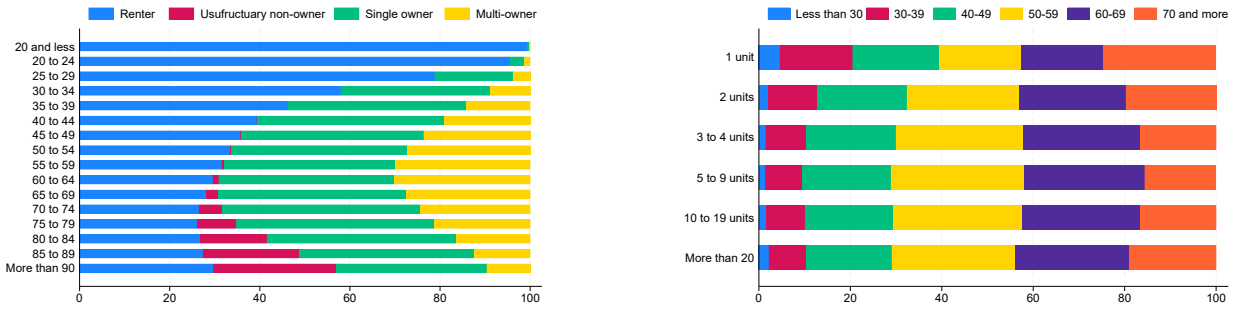
an uncompensated 10% increase of the general pension level (C5), a 10% increase of the housing sector productivity (C6), a 10% increase of production sector productivity (C7), an uncompensated 10% decrease in property tax rate (C8).

Detailed results are relegated in Appendix D.2. The pension increase naturally benefits the pensioners (average increase in welfare of 9%) and disadvantages the workers (pass-through to rents). The increase in the housing sector productivity makes housing more affordable, hence increasing welfare along the age distribution. The increase in production sector exogenous productivity compensates the decrease wage due to lower agglomeration economies. It also passes through rents but is welfare-improving. Finally, the decrease in property tax rate benefits the owners, and especially the full owners. However, the pass-through to rent is large (more than 4% increase), leading to only a moderate effect on welfare at the expense of larger inter-generational inequalities.

6.2. Model extension: multi-owners

The model allows households to consume housing in a unique location, and rents and mortgages are paid to an absentee landlord. However, 35% of owners own at least two units

(INSEE, 2025).[7] Among multi-owners, 51% of them rent at least one unit, 32% own at least one secondary house, and 25% own at least one vacant unit. Moreover, as shown on Figure 11, multi-owners are mainly concentrated around retirement age households, and among multi-owners owners, the population aged more than 50 is the one owning the more flats on average.



(a) Share of owners and multi-owners by age

(b) Number of units owned by age

Data: INSEE, 2022. Left panel: share of renters, usufructuaries, owners, and multi-owners by age in 2022. Right panel: Number of units owned by owners, by age class. Lecture: At age 30-34, 58% of households are renters, 33% are owners, and 9% are multi-owners (left panel); Among the owners of 5 to 9 flats, 1.5% are aged less than 30, 8% are aged between 30 and 39, 19% are aged between 40 and 49, 29% are aged between 50 and 59, 26% between 60 and 69, and 15.5% are aged more than 70.

Figure 11: Ownership structure by age

To account for this ownership structure, I adapt the model in three ways, namely by parametrizing multiownership. First, I allow a pre-determined share of owner households (ie, the pensioners) ζ^{old} to perceive the rents paid by renters, independently on their location. By doing so, I allow an intergenerational transfer from renters to homeowners. Only a specific share of renters live in a housing unit owned by the multi-owners in the model. I denote this share ζ_{-}^{θ}. Finally, I also add to the local housing demand HD_d the measure of secondary housing units (units that are not rented nor fully occupied) in each location Z_d, to add pressure on demand.[8]

[7] Note as well that 2/3 of housing units are owned by multi-owners and 77% of housing units are owned by natural persons (FILOCOM).

[8] An alternative strategy would be to model the full ownership structure, with several nests: (i) whether or not to own a flat (ii) how many flats to own (iii) where to own, which would require extra data on the ownership structure and income source of households. However, those data are not readily available in

ζ is parametrized using the share of multi-owners aged 60 times the share of multi-owners that rent at least their second housing units, hence $\zeta = 22\% \times 51\% = 11.1\%$. This extension also requires to know the share of renters that pay a rent to a multi-owner in the model, namely to multi-owner pensioners. From FILOCOM, I compute the average age of owners for renters. The average age of owners is 62. 33% of young renters and 46% of renting families pay a rent to a landlord aged 60+. Finally, Z_d is computed using FILOCOM as the total floorspace area left inhabited in each location (both left vacant or as secondary home). I compare the baseline scenario with the 2030 scenario, both cases with multi-owners and secondary homes. Interestingly, the pensioners welfare is decreasing: due to the decrease in the young population (-6%) and the increase in the pensioners population, the transfer from renters to the multi-owner pensioners is decreasing in absolute terms. All households experience welfare losses (Figure 12). Inequalities are also increasing by a large magnitude (Figure 13).

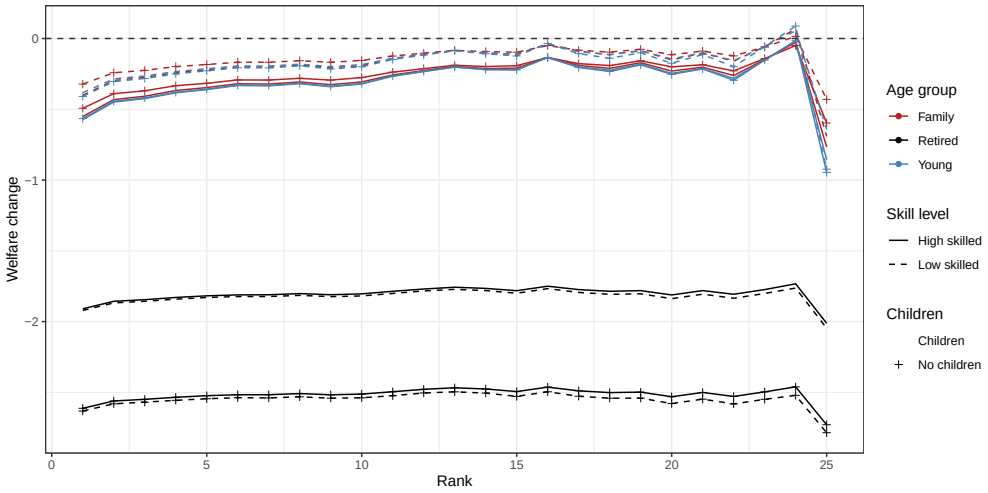
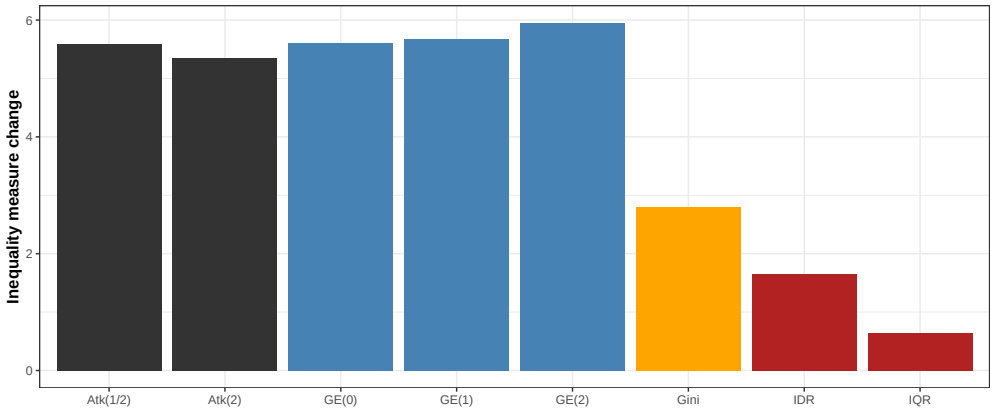


Figure 12: Counterfactual ageing (2030) with multi-ownership

France, with a spatial dimension. The exercise I propose can only be perceived as a crude approximation of the mechanisms at play.



Population forecast in 2030 and allowing for multi-ownership and secondary homes. Inequality indicators are measured across areas for all types. Variation in percentage change. Atkinson's index for $e = 1/2$ and $e = 2$. Generalized entropy index for $\tau = \{0, 1, 2\}$. IDR and IQR stands for inter-decile and inter-quantile ratio.

Figure 13: Counterfactual change in inequality measures (+ 2030 forecast)

7. Conclusion

In this paper, I investigate the spatial effects of a large demographic shift: population ageing combined with a drop in fertility. To this aim, I rely on spatially disaggregated data in contemporaneous France, as well as administrative individual data. Pensioners exhibit different preferences for housing and location than younger households. Retired households consume a large quantity of housing per capita and are not mobile: they tend to age in place (where they used to be productive), in large dwellings. In a context of low housing supply, it creates frictions on the housing market, leading to higher rents. It also turns out that the increase in the share of retired households is associated with greater tax revenues at the local level, and better public good provision. Hence, the welfare effect is ambiguous. To estimate welfare effect, I rely on a state-of-the-art augmented version of the canonical quantitative spatial model of cross-region migration. In particular, I enrich the model with age-, family composition-, and skill-based heterogeneity, as well as type-targeted local amenities. Bringing the model to the data, I show that population ageing is associated with a mild but positive effect on welfare. However, this goes with an increase in inequalities, especially at the bottom of the distribution. Decomposition exercises show that age-specific and

area-specific inequalities drive overall inequality arising from ageing.

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Appendix

A. Data

A.1. Data description

Population data Population is measured with the full-count French census for 2019. It contains information on age, skills, household size, employment status, location, and past location. Since 2010, a twelfth of the French population is included in a panel dataset, matched with administrative and fiscal data, the *Echantillon Démographique Permenent* (EDP), or permanent demographic sample. It provides individual-level precise data on income, including pension and capital earnings, work arrangement, and taxes paid.

Income data For wage earners, I rely on an exhaustive administrative employer-employee dataset, the *Données annuelles de déclaration sociales* (DADS), covering all wage-earning workers in France. I compute hourly wage for private sector, full-time workers, winsorizing the top and bottom 1% of the distribution (as in Combes et al. (2008)). For pension level, I rely on the *Echantillon Démographique Permanent* (2019). I compute an hourly pension as the average yearly pension divided by the average hours worked by the workers (1908 hours per year). For simplicity, I do not include capital income.

Local fiscal data FILOCOM covers the universe of taxed dwellings since 1997. It contains information on the socio-demographic dwelling composition, a measure of imputed rent, and dwelling area. I keep dwellings whose floorspace is above 8sqm (the legal minimum in France) and below the 99.9th percentile of the floorspace distribution, mainly to avoid coding mistake. I also drop secondary homes, usually owned by an household residing outside of the area. By doing so, I can directly map the mass of tax-paying households in a location to the local fiscal revenue. Hence, I underestimate fiscal revenue arising from housing taxation for some locations, especially on coastal and mountainous areas. For municipal spendings, I rely on the *Observatoire des finances et de la gestion publique locales*' (OFGL), a governmental research group on local public finance, and French Ministry of Finances' dataset containing the universe of municipal and inter-municipal cooperation unit spendings and revenues. In particular, I extract the lump-sum transfer from central government g_d, the total revenues from property and housing taxes. I also measure targeted and non-targeted municipal spendings.

Geographical units Land area data are from IGN. In particular, the BD THOPO provides the surface of each area and RGE ALTI the altitude at the 5x5m resolution (from which I compute the average slope of each area). I work with the 2019 EPCI geography[9], except for Paris and Aix-Marseille. Starting in 2016, the Métropole du Grand Paris and the Aix-Marseille Métropole absorbed a large number of EPCI to create two very large EPCI, accounting for 20% of the French population. However, pre-existing units still continue to exist and have local prerogatives. To keep enough granularity, for these two units, I keep the pre-2016 definition. Note that for fiscal data, I sum the municipal and the EPCI level data, as the rates and amounts are additive.

Local amenities Temperature data are from Copernicus grid cell data for 2019. I aggregate the average temperature at the month $\times$ IMCU level. Natural amenities are collected from Corinne Land Cover (water courses, water bodies, share of forest, presence of a seashore, and the count of different non-artificialized landscapes), BD TOPO (mean altitude, maximum altitude, difference between minimum and maximum altitude, distance to the sea). Local services are from the *Base permanente des équipements*, a nationwide yearly survey filled by the municipalities on their equipments. More than a hundred equipments are surveyed. INSEE aggregates them into four different bundles: daily life (Banks, Bakery, Post office, Dentist, Hairdresser, Middle school, Preschool, Driving school, Minimarket, Grocery store, Preschool childcare, Nurse, Medical lab, Bookstore, General doctor, Pharmacy, Sports hall, Police, Restaurant, Specialized sports area, Elderly aid service, Gas station, Supermarket, Emergency), young (Driving school, Specialized sports area, Job center, Athletics, Swimming pool, Apprentice training center, Cinema, Regional train station, Maternity clinic, Gynecologist), families (Sports hall, Specialized sports area, Job center, Athletics, Swimming pool, Cinema, Regional train station, Maternity clinic, Gynecologist, Tennis, Middle school, Preschool childcare, Emergency, Elementary school, General high school, Vocational high school, Speech therapist, Orthoptist, Midwife, Home care – disabled children, Pediatrician), and pensioners (Sports hall, Athletics, Swimming pool, Cinema, Tennis, Emergency, Nurse, Medical lab, General doctor, Pharmacy, Elderly aid service, Elderly housing, Optician, Physiotherapist, Home care – elderly, Cardiologist). On top of this age-specific classification, I aggregate them into broader categories for computational efficiency: Education, Services, Health, Culture and sport, Retail, Transport.

[9]The change of geography was done using the R `COGugaison` package developed by Kim Antunez.

A.2. Local tax rates

The observed tax rates are from the *Recensement des Elements d'Imposition*, an exhaustive list of all tax rates applied locally. Until 2020, the local tax rate was the sum of the tax rates applied on all households (housing tax) and the tax rates applied only on owners (property tax), on two different bases. The tax was progressively removed until 2023. For simplicity, I model the current tax schedule, with only the property tax. The local fiscal tax scheme is complicated in France, due to numerous exemptions across many dimensions. Tax rebates exist on the applied rate, the tax base, with a potential cap on the total amount. Below, I present how I retrieve group-area-specific tax bases and rates for the property tax (paid by owners) and the housing tax (paid by all occupiers).

Property tax The property tax revenue per area d is the sum across all taxed dwellings of the rental value divided by two (the tax base defined by law) and multiplied by the observed tax rate.

$$\texttt{Property tax revenue}_d = \sum_{i \in N_d} \tau_d \frac{\texttt{Rental value}_i}{2}$$

The imputed rental value (which I observe in FILOCOM) is computed by the tax administration for each dwellings based on its observable characteristics. It roughly corresponds to the expected rent one would pay to rent the dwelling. The number of taxed dwellings N_d is computed from FILOCOM as the number of (i) owner-occupants (ii) whose income is above a threshold defined nationally.

Housing tax For housing tax, the exercise is particularly challenging, as the function depends on many parameters that are not publicly available. To overcome this difficulty, I first compute for each household type its contribution to area d housing tax revenue. From the EDP, I observe the average amount of tax paid by each household type M_d^θ. I multiply this amount to the number of tax payers $\tilde{N}_d^\theta$ I observe in FILOCOM after a match on observable characteristics.[10]

$$\texttt{Housing tax revenue}_d = \sum_\theta \tilde{N}_d^\theta M_d^\theta$$

[10] Observable characteristics are age (5 year bin) of reference person, location, ownership status, area (5sqm bin), household size, number of children aged less than 14 (censored at 5 and more), year of construction (10 year bin). EDP panel in 2019 includes around 2,4m observations, and 91% are matched to FILOCOM.

The average amount of tax paid is a function of the rental value and the tax rate. Hence:

$$\tau_d^\theta = \frac{M_d^\theta}{\sum_\theta \texttt{Rental value}_d^\theta}$$

To assess the validity, I regress the observed housing tax rate on the group-specific tax rates τ_d^θ I infered. I obtain: $\hat{\beta}_0 = 0.06$ (.00), $\hat{\beta}_1 = 1.06$ (00) and $R^2 = 0.51$.

Rental value and rents A last concern deals with the correlation between rental value and rents. In reality, the tax revenue is computed as function of imputed rental rents. In the model, I directly compute tax revenue as a function of equilibrium rents. Imputed rents are computed by the tax administration using criterions from the 1970s and those criterion were not updated since.[11] Hence, are these two measures correlated? The measure of rent I use in the structural estimation is from the Carte des Loyers, a hedonic price index covering all French cities, using data from the major only realtors. I replicate their hedonic price analysis using the imputed rent. In particular, I regress the log imputed rent per square meter on the piecewise third order polynomial of the total surface, the average room surface, and an EPCI fixed effect. I do it for 4 sub-samples: all flats, flats with 1 to 2 rooms, flats with more than 3 rooms, and all houses. The correlation coefficients are statistically significant and between 0.71 and 0.99. This suggests that rents from Carte des Loyers are a relatively good proxy for imputed rents used in by the tax administration to collect taxes.

A.3. Local public finance

Each municipality and inter-municipal cooperation units (populated by more than 3,500 inhabitants) has to publish a functional presentation of its accounts. 92% of cities are populated by less than 3,500 inhabitants but they account for 32% of population only.[12] I aggregate available accounts (both municipal and IMCU) at the IMCU level and compute the shares of municipal spendings. It describes, for each item, the amount of taxpayer money that is spent each year. This presentation is organized around 10 main parts: (0) general services (1) security (2) education (3) culture (4a) sport (4b) youth (5) social intervention

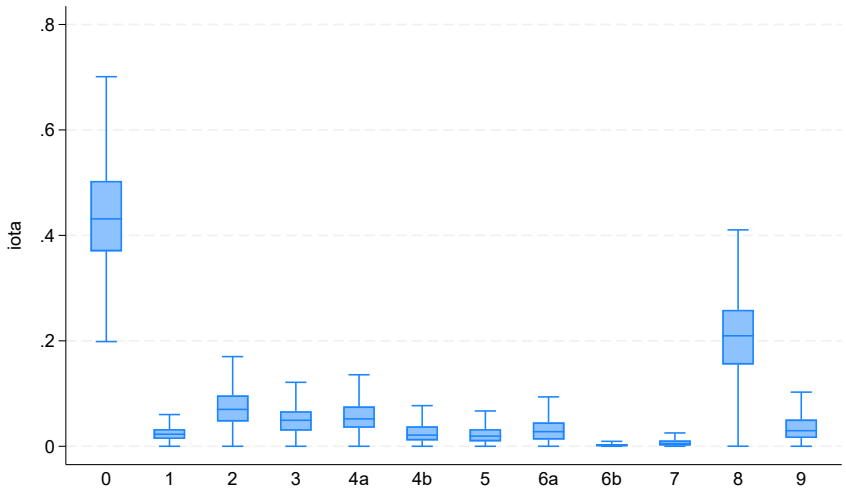
[11] For an interesting discussion on the subject, see (Botey and Chapelle, 2023).

[12] There are 24 IMCU for which the accounts are not reported as their population is below the threshold. I set the values to the national average.

(6a) family (6b) old-age support (7) housing (8) urbanism (9) economic action. Then:

$$\iota^G = (0) + (1) + (3) + (4a) + (5) + (7) + (8) + (9)$$
$$\iota^F = (2) + (4b) + (6a)$$
$$\iota^R = (6b)$$

The distribution of each ι is plotted on Figure A1. The main spending item is the general spending. Spendings for old age support represent the smallest expenses item, with some heterogeneity (range from 0 to 0.2).



Data: Balances SPL 2019. Note: The share corresponds to the ratio between total spendings per item (municipal+IMCU) divided by the total spendings.

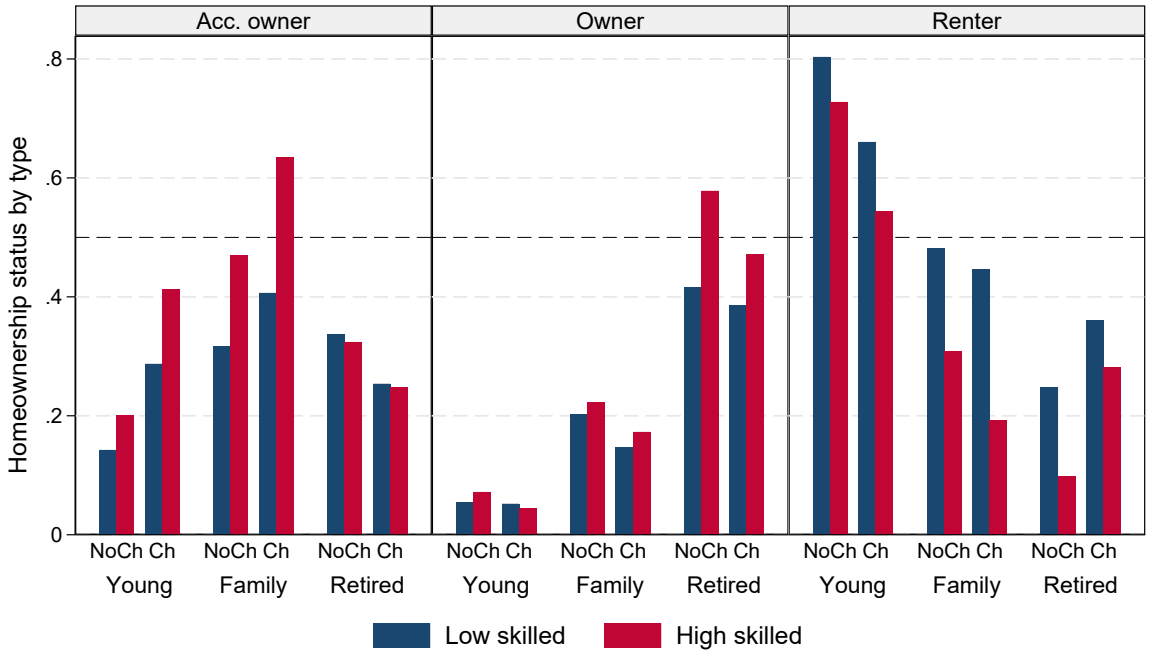
Figure A1: Distribution of municipal spending shares ι

A.4. Typology of households

In the model (Section 3), I allow households differ by type θ. In Brülhart et al. (2022) and in Ahlfeldt et al. (2025), households differ along three dimensions: age, family composition, and skills. I follow them and allow for 12 types: (`Young`, `Family`, `Retired`) × (`NoChild`, `Children`) × (`LowSkill`, `HighSkill`). Young are aged between 20 and 30, Family are aged between 30 and 60, and Retired are aged between 60 and 85. Family composition is either having at least one child living in the household or not. Skilled depends on the socio-professional status (basically, blue collar vs. white collar) if available, and diploma if the CPS is not available (high-skilled if went to higher education). Below, I show that this typology is a good proxy for homeownerhsip status. I take advantage of the SRCV

(*Statistiques sur les ressources et conditions de vie*) data, a representative nationwide survey of French households in 2019.

I set all young households as renters. Low-skilled families are renters. High skilled families are accessing owners. Retirees are owners.

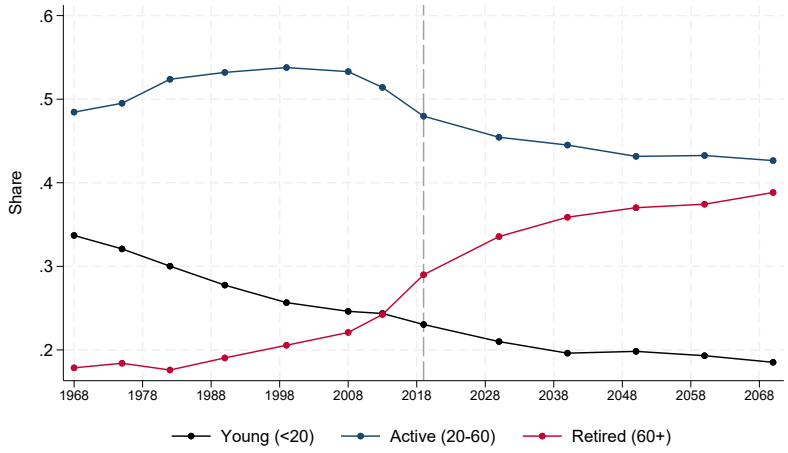


Data: SRCV2019. Note: Income is the disposable income. Full owners are household who pay a mortgage for their main residence between 0 and less than 10% of their income. Accessing owner are owners who pay a mortgage for their main residence above 10% of their income. Renters rent their main residence. NoCh and Ch stands for households without child and households with at least 1 child.

Figure A2: Homeownership share by age and income quartile

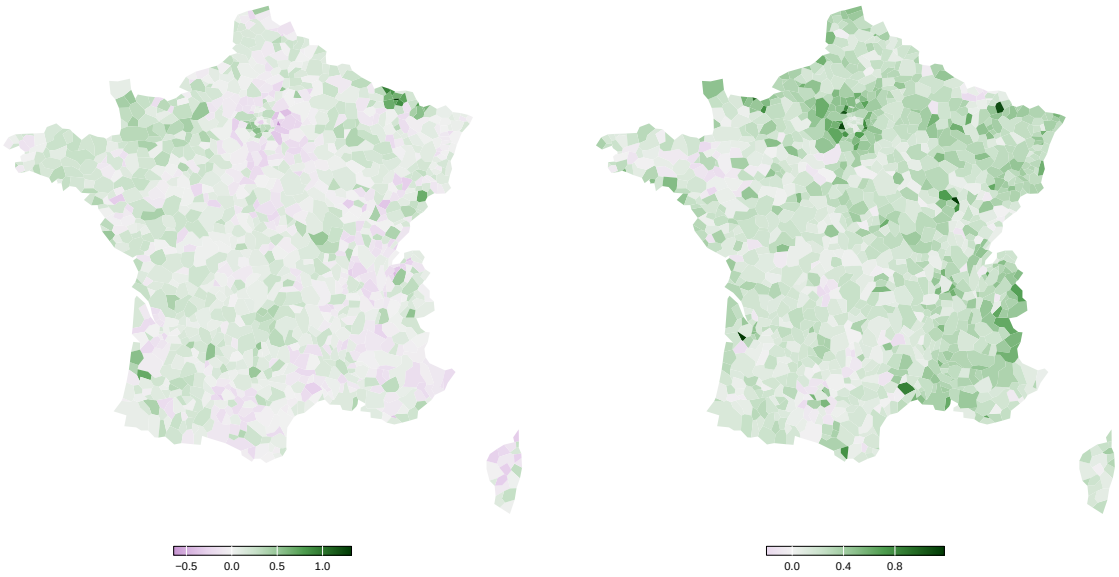
B. Additional evidence

B.1. Motivating evidence



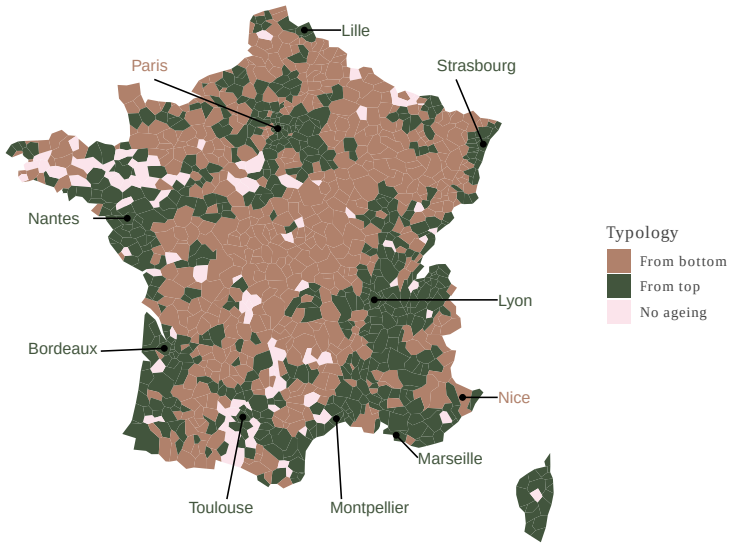
Data: RP 1968-2019, Omphale 2019-2070 central scenario.

Figure B3: Population prevision by age group



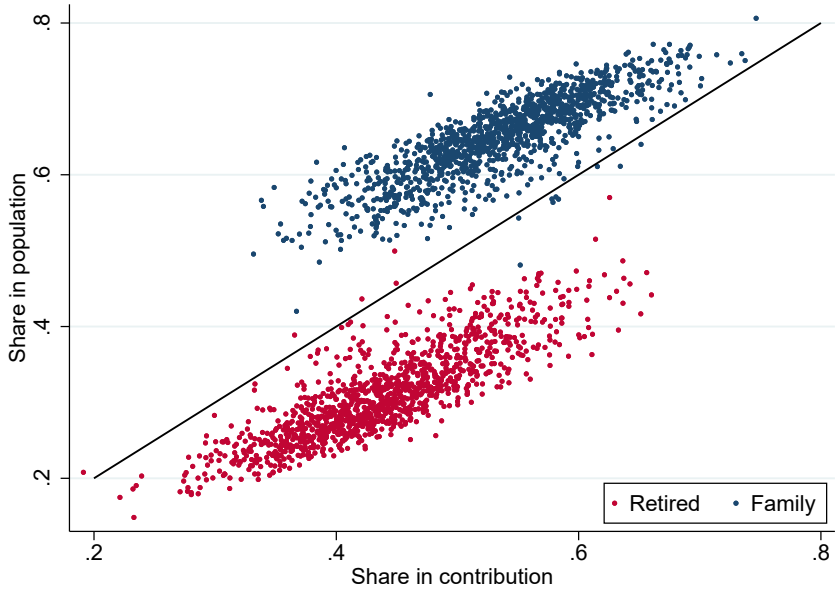
Data: Recensement Permanent 1975, 1999, 2019. Note: Change in the share of 60-80 in the total population aged less than 80 between 1975 and 1999, and between 1999 and 2019, at the EPCI level.

Figure B4: Ageing between 1975-1999 and 1999-2019



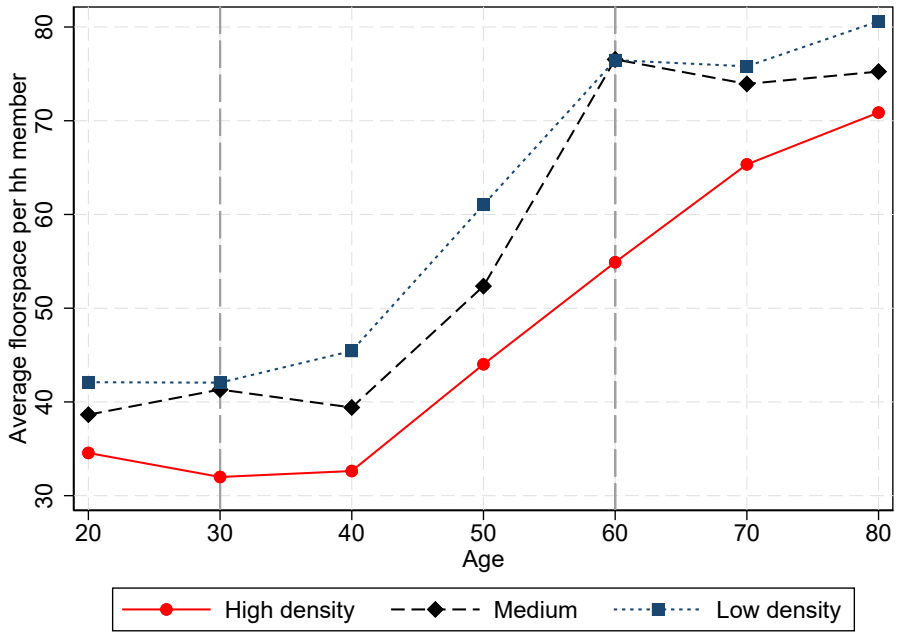
Data: Recensement Permanent 1999, 2019. Note: Ageing typology by EPCI in 2019. Ageing from the bottom: increase in the share of 60-80 and decrease in the share of 20-60. Ageing from the top: increase in the share of 60-80 and increase in the share of 20-60. No ageing: decrease in the share of 60-80.

Figure B5: Ageing typology (1999-2019)



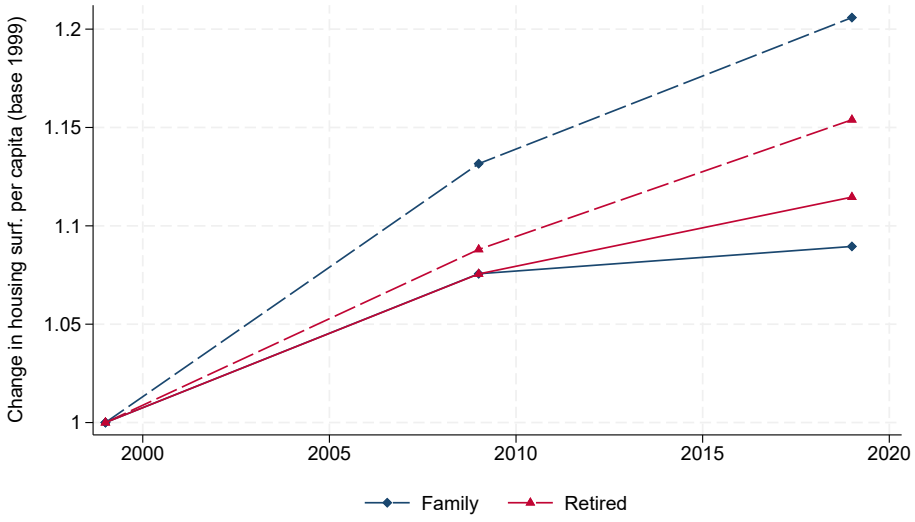
Data: FILOCOM 2019. Each dot is an EPCI. The black line is the 45° line. If a dot lies on the 45° line, then the share in population is equal to the share in contribution to local tax revenue.

Figure B6: Share in population and in contribution to the housing tax by demographic group



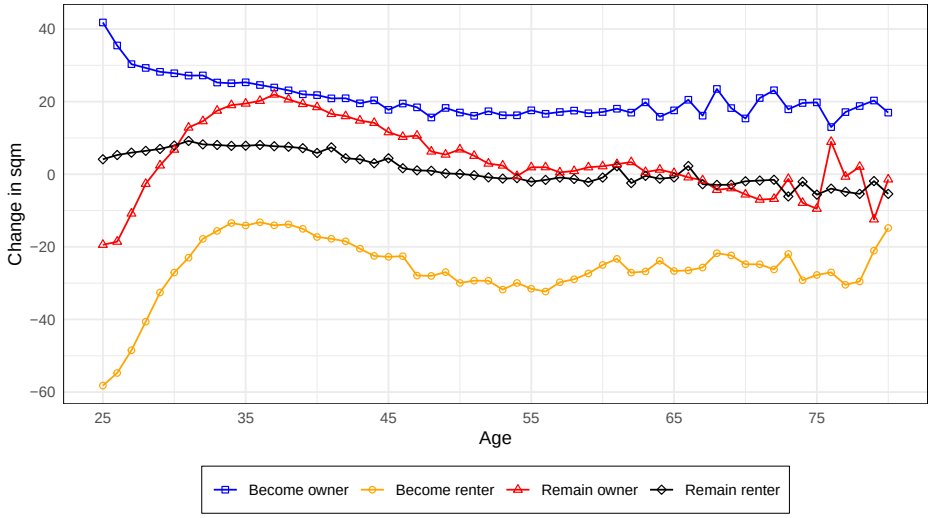
Data: SRCV2019. Note: Density is defined as the 1st, 2nd, and 3rd quartile of population density in 2019.

Figure B7: Housing consumption per capita



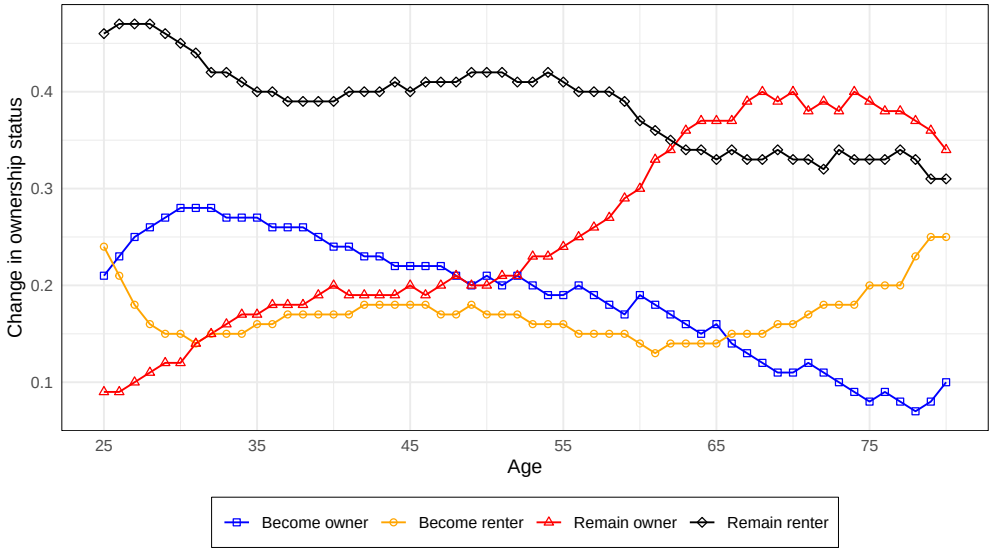
Data: FILOCOM 1999-2019. Note: Plain line for bottom 1999 density quartile. Dotted line for top 1999 density quartile. Values are normalized to 1999 values. Family is defined as households aged 30 to 60 and retired as households aged more than 60.

Figure B8: Change in housing consumption per capita



Data: EDP 2011-2019. Conditional on being a mover, does the household change its residential floorspace consumption? Lecture: At age 60, conditional on moving and remaining homeowner (red line), on average, households increase their residential floorspace consumption by 2sqm.

Figure B9: Change in residential floorspace consumption conditional on moving



Data: EDP 2011-2019. Conditional on being a mover, does the household change its occupational status? Lecture: At age 60, 33% of movers remained owners, 35% remained renters, 17% became owners, and 15% became renters.

Figure B10: Change in ownership status conditional on moving

B.2. Ageing effects on local outcomes

As mentioned in the main text, estimating (2) raises legitimate concern about reverse causality. Common shocks can affect both rents and population in local areas. I follow Maestas et al. (2023) and instrument current population with lagged population interacted with the cohort national survival rate. This strategy falls into the shift-share instrument family, where the "share", i.e. lagged population, is endogenous, and the shift, the survival rate, is exogenous. I hence predict population for each age bin in 2019. As full count census are available in 1968, 1975, 1982, 1990, and 1999, I use the deepest lag possible for each age. To make it clearer, I use the following lagged population:

Table B1: Lagged census years used to compute the instrument

Age in 2019	Birth year	Closest census	Age at closest census	Survival rate
20	1999	1999	0	0.9926340
30	1989	1990	1	0.9829388
40	1979	1982	3	0.9657955
50	1969	1968	1	0.9240118
60	1959	1968	9	0.8329196
70	1949	1968	19	0.6585356
80	1939	1968	29	0.3685227

Hence, the population aged 40 in 2019 (born in 1979) is instrumented using the population aged 3 in 1982 and the survival rate of that cohort in 2019. The population aged 80 in 2019 (born in 1939) is instrumented using the population aged 29 in 1968 and the survival rate of the cohort in 2019. A survival rate of 0.66 (for the cohort aged 70 in 2019) indicates that out of all individuals aged 19 in 1968, 66% were expected to reach 70. I report the first stage estimation results on Table B3. The first stage appears strong, with a F-statistics above the standard threshold of 10. In Table B4, I report the results for the second stage. The lower magnitudes obtained with the instrumental variable approach is consistent with the presence of endogeneity in the OLS estimates. I also report the coefficients for the IV estimation of the effects of population interacted with the ageing typology defined in Fact 2 (ageing from the bottom, from the top, and no ageing). It highlights that the increase in housing cost due the increase of older households' demand is stronger in areas which age from the top (mainly urban cores) or areas which do not age.

Table B2: OLS estimation

	lrent_cdl	lrent_cdl	lrent_cdl	lrent_cdl	lrent_cdl	lrent_cdl	lrent_cdl	lrent_cdl	lrent_cdl	lrent_cdl	lrent_cdl	lrent_cdl	lrent_cdl
Pop.	0.120^a	0.128^a	0.135^a	0.139^a	0.142^a	0.143^a	0.144^a	0.142^a	0.137^a	0.133^a	0.131^a	0.125^a	0.117^a
	(0.00512)	(0.00520)	(0.00529)	(0.00538)	(0.00550)	(0.00576)	(0.00609)	(0.00642)	(0.00688)	(0.00716)	(0.00695)	(0.00707)	(0.00752)
Age bin	20	25	30	35	40	45	50	55	60	65	70	75	80
N	1252	1252	1252	1252	1252	1252	1252	1252	1252	1252	1252	1252	1252
R2	0.423	0.439	0.452	0.458	0.454	0.439	0.422	0.395	0.357	0.336	0.337	0.316	0.276
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Data: RP 2019 and Carte des Loyers 2021. Note: Each regression includes geographical controls (latitude, longitude, area). EPCI-level clustered standard errors in parentheses. ^{c} $p < 0.1$, ^{b} $p < 0.05$, ^{a} $p < 0.01$

Table B3: First stage estimation

	Pop.	Pop.	Pop.	Pop.	Pop.	Pop.	Pop.	Pop.	Pop.	Pop.	Pop.	Pop.	Pop.
Pop. IV	1.113^a	1.079^a	1.019^a	0.998^a	0.971^a	0.910^a	0.941^a	0.942^a	0.936^a	0.916^a	0.895^a	0.889^a	0.871^a
	(0.00771)	(0.00675)	(0.00678)	(0.00778)	(0.00853)	(0.0105)	(0.0104)	(0.0102)	(0.0100)	(0.00961)	(0.00910)	(0.00828)	(0.00799)
Age bin	20	25	30	35	40	45	50	55	60	65	70	75	80
N	1252	1252	1252	1252	1252	1252	1252	1252	1252	1252	1252	1252	1252
R2	0.969	0.969	0.952	0.933	0.920	0.889	0.883	0.885	0.888	0.887	0.896	0.917	0.926
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Data: RP 2019 and Carte des Loyers 2021. Note: Each regression includes geographical controls (latitude, longitude, area). EPCI-level clustered standard errors in parentheses. ^{c} $p < 0.1$, ^{b} $p < 0.05$, ^{a} $p < 0.01$

Table B4: Second stage estimation

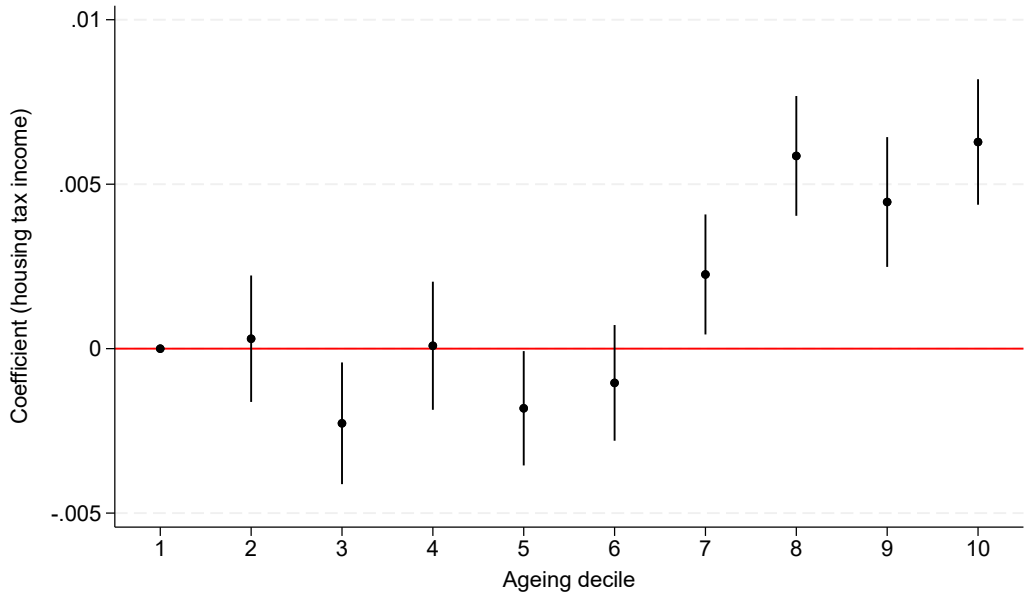
	lrent_cdl	lrent_cdl	lrent_cdl	lrent_cdl	lrent_cdl	lrent_cdl	lrent_cdl	lrent_cdl	lrent_cdl	lrent_cdl	lrent_cdl	lrent_cdl	lrent_cdl
Pop.	0.118^a	0.123^a	0.122^a	0.119^a	0.115^a	0.108^a	0.102^a	0.0980^a	0.0946^a	0.0957^a	0.104^a	0.111^a	0.114^a
	(0.00529)	(0.00526)	(0.00556)	(0.00585)	(0.00618)	(0.00678)	(0.00745)	(0.00800)	(0.00854)	(0.00879)	(0.00835)	(0.00807)	(0.00829)
Age bin	20	25	30	35	40	45	50	55	60	65	70	75	80
N	1252	1252	1252	1252	1252	1252	1252	1252	1252	1252	1252	1252	1252
R2	0.423	0.439	0.449	0.449	0.439	0.416	0.391	0.362	0.327	0.313	0.325	0.312	0.276
KP F-Stat	20872.3	25501.8	22626.1	16461.0	12967.9	7526.5	8138.2	8496.5	8729.3	9079.4	9664.2	11516.0	11887.4
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Data: RP 1968-2019. Note: Each regression includes geographical controls (latitude, longitude, area). EPCI-level clustered standard errors in parentheses. ^{c} $p < 0.1$, ^{b} $p < 0.05$, ^{a} $p < 0.01$

Table B5: Second stage estimation with interaction

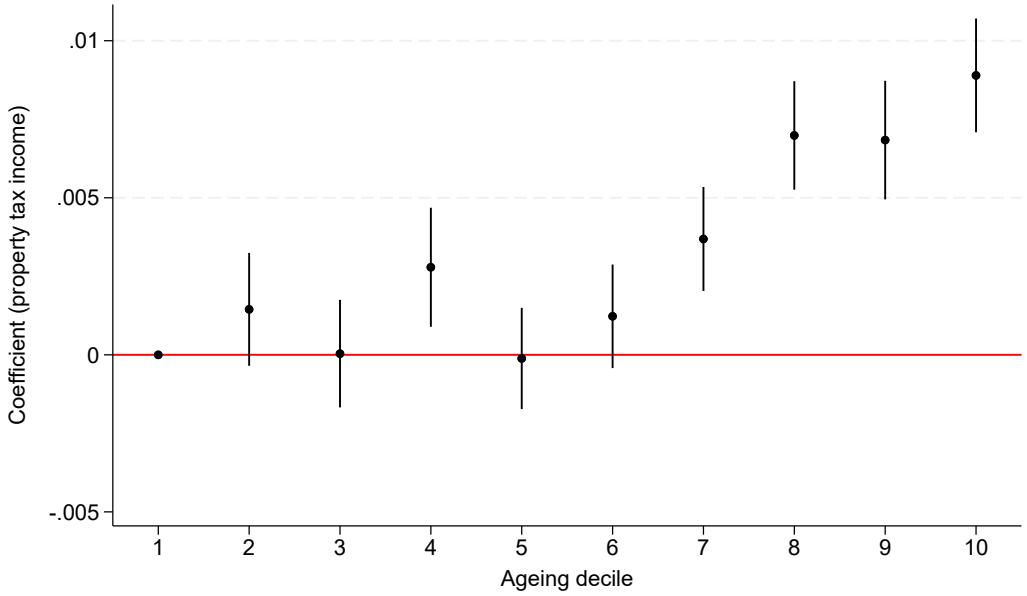
	Rent	Rent	Rent	Rent	Rent	Rent	Rent	Rent	Rent	Rent	Rent	Rent	Rent
From bottom × Pop.	0.0926^a	0.0969^a	0.0827^a	0.0731^a	0.0674^a	0.0677^a	0.120^a	0.158^a	0.148^a	0.126^a	0.0820^a	0.0578^a	0.0538^a
	(0.00850)	(0.00866)	(0.00927)	(0.00970)	(0.0100)	(0.0105)	(0.0102)	(0.0102)	(0.0110)	(0.0113)	(0.0117)	(0.0118)	(0.0123)
From top × Pop.	0.135^a	0.139^a	0.123^a	0.114^a	0.109^a	0.109^a	0.160^a	0.199^a	0.191^a	0.170^a	0.128^a	0.106^a	0.105^a
	(0.00800)	(0.00814)	(0.00865)	(0.00909)	(0.00944)	(0.00994)	(0.00976)	(0.00983)	(0.0107)	(0.0110)	(0.0114)	(0.0115)	(0.0119)
No ageing × Pop.	0.109^a	0.112^a	0.0951^a	0.0845^a	0.0787^a	0.0793^a	0.137^a	0.179^a	0.169^a	0.145^a	0.0964^a	0.0701^a	0.0654^a
	(0.00973)	(0.00972)	(0.0102)	(0.0106)	(0.0110)	(0.0114)	(0.0113)	(0.0114)	(0.0122)	(0.0126)	(0.0130)	(0.0131)	(0.0137)
Age bin	20	25	30	35	40	45	50	55	60	65	70	75	80
N	2504	2504	2504	2504	2504	2504	2504	2504	2504	2504	2504	2504	2504
R2	0.229	0.213	0.224	0.226	0.230	0.241	0.287	0.348	0.307	0.283	0.235	0.207	0.270
KP F-Stat	8746.6	6783.7	7801.7	6404.8	5232.1	3973.6	4440.4	5842.3	6390.7	5544.0	5161.3	5497.5	4149.7
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Data: RP1968-2019. Note: Each regression includes geographical controls (latitude, longitude, area). The dependent variable is interacted with an ageing typology dummy (ageing from the bottom, from the top, or no ageing). EPCI-level clustered standard errors in parentheses. ^{c} $p < 0.1$, ^{b} $p < 0.05$, ^{a} $p < 0.01$



Data: Cagé and Piketty (2023) and RP1968-2019. Note: Correlation coefficients and associated 95% confidence intervals for the the log change in housing tax revenues between 1999 and 2019 and the decile in the ageing distribution. Latitude, longitude, average wage, density, and total population are included as controls, as well as a region fixed effects.

Figure B11: Correlation between ageing and variation in housing tax revenues



Data: Cagé and Piketty (2023) and RP 2019. Note: Correlation coefficients and associated 95% confidence intervalss for the log change in property tax revenues between 1999 and 2019 and the decile in the ageing distribution. Latitude, longitude, average wage, density and total population are included as controls as well as region fixed effect.

Figure B12: Correlation between ageing and variation in property tax revenues

C. Model appendix

Following the Stone-Geary specification for utility and the different household types, especially with respect to their homeownership status, we can derive the demand functions for housing and for the composite good, as well as their expected utility, which enter the indirect utility and the migration probabilities.
Renters do not pay property taxes and only demand floorspace. Hence, the solution to a given household maximization program is:

$$h_d^{\texttt{renter}} = (1-\alpha)\frac{w_d^\theta}{r_d} + \alpha \underline{h}^\theta$$

For accessing owners, housing demand depends on tax-inclusive rents:

$$h_d^{\texttt{acc.owner}} = (1-\alpha)\frac{w_d^\theta}{(1+\tau_d)r_d} + \alpha \underline{h}^\theta$$

Owners do not pay rent any more, but still need to pay property taxes:

$$h_d^{\texttt{owner}} = (1-\alpha)\frac{w_d^\theta}{r_d\tau_d} + \alpha \underline{h}^\theta$$

Similarly, we can derive the composite good demand:

$$c_d^\theta = \begin{cases} \alpha(w_d^\theta - r_d\underline{h}^\theta) & \text{if } \theta \in \texttt{renter} \\ \alpha(w_d^\theta - r_d(1+\tau_d)\underline{h}^\theta) & \text{if } \theta \in \texttt{acc.owner} \\ \alpha(w_d^\theta - r_d\tau_d\underline{h}^\theta) & \text{if } \theta \in \texttt{owner} \end{cases}$$

We can now derive v_d without loss of generality as proportional to:

$$\begin{aligned} v_d^\theta &\propto A_d^\theta \left(w_d^\theta - r_d^\theta \underline{h}^\theta\right)^\alpha \left(\frac{w_d^\theta}{r_d^\theta} - \underline{h}^\theta\right)^{1-\alpha} \\ &\propto A_d^\theta \frac{w_d^\theta - r_d^\theta \underline{h}^\theta}{{r_d^\theta}^{1-\alpha}} \end{aligned}$$

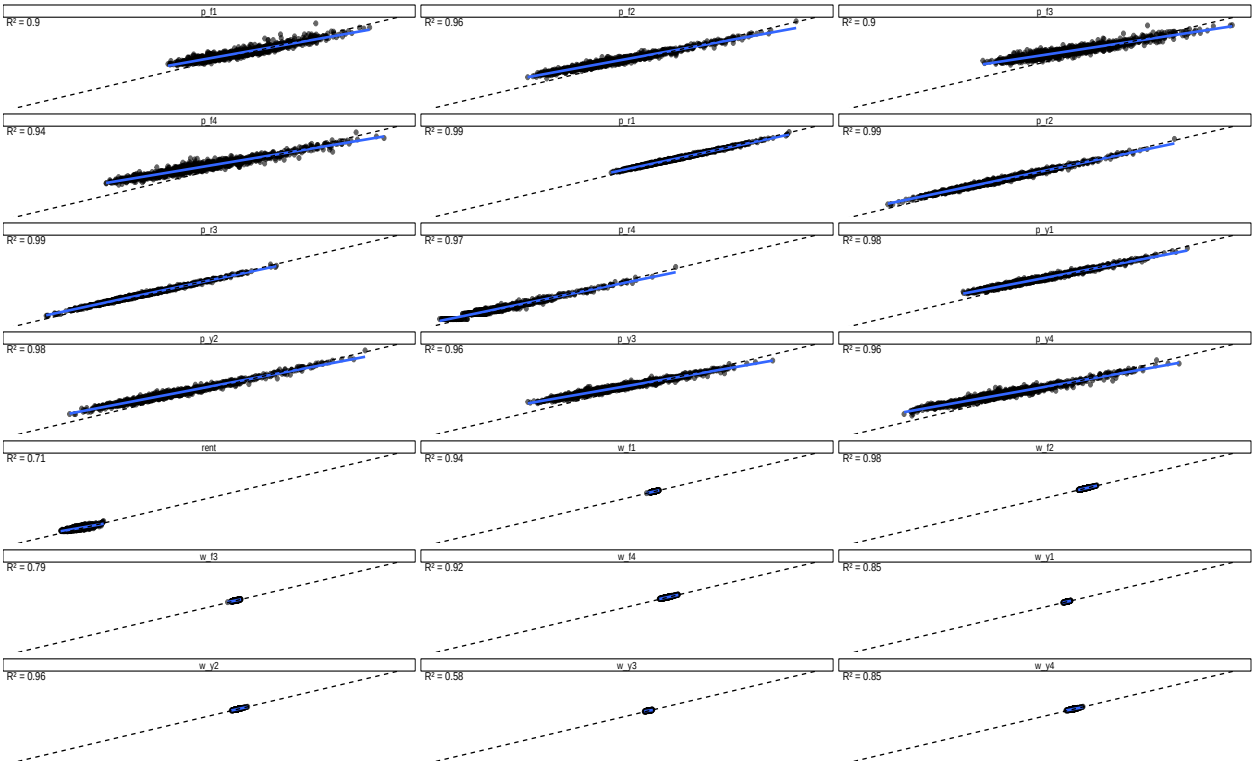
where r_d^θ is either r_d, $r_d(1+\tau_d)$ or $r_d\tau_d$ depending if the household is renter, accessing owner, or owner, respectively. Logically, indirect utility increases with amenities and income, and decreases with rents, taxes, and housing consumption requirement.

D. Additional counterfactual results

D.1. Goodness of fit

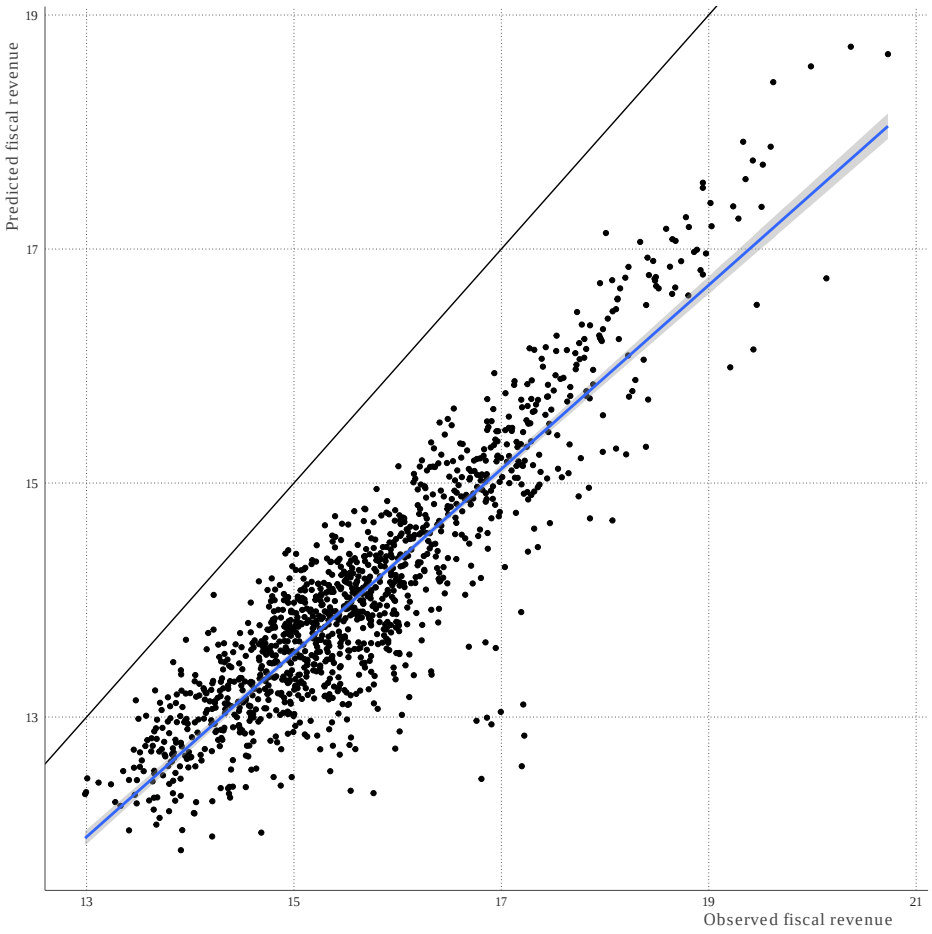
To assess the validity of the model prediction, I regress the observed population in 2019 and the predicted population in 2019. A high R2 suggests a good model prediction for population. Recall that the model estimation procedure target the rent and the wage. For all variables, the R2 of fit is between 92% and 100%, and the slope coefficients lie between 0.83 and 0.99.

I also confirm the goodness of fit through the out-of-sample estimation of the local fiscal revenues. I compare the observed revenue from households' taxation in the data and the one predicted by the model (Figure D14).



Each sub-panel plots the linear fit line between the observed value and the predicted baseline value of each variable (in log).

Figure D13: Goodness of fit



Data: Balance des comptes communaux 2019. I compute the fiscal revenue as the total property tax collection.

Figure D14: Out-of-sample estimation of the local fiscal revenue

D.2. Policy scenarios

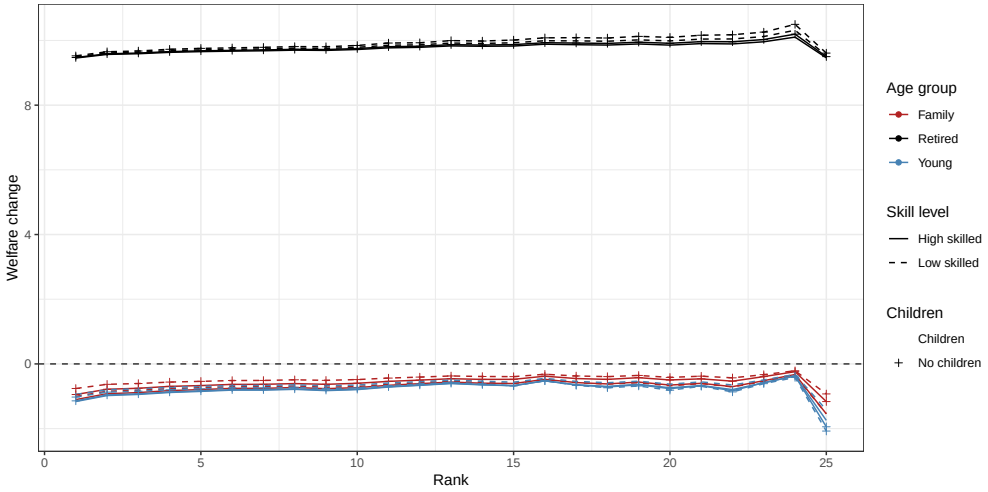
The first policy considered is an uncompensated 10% increase in general pension level. A pension increase (Fig. D15a) definitely benefits the welfare of pensioners. Note that a 10% increase translates into a less than 10% increase in welfare, as part of the increase is capitalized into rents for all households, including pensioners. All other age groups see their utility decrease by a sizeable amount (around 1%), driven by the increase in rents (Figure D21), from 4% in the bottom areas to 2% in the top areas. Interestingly, this triggers an increasing sorting to the top areas, especially of pensioners (as they get richer, the moving cost relatively decreases).

The second policy considered is a 10% increase in the housing sector total factor productivity factor $\overline{H}_d$, over the territory (Fig. D15b). This can be thought as a relaxation of the housing supply constraint. For the housing supply elasticity increase (Figure D22), rents mechanically decrease and a large share of young households flows to top areas as rents become cheaper. From the welfare perspective, low-skilled workers are especially better-off as housing represents a larger share of their consumption bundle. The 10% increase in housing sector productivity imperfectly passes trough rents (3.5% decrease on average). The sorting of pensioners remained relatively unchanged as they are affected by rents only through the tax base. A sizeable share of the workforce however flows to the top areas.

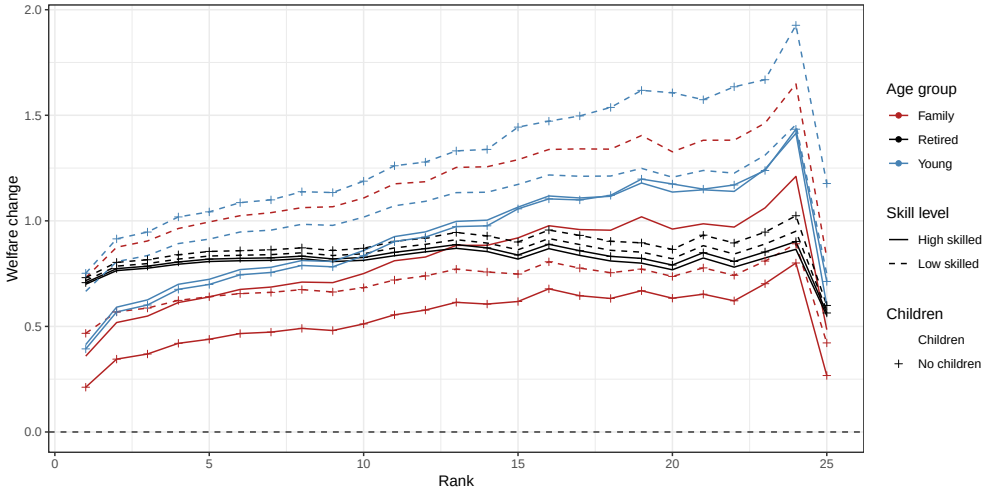
Similar to the increase in pension, the increase in production sector total factor productivity maps into an increase in wages (Figure D23).

The decrease in property tax rates (Figure D15d) positively affects pensioners and workers without children. Indeed, those households are paying taxes (whereas young households do not as they are renters). Families with children also lose welfare as they are more sensitive to change in rents.

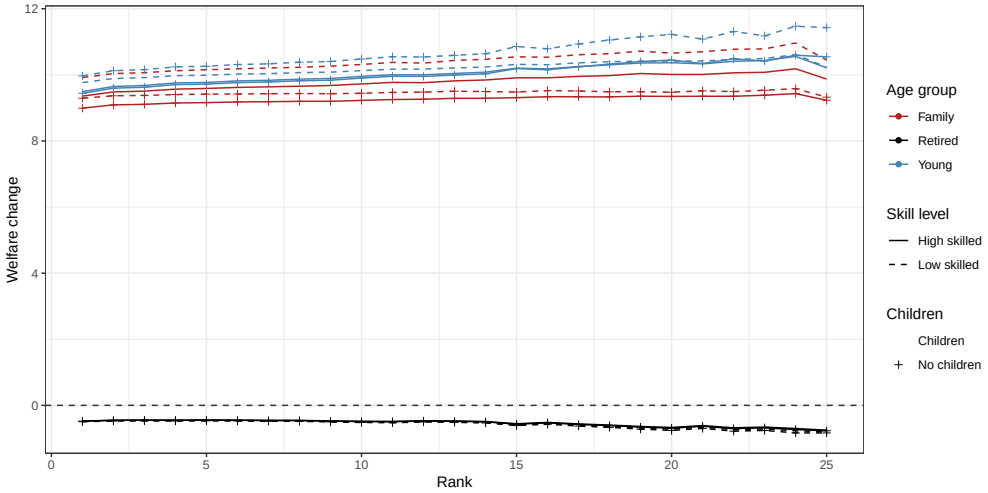
I combine two policies in D15e: the increase in pension and the increase in housing sector TFP. The former had a positive impact on the level of housing cost and the latter a positive impact. Hence, which instrument offsets the other? The policy is welfare improving for all the population, especially the pensioners (11% increase in welfare), driven by a decrease of 2% in housing cost.



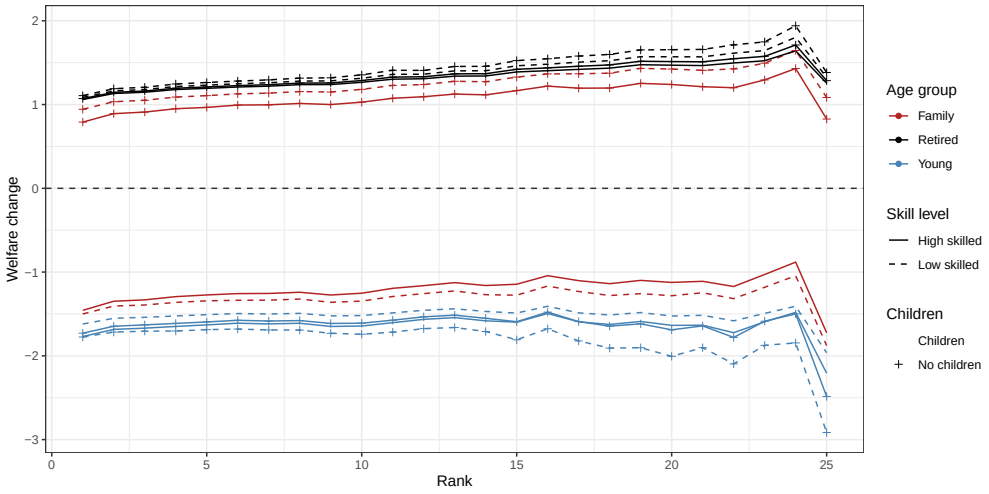
(a) Pension increase



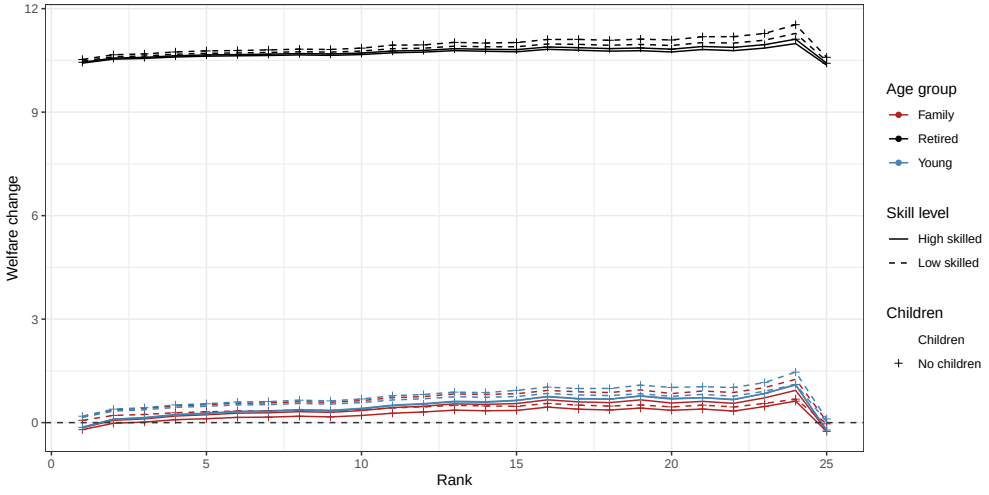
(b) Housing total factor productivity increase



(c) Production total factor productivity increase



(d) Property tax decrease

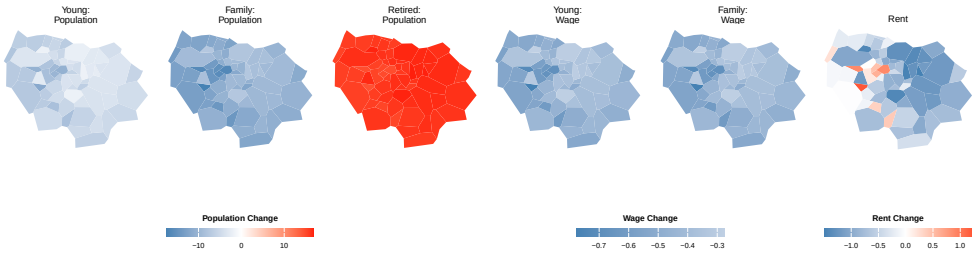


(e) Increase in pension and in housing TFP

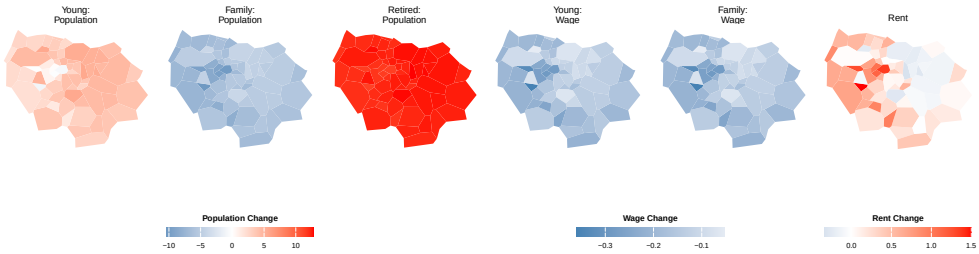
Figure D15: Counterfactual change in welfare (ageing in 2030 + policy change)

D.3. Case study: Paris' area

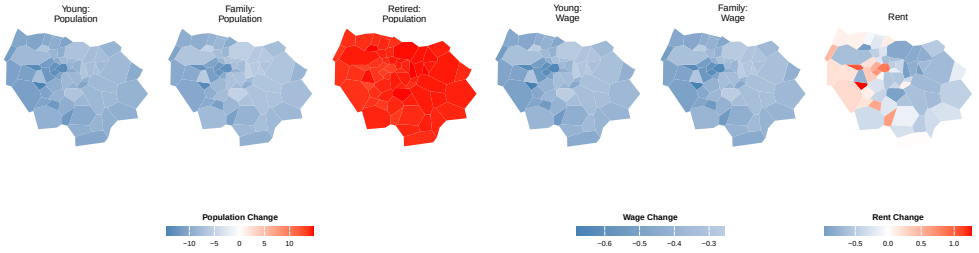
Almost one fifth of the French population lives in the Paris area (*Île-de-France région*). In this case study, I focus more specifically on the local effects of ageing in the area. I only focus on the ageing counterfactuals in 2030, 2050, and 2070. Results are displayed in Figure D16. The analysis reveals that the pensioners population is expected to move out from Paris and locate in the nearby suburbs. The pattern is even stronger for younger age classes. Due to the decrease in housing demand stemming from the young and the families, rents will decrease in most of the Ile-de-France. In all the welfare gains are very small.



(a) 2030



(b) 2050

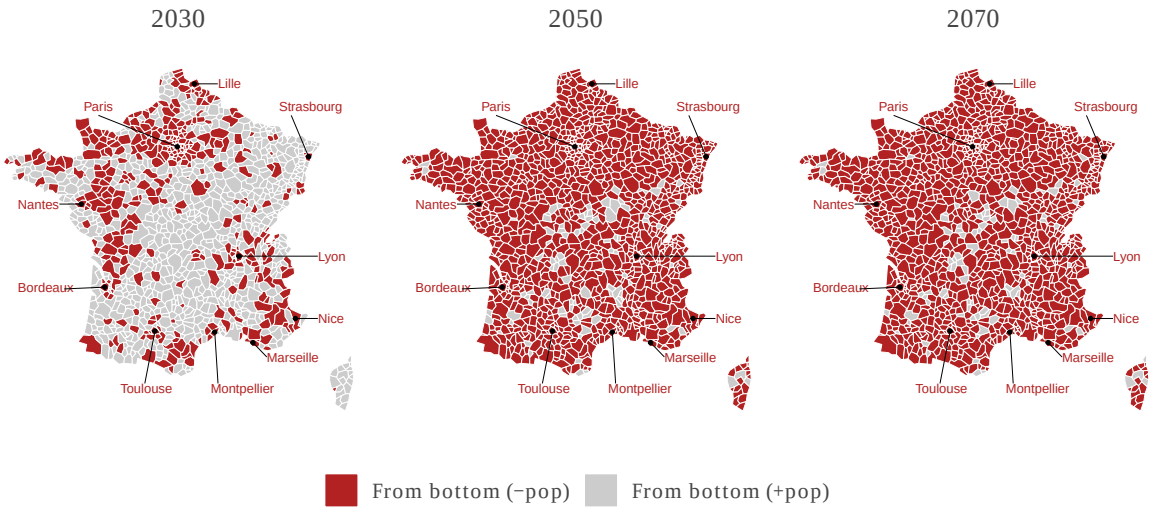


(c) 2070

Figure D16: Change in endogenous variables in Île-de-France

D.4. Bottom-up or bottom-down ageing?

An under-studied aspect of ageing as a demographic process is whether ageing comes from the top (relatively more elderly, especially due to the increase in life expectation or the arrival of pensioners) or from the bottom (relatively less young, especially due to less fertility or the out-migration of the young households). Following the definition given in Fact 2, I plot the different types of ageing types in 2030, 2050, and 2070. A striking fact is that all areas are expected to age from the bottom over the longe run. It highlights the pattern that on top of ageing, total population is going to increase until the 2030s. However, due to fertility drop, population is still going to age, but decrease at the same time for the remaining decades. It confirms the relative decline of France in demographic terms, which correlates with a drop in rents and a concentration of population in highly populated areas.



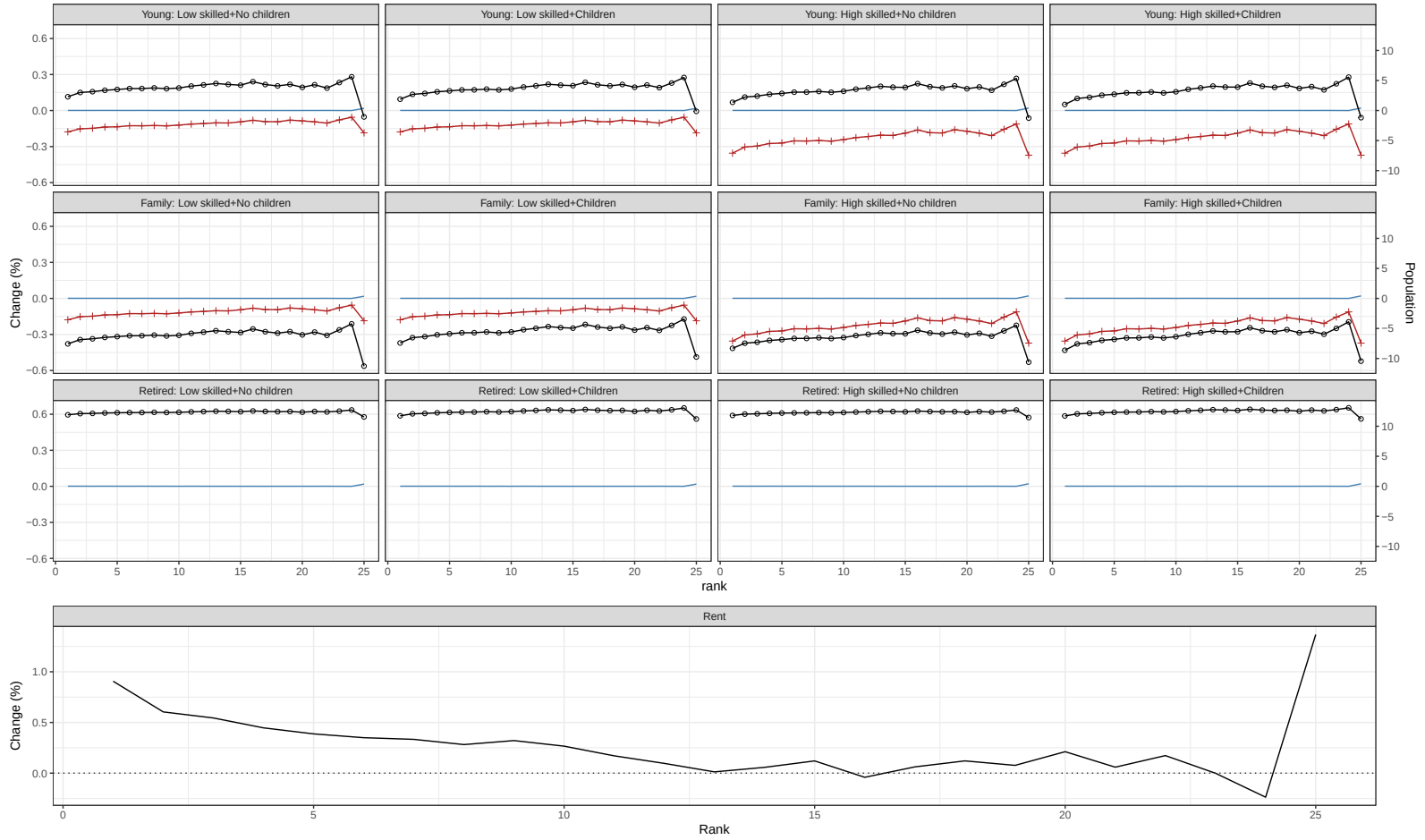
In orange, areas that aged from the bottom (more pensioners and less active) but gained population. In green, areas that aged from the bottom (more pensioners and less active) but lost population.

Figure D17: Ageing typology depending on the counterfactual scenario

D.5. Welfare change decomposition

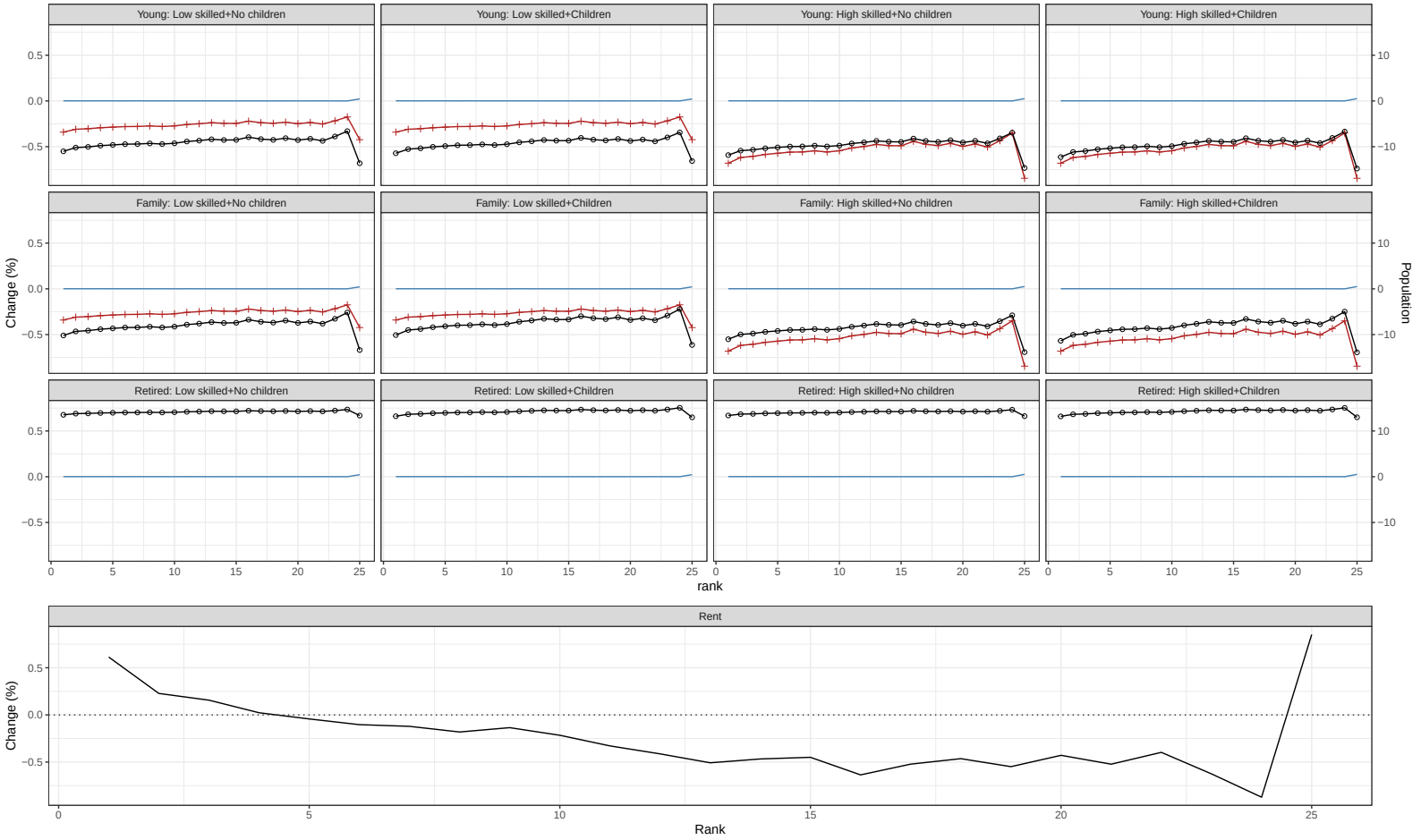
As show in Equation (6), welfare is a function of indirect utility, which in turn depends only on income (positively), rent (negatively), and amenities (positively). For each counterfactual exercise and each household type, I decompose the welfare variation for each quantile of the baseline population distribution (2019). All variables are expressed in percentage change from the baseline. Rent is not tax-inclusive.

Figure D18: Decomposition of welfare change (Ageing 2030)



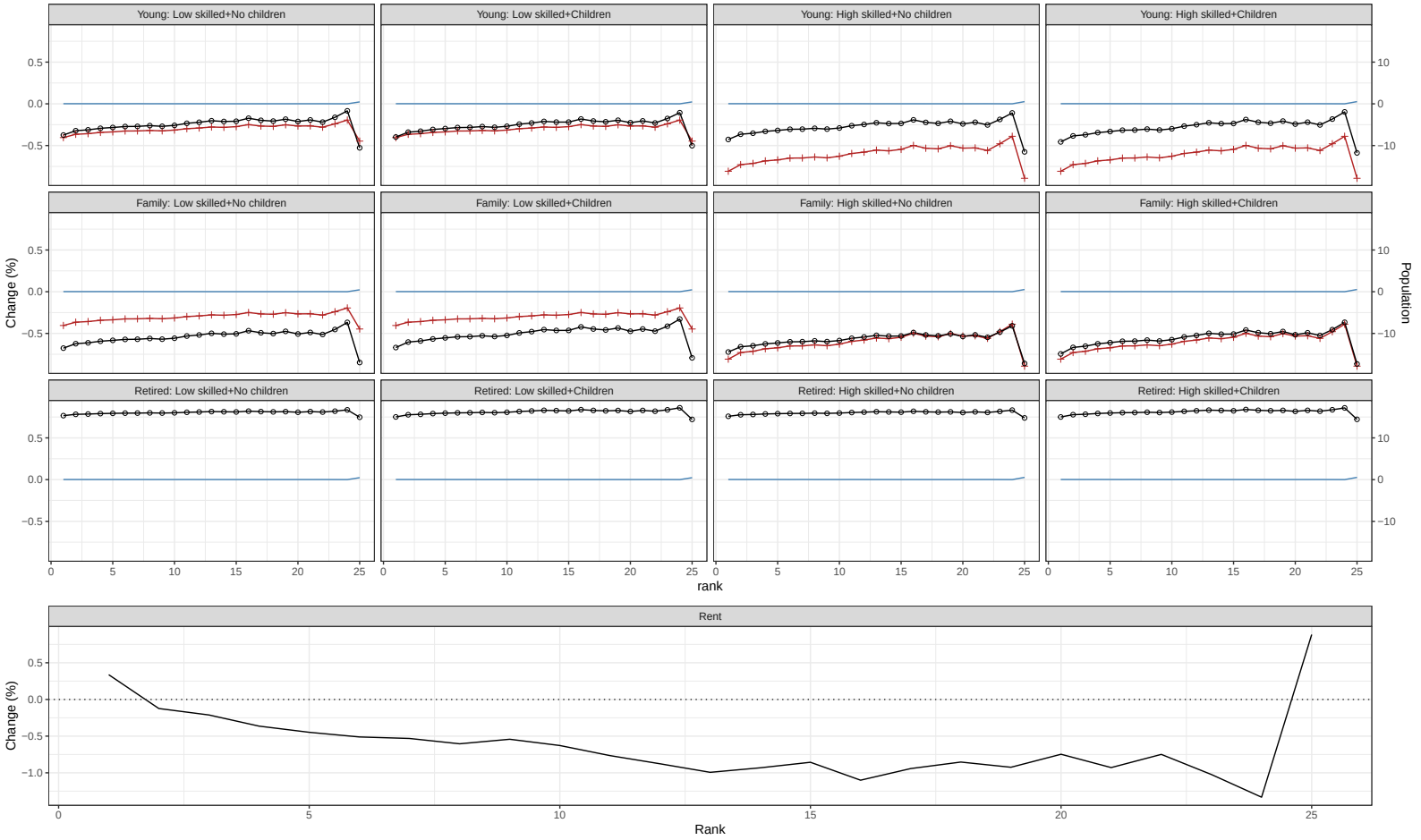
Black line with hollow cirles is population. Plain blue line is amenity. Red line with crosses is wage. Plain black line (bottom panel) is rent.

Figure D19: Decomposition of welfare change (Ageing 2050)



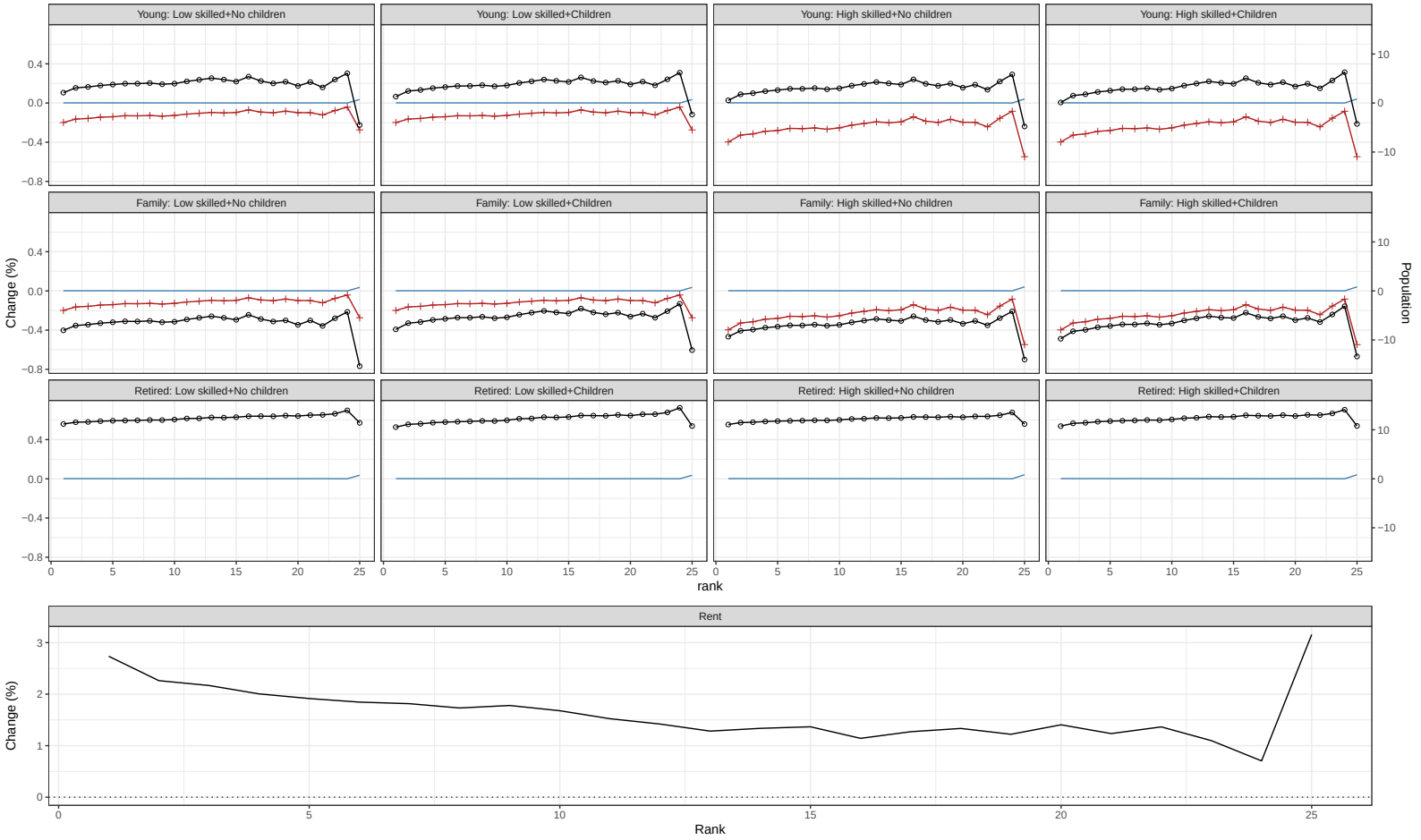
Black line with hollow cirles is population. Plain blue line is amenity. Red line with crosses is wage. Plain black line (bottom panel) is rent.

Figure D20: Decomposition of welfare change (Ageing 2070)



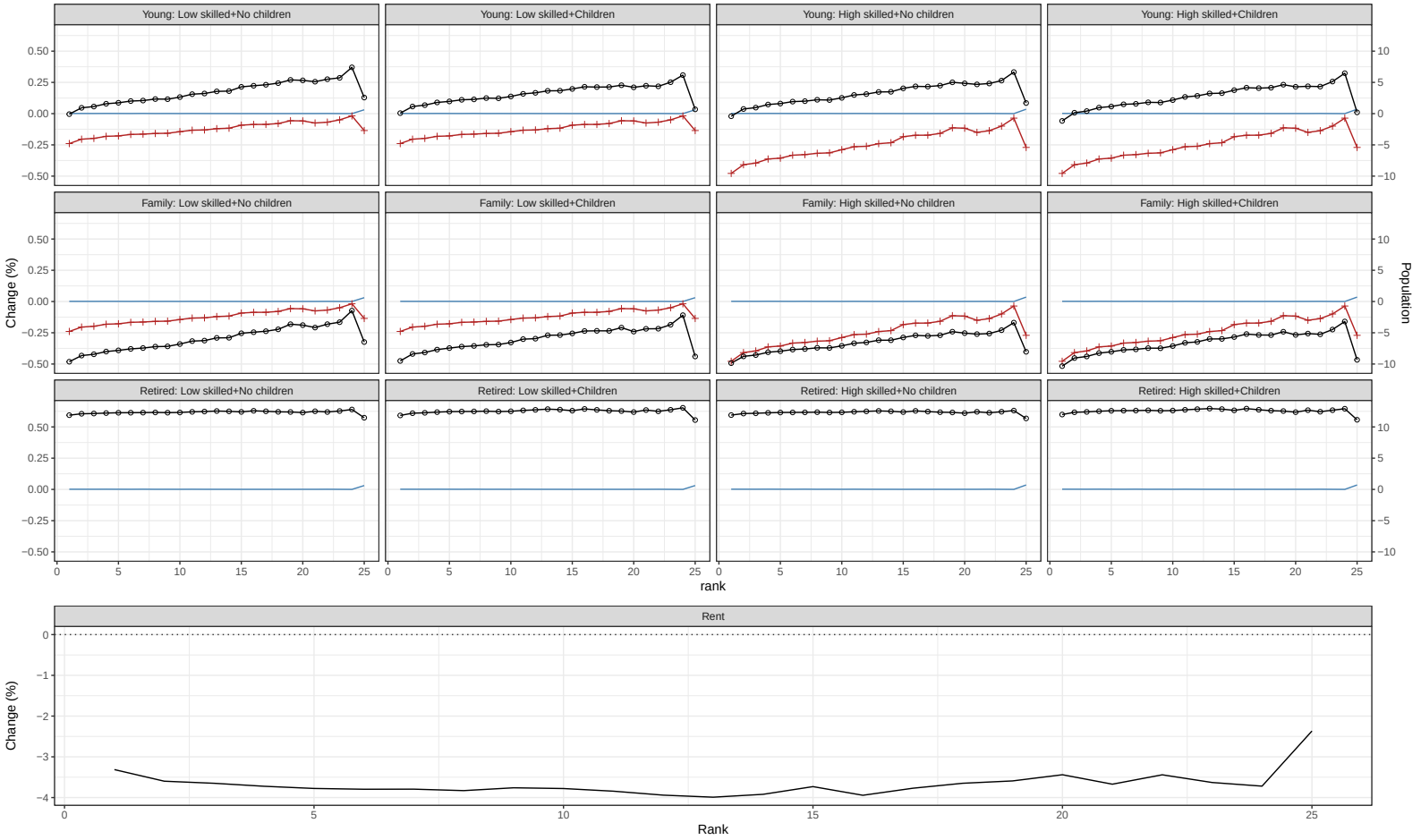
Black line with hollow cirles is population. Plain blue line is amenity. Red line with crosses is wage. Plain black line (bottom panel) is rent.

Figure D21: Decomposition of welfare change (Pension increase)



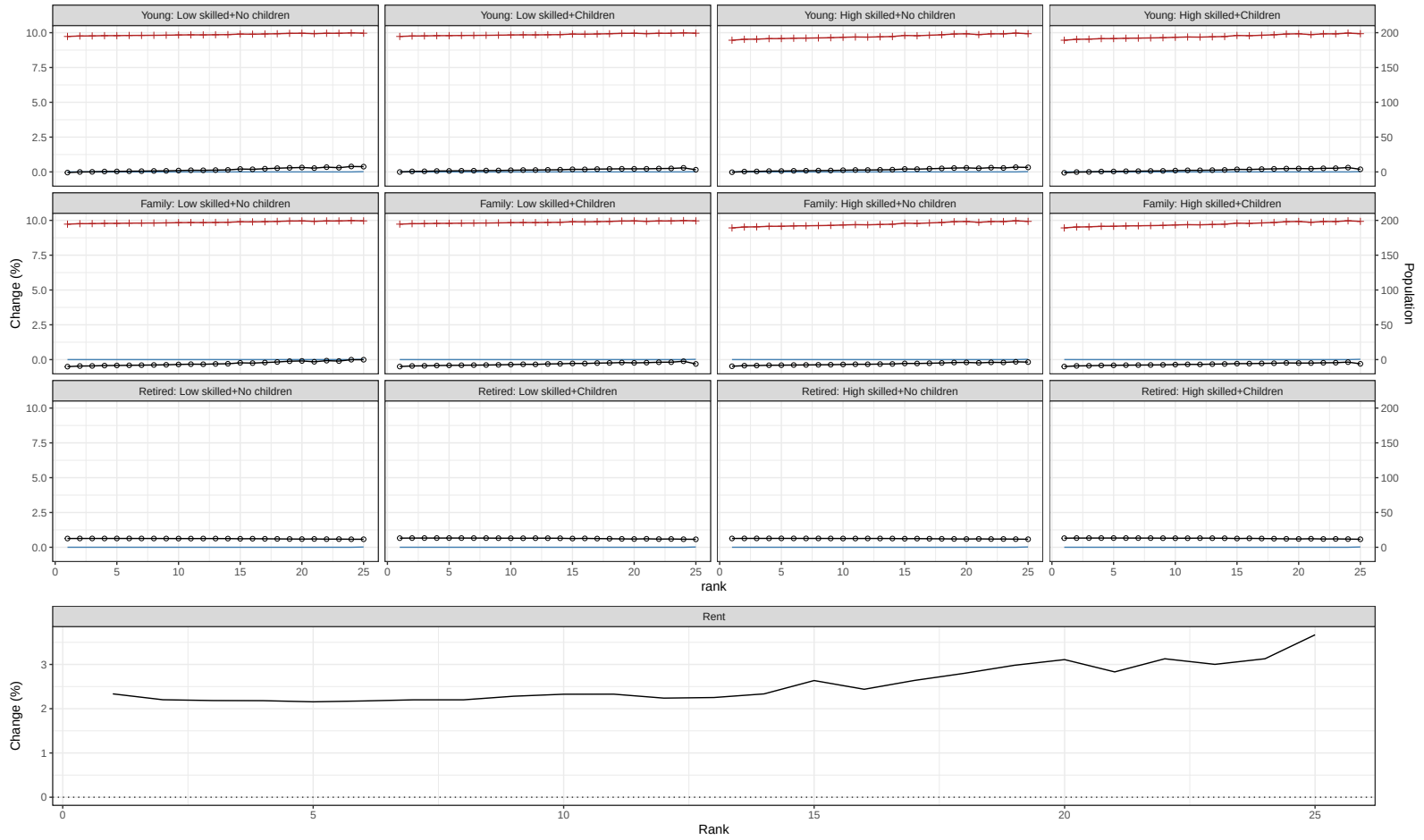
Black line with hollow circles is population. Plain blue line is amenity. Red line with crosses is wage. Plain black line (bottom panel) is rent.

Figure D22: Decomposition of welfare change (Housing supply TFP increase)



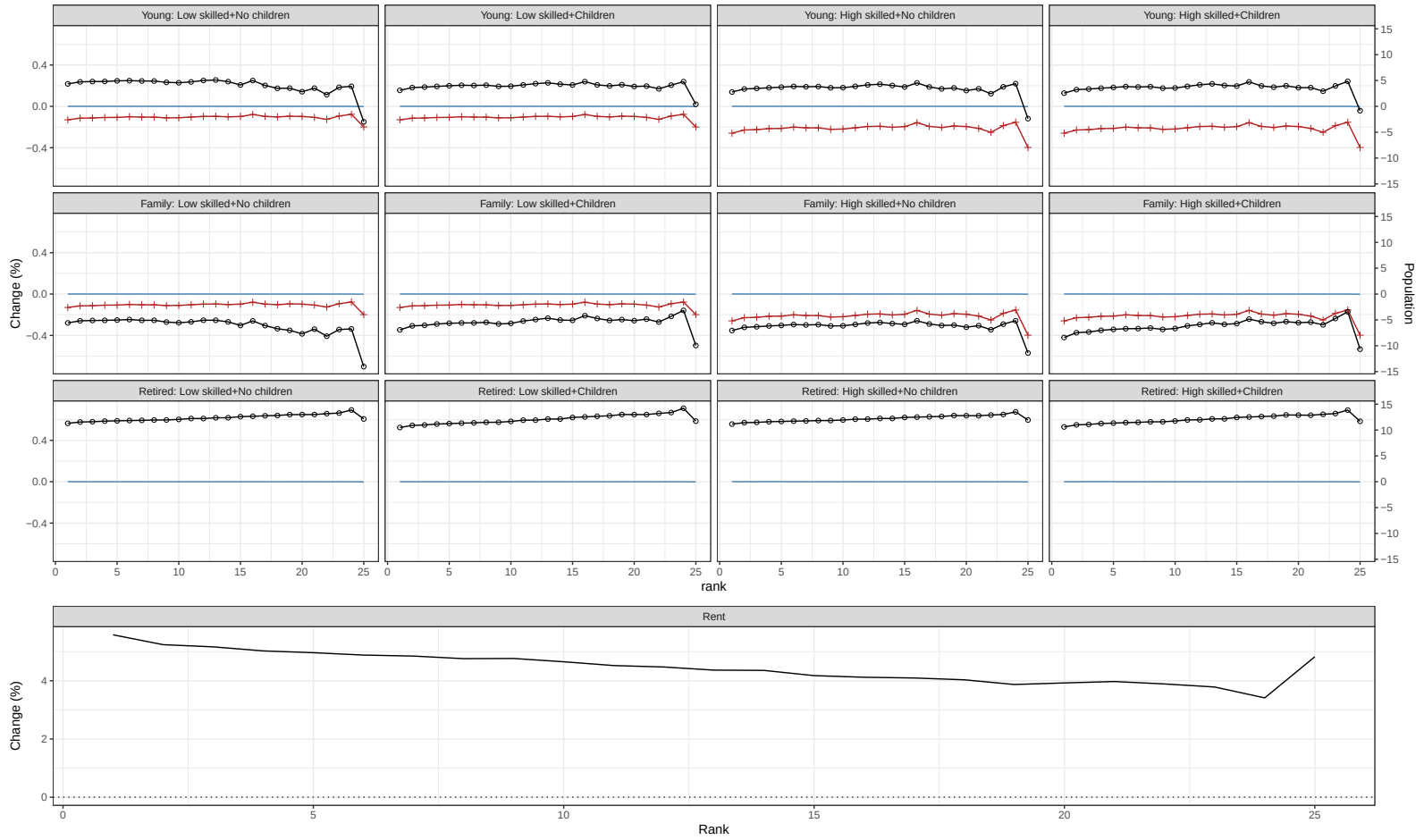
Black line with hollow circles is population. Plain blue line is amenity. Red line with crosses is wage. Plain black line (bottom panel) is rent.

Figure D23: Decomposition of welfare change (Production TFP increase)



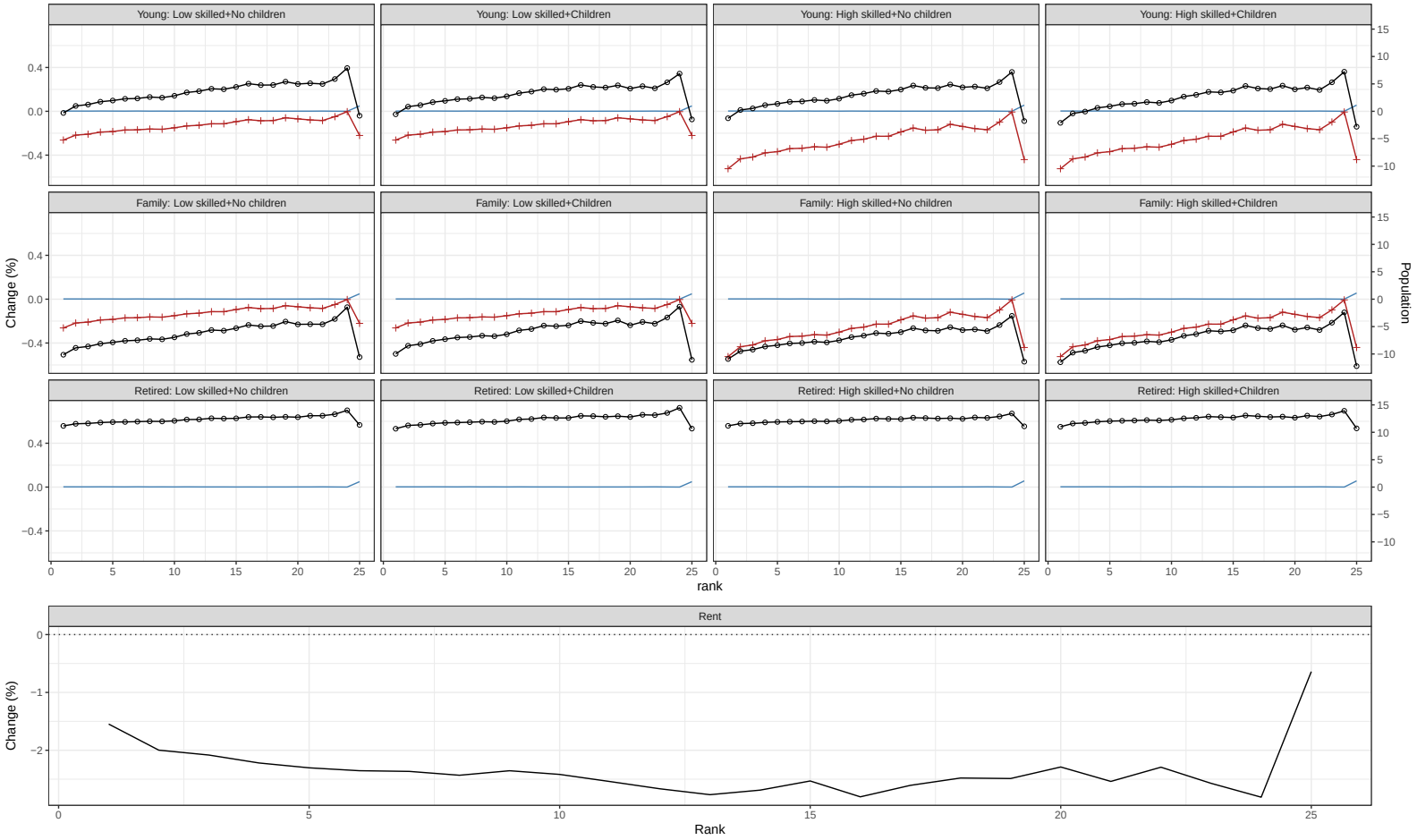
Black line with hollow circles is population. Plain blue line is amenity. Red line with crosses is wage. Plain black line (bottom panel) is rent.

Figure D24: Decomposition of welfare change (Property tax rate decrease)



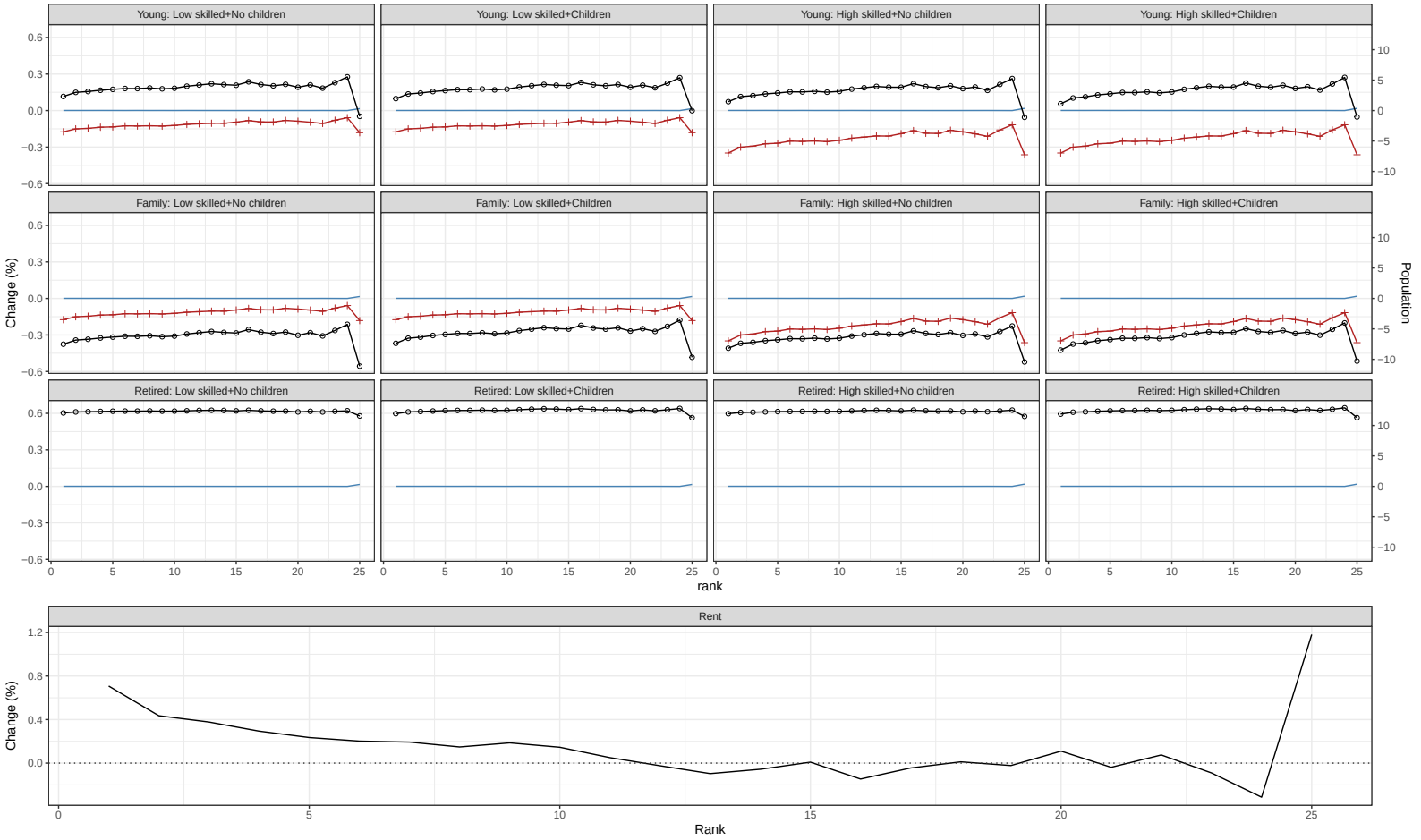
Black line with hollow circles is population. Plain blue line is amenity. Red line with crosses is wage. Plain black line (bottom panel) is rent.

Figure D25: Decomposition of welfare change (Pension increase and housing TFP increase)



Black line with hollow circles is population. Plain blue line is amenity. Red line with crosses is wage. Plain black line (bottom panel) is rent.

Figure D26: Decomposition of welfare change (Multi-ownership and secondary homes)



Black line with hollow circles is population. Plain blue line is amenity. Red line with crosses is wage. Plain black line (bottom panel) is rent.