The Geography of Life: Evidence from Copenhagen

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Motivation

- Large literatures have investigated how age and life events, such as marriage, children or retirement, shape economic decisions:
  - Franco Modigliani's pioneering work introduced the idea that wages, consumption and savings are intimately linked to age.
  - Gary Becker's work portrays marriage and children as fundamental determinants of labor supply and time allocation more broadly.
  - Vast empirical literatures show how age and life events profoundly shape economic outcomes such as labor supply, wages and savings.
- Despite this long tradition we know surprisingly little about how age and life events shape location choices.
- Given large differences in prices and amenities across space, location choices are one of the most important economic decisions that people make.

This Paper

- We document a substantial life cycle in location choices within cities using newly assembled employer-employee-property-family panel dataset for Copenhagen covering more than 30 years.
- We use event study estimates to explore the contribution of both life events and age to the overall life cycle in location choices.
- We then develop a quantitative spatial model to examine mechanisms that can explain the striking sorting in the city.
- Finally, we use model counterfactuals to explore how demographic trends such as population aging and fertility changes will shape the geography of cities.

Preview of Results

- Mobility: We document mobility across residences and workplaces within cities that is nearly an order of magnitude larger than mobility across cities.
- Life cycle: We estimate a substantial life cycle in location choices within cities using individual fixed effects, ruling out cohort effects as confounders.
- Life Events: We show that observable life events contribute a substantial part to the overall life cycle in location choices.
- Mechanisms: We use a QSM to examine the mechanisms behind the location choices over the life cycle and find a key role for urban amenities.
- Demographic Change: Model counterfactuals show that different demographic changes (aging, lower fertility, single households) can have large effects but may partially neutralize each other.

Related Literature

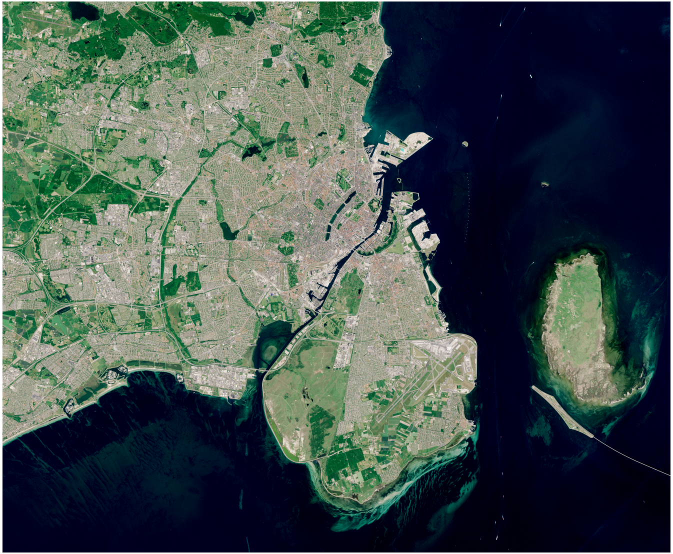
- **Effect of age on wages, income and savings**: Modigliani (1966), Mincer (1974), Meghir and Pistaferri (2011)
- **Effect of marriage and children on labor supply and consumption:** Becker (1973, 1974), Eckstein and Wolpin (1989), Blundell et al. (1994), Van Der Klaauw (1996), Adda et al. (2017), Kleven et al. (2018)
- **Quantitative urban models**: Ahlfeldt et al. (2015), Allen et al. (2015), Monte et al. (2018), Heblich et al. (2020), Tsivanidis (2023), Miyauchi et al. (2022)
- **Retirement, Fertility and Location Choices**: Komissarova (2022), Moreno-Maldonado and Santamaría (2024), Coeurdacier et al. (2023), Albuoy and Faberman (2025), Badilla Maroto et al. (2024)

Overview of the Presentation

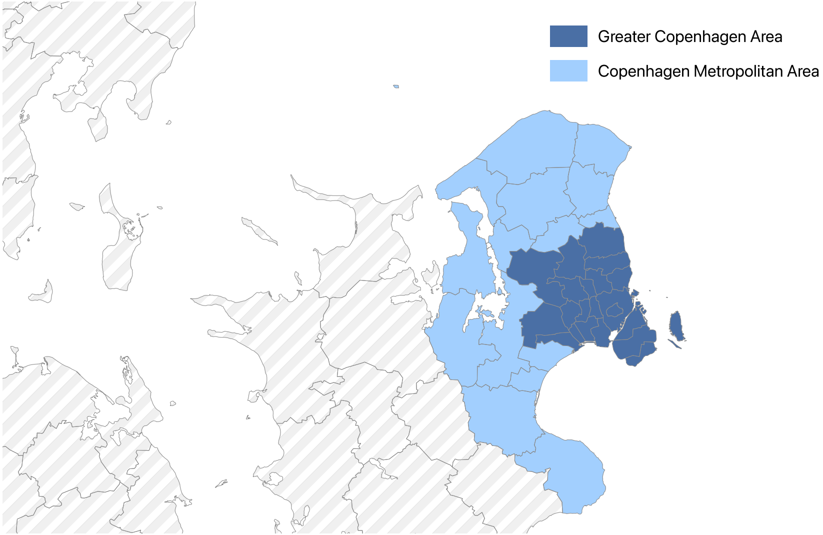
- Empirical Setting and Data
- Stylized Facts
- Theoretical Model
- Quantification
- Counterfactuals
- Conclusion

Empirical Setting

A View from Space



Copenhagen Metro Area (CMA)



Data

- We use an employer-employee-property-family panel of both workers and the non-working population in the Copenhagen Metro Area from 1986 to 2019.
- For each person we observe in each year the following information:
  - Residence and workplace (if working) location in 100 x 100m grid cells.
  - Wage and non-wage income, education, and sector of employment (if working).
  - Size and type of residence including estimates of the square meter price.
  - Family status, including number and age of children and marital status.
- We have the same data also for other parts of Denmark and see when people move away from or into Copenhagen.
- We combine this data with detailed information on the geography of Copenhagen including travel times by several different modes.

Stylized Facts: Mobility

Mobility Over the Life Cycle

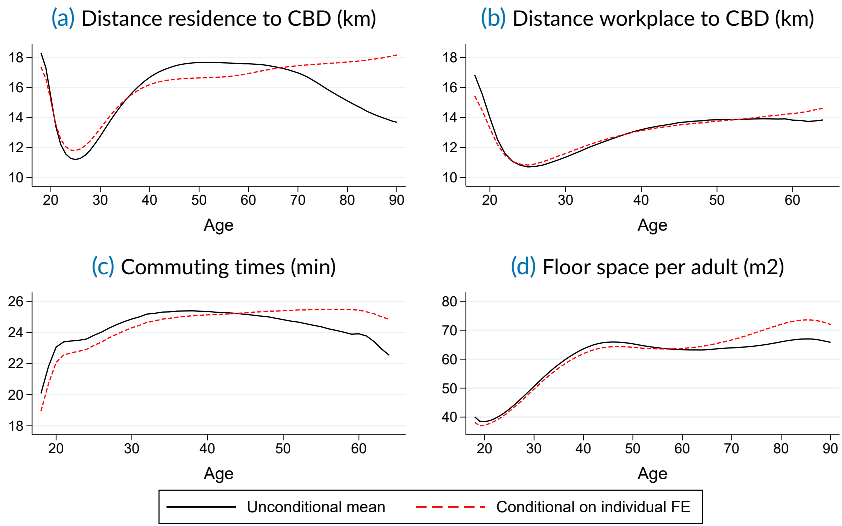
(a) Probability of moving residence or workplace

(b) Conditional probability of moving within CMA

▸ Different Cohorts ▸ Commuting Zones Outside Copenhagen

Stylized Facts: Age

The Life Cycle in the City



▸ Gender Gaps ▸ Smaller Definition of Copenhagen ▸ Back to Decomposition

Stylized Facts: Life Events

Life Events

- An obvious question is whether observable life events can explain the pronounced life cycle in location choices.
- To explore this question, we estimate event-study regressions for a large number of life events that we observe in our data.
- We consider the following life events: cohabitation, children, separation, empty nesting, retirement, and death of the spouse (which can all repeat).
- The regressions include 11 life events that happen to at least 2.5% of the people in our data.
- We run separate regressions for early and late life events (median age of event occurrence below or above 40). ▸ Early Life Table ▸ Late Life Table
- The timing and sequence of life events varies substantially. ▸ Graph Early ▸ Graph Late

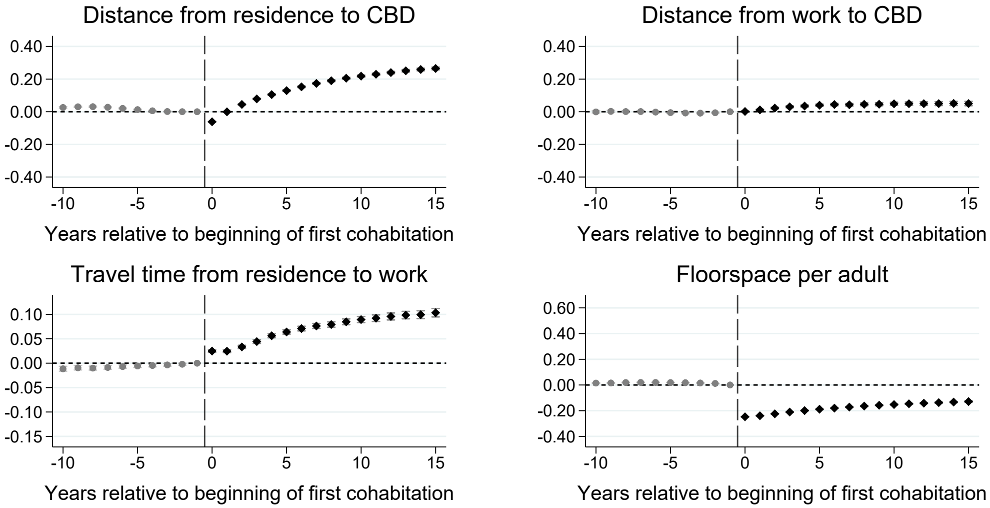
Regression Specification

- We estimate the following event-study regressions for outcome y_{it} of person i in year t using a variant of the imputation method (Borusyak et al. 2024):

$$\ln\left(y_{it}\right) = \hat{\theta}_i + \hat{\eta}_a + \sum_{e \in \mathbb{E}} \sum_{\substack{h=-m \\ h \neq -1}}^{n} \beta_h^e \mathbb{1}[K_{it}^e = h] + \varepsilon_{i,t}$$

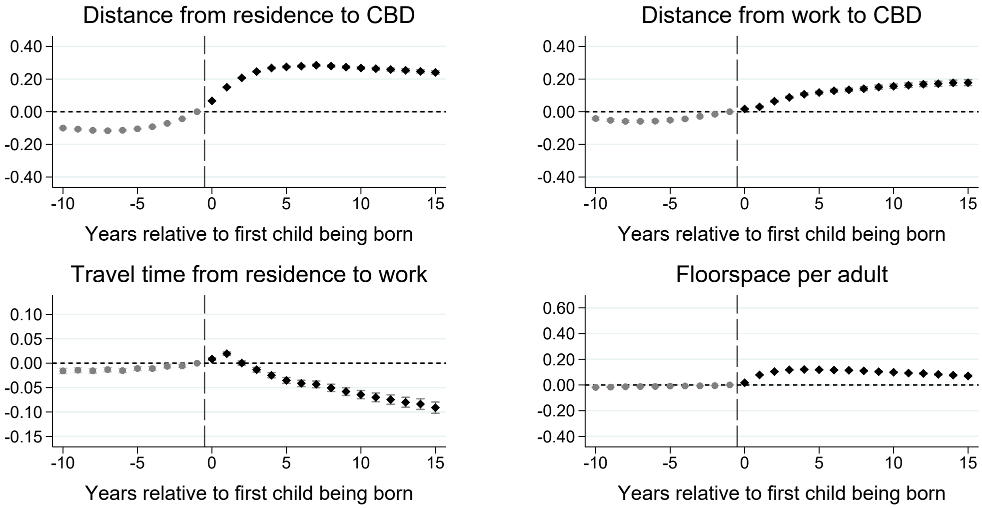
  - $\hat{\theta}_i$ and $\hat{\eta}_a$ are imputed individual and age fixed effects.
  - $K_{it}^e = t - E_i^e$ is the difference between the current year (t) and the year in which individual i experiences event e (E_i^e), and $\mathbb{1}[K_{it}^e = h]$ is a dummy for difference h.
  - β_h^e: are the treatment effects of either the early or late life events.
  - The regressions contain all leads and lags but the graphs show -10 to +15.
  - Leads and lags are jointly estimated to avoid artificial jumps under pre-trends
  - Standard errors are clustered on each person

First Cohabitation



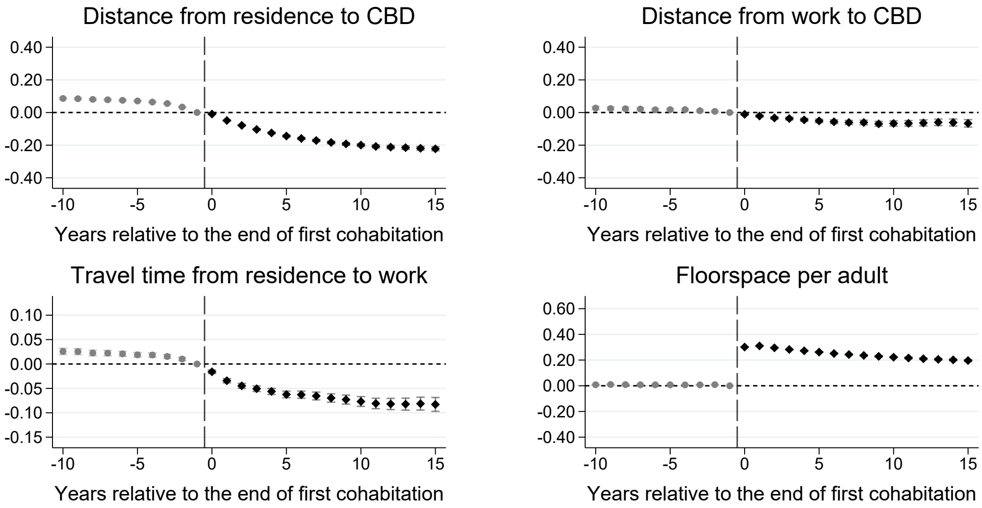
By Gender
OLS Robustness

First Child

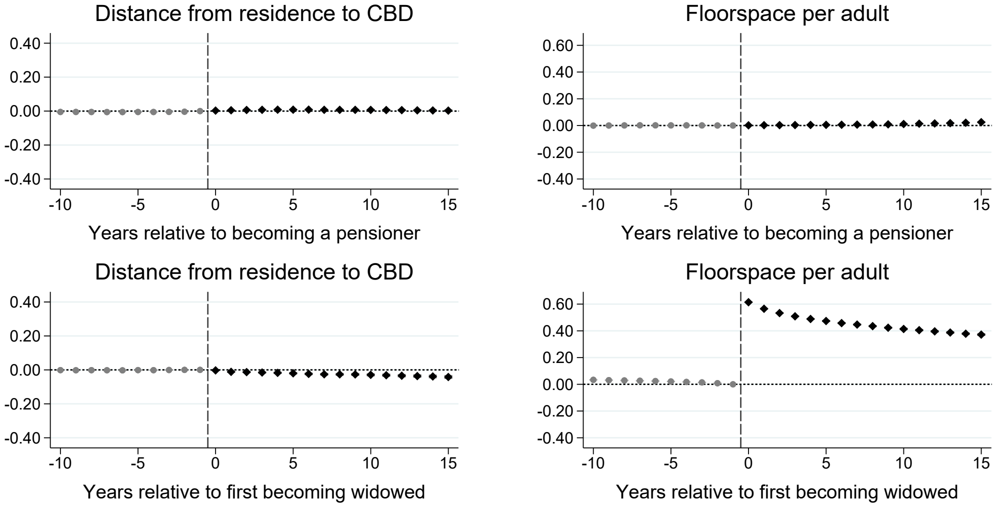


By Gender Second Child

First Separation



Retirement and Death of Spouse



▸ Empty Nest

Life Events versus Aging

Decomposing the Life Cycle

- How much of life cycle in location choices can be explained by observable life events and how much is just explained by people getting older?
- The life cycle outcome at age s (conditional on person fixed effects) is:

$$\bar{\mathcal{Y}}_s = \mathbb{E}\left(y_{it} - \alpha_i \mid \text{Age}_{it} = s\right)$$

- We use our event study estimates to predict the treatment effects of all leads and lags of life events that person i experiences:

$$\hat{\mathcal{L}}_{it} = \sum_e \sum_{h=-a}^{b} \widehat{\beta}_h^e \mathbb{1}[K_{it}^e = h]$$

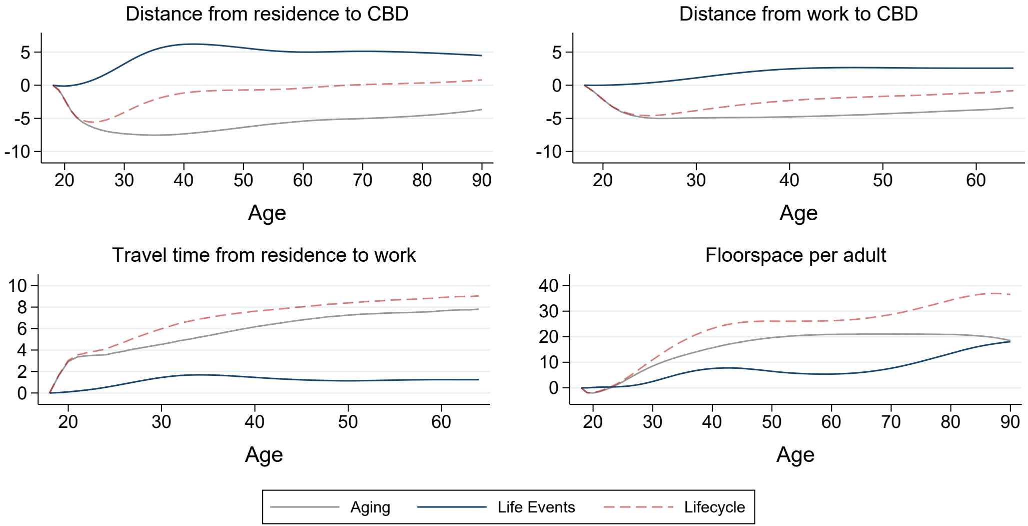
- We average the treatment effect of life events for each age bin

$$\bar{\mathcal{L}}_s = \mathbb{E}(\hat{\mathcal{L}}_{it} \mid \text{Age}_{it} = s)$$

- Compute effect of aging ($\bar{\mathcal{A}}_s$) as: $\bar{\mathcal{A}}_s = \bar{\mathcal{Y}}_s - \bar{\mathcal{L}}_s$ (normalized to 0 at age 18)

▸ Red Dashed Line

Life Events versus Aging



Key Take Aways from Reduced Form Evidence

1. There is substantial within city mobility and distance of residence and workplace to the center follow a U-shaped pattern.
2. Most life events lead to a decentralization of residence and workplace location, but separation reverses the (spatial) effects of cohabitation.
3. Residential floor space consumption is affected by children, but cohabitation has an even larger effect than the first child.
4. There is no evidence of “downsizing” residential space consumption at older ages and empty nesting and retirement have little effect on location choices.
5. Both life events and aging are quantitatively important in explaining location choices over the life cycle.

Theoretical Framework

Model Overview

- We develop a quantitative urban model in the tradition of Ahlfeldt et al. (2015) which differs from the existing literature in three main ways:
  - Several different worker types ("occupations"): low/high skilled and young/old.
  - Workers can have different family types (married, children etc.), which affect commuting costs, housing expenditure and preferences over amenities.
  - Non-working population: pensioners and students.
- We use the model for two purposes:
  - We use the model to shed light on the mechanisms that drive the strikingly different location choices at different ages.
  - We use model counterfactuals to examine the effect of demographic changes, such population aging or lower birth rates, on the geography of cities.

▸ Groups

Model Setup

- The city
  - consists of locations that are connected by a transport technology.
  - is for simplicity a closed city (no in and outflows).
- Workers and non-working population
  - choose where to live and where to work (if working).
  - consume a final good and floor space.
  - value residential amenities depending on their family type f and occupation o.
- Firms
  - use labor and floor space to produce the freely tradable final good.
  - view workers as perfect substitutes across family types but not occupations.
- All markets are competitive

Preferences and Production

- Indirect utility of worker ω living in location n, working in location i, of occupation o and family type f is:

$$U_{ni}^{of}(\omega) = \frac{B_{ni}^{of} w_i^o z_{ni}^{of}(\omega)}{\kappa_{ni}^{of}(P_n)^{\alpha^{of}}(Q_n)^{1-\alpha^{of}}} \quad 0 < \alpha^{of} < 1. \tag{1}$$

- Indirect utility function of non-worker ρ of group r living in n is:

$$U_n^r(\rho) = \frac{B_n^r \bar{w}^r z_n^r(\rho)}{(P_n)^{\alpha^r}(Q_n)^{1-\alpha^r}} \quad 0 < \alpha^r < 1 \tag{2}$$

- Output (Y_i) in i is produced using all types of labor (L_{Fi}^o) and floor space (H_{Fi}):

$$Y_i = A_i \prod_{o \in \mathbb{O}} \left(\frac{L_{Fi}^o}{\beta_i^o}\right)^{\beta_i^o} \left(\frac{H_{Fi}}{\beta^H}\right)^{\beta^H}, \quad 0 < \beta_i^o, \beta^H < 1, \quad \sum_{o \in \mathbb{O}} \beta_i^o + \beta^H = 1, \tag{3}$$

Residential sorting

- The residential choice probability of workers in group *of* is given by:

$$\lambda_{Rn}^{of} = \frac{L_{Rn}^{of}}{L^{of}} = \frac{\sum_{\ell \in \mathbb{N}} \left(B_{n\ell}^{of} w_{\ell}^{o} \right)^{\varepsilon^{of}} \left(\kappa_{n\ell}^{of} \left(Q_n \right)^{1-\alpha^{of}} \right)^{-\varepsilon^{of}}}{\sum_{k \in \mathbb{N}} \sum_{\ell \in \mathbb{N}} \left(B_{k\ell}^{of} w_{\ell}^{o} \right)^{\varepsilon^{of}} \left(\kappa_{k\ell}^{of} \left(Q_k \right)^{1-\alpha^{of}} \right)^{-\varepsilon^{of}}} = \frac{\Phi_n^{of}}{\Phi^{of}} \tag{4}$$

- With $B_n^{of} = \mathcal{B}_n^{of} \mathcal{B}_i^{of}$ and $w_i^{of} = \mathcal{B}_i^{of} w_i^{o}$, and $\kappa_{ni}^{of} = t_{ni}^{\phi^{of}}$, we obtain:

$$\frac{L_{Rn}^{of}}{L^{of}} = \frac{\left(\mathcal{B}_n^{of} / Q_n^{1-\alpha^{of}}\right)^{\epsilon^{of}} \sum_{\ell \in \mathbb{N}} \left(w_{\ell}^{of} / t_{n\ell}^{\phi^{of}}\right)^{\varepsilon^{of}}}{\Phi^{of}} \tag{5}$$

- The residential choice probability of non-workers in group r is given by:

$$\lambda_n^{r} = \frac{L_{Rn}^{r}}{L^{r}} = \frac{\left(B_n^{r} / Q_n^{1-\alpha^{r}} \right)^{-\varepsilon^{r}}}{\sum_{k \in \mathbb{N}} \left(B_k^{r} \right)^{\varepsilon^{r}} \left(Q_k^{1-\alpha^{r}} \right)^{-\varepsilon^{r}}} \tag{6}$$

Equilibrium

- Given model parameters $\{\phi^{of}, \alpha^{of}, \alpha^{r}, \beta^{H}, \beta^{o}, \varepsilon^{of}, \varepsilon^{r}\}$, group sizes $\{L^{of}, L^{r}\}$, and exogenous location characteristics (fundamentals) $\{A_i, B_{ni}^{of}, B_n^r, H_{Fi}, H_{Ri}\}$, the general equilibrium of the model is referenced by the vector of six variables $\{L_{Ri}^{of}, L_{Ri}^{r}, w_i^o, L_{Fi}^{of}, Q_i, q_i\}$
- We solve for these six variables using these equations:
  1. Residential choice probabilities for workers (λ_{Rn}^{of})
  2. Non-worker residential choice probabilities (λ_n^r)
  3. Zero profit condition (w_i^o)
  4. Worker workplace choice probabilities (λ_{Fi}^{of})
  5. Residential floor space market clearing (Q_i)
  6. Commercial floor space market clearing (q_i)

Full Equations

Quantification

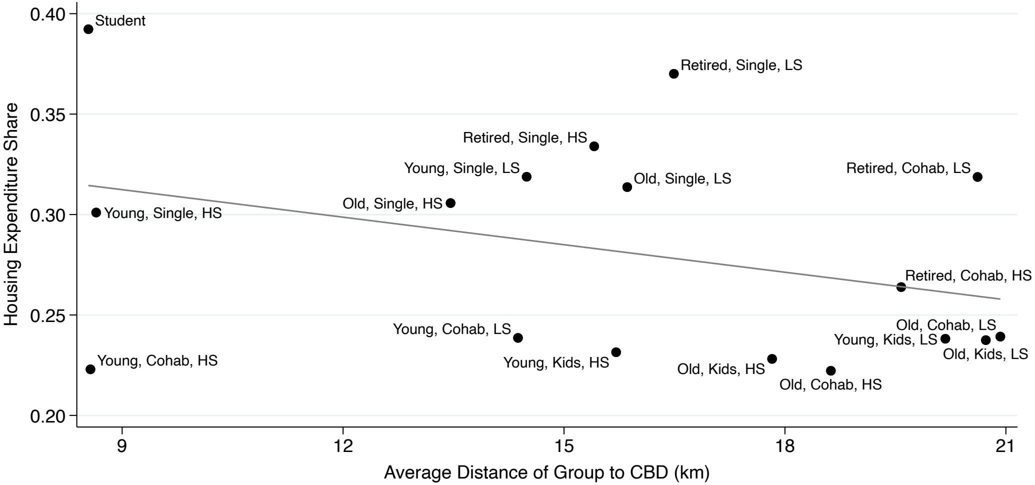
Overview Estimation of Key Model Parameters

- Housing expenditure shares (α^{of} and α^{r}):
  - are estimated using observed income and rents imputed from house prices
- Gravity commuting:
  - uses data on commuting flows across parishes for each type of worker
  - makes use of weighted average travel times across different modes
  - uses PPML with straight-line distance as an instrument for travel times
- Fréchet shape parameters (ϵ^{of} and ϵ^{r}):
  - for workers are estimated using the variance of observed wages across parishes as the empirical moment
  - for the non-working ϵ^{r} is set to the value of the closest worker group
- Production function parameters (β_i^{o} and β^{H}):
  - for labor (β_i^{o}) are calibrated to match (model) wage bill shares in each location
  - for the share of floor space in costs (β^{H}) is set to 0.15

What Explains the Striking Sorting?

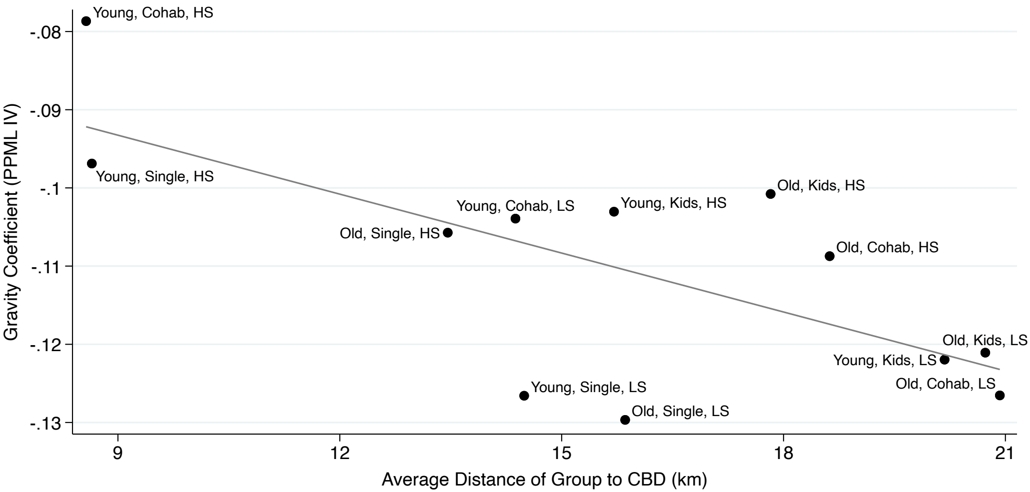
- In the model a number of mechanisms can explain the striking sorting of different groups in the city including:
  - Groups with high housing expenditure shares should (all else equal) prefer locations with lower house prices
  - Groups with higher commuting costs should favour central locations with better commuter market access.
  - Different groups attach different amenity values to a location
- To disentangle these mechanisms, we
  - inspect how groups' primitives relate to residential choices
  - 'flatten' model primitives across groups and solve for the counterfactual

Role of Housing Expenditure Shares



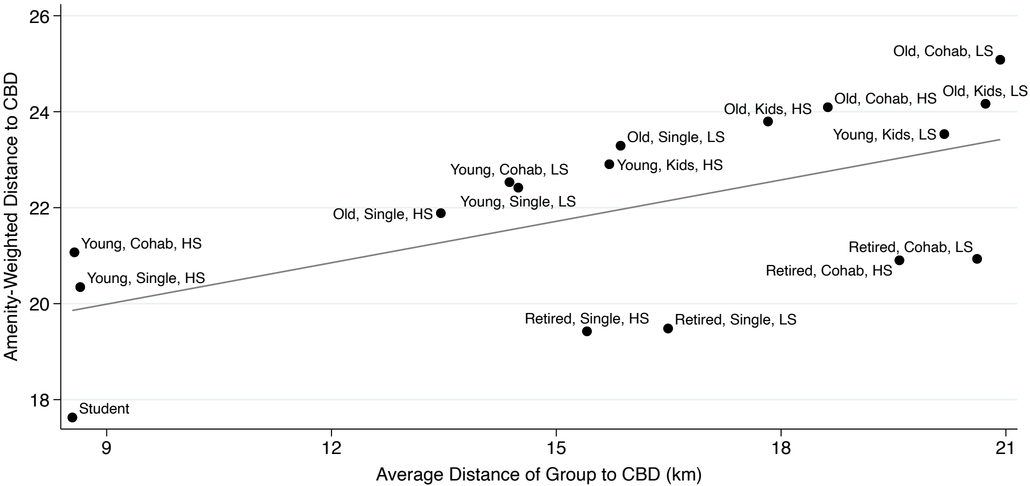
▸ Table with Estimates

Role of Commuting Costs

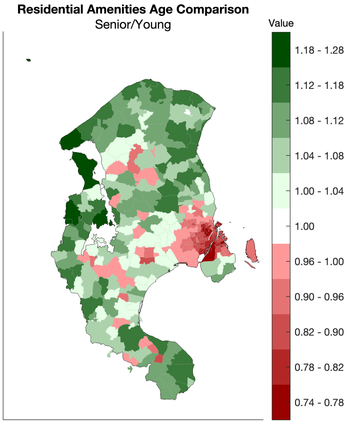


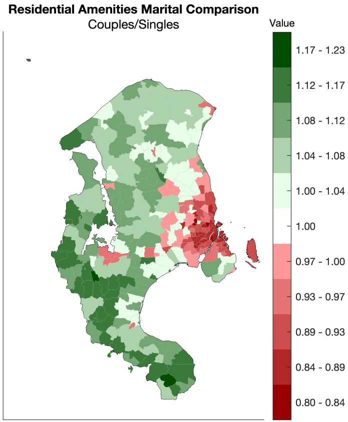
▸ Full Gravity Estimates ▸ Epsilon ▸ Phi

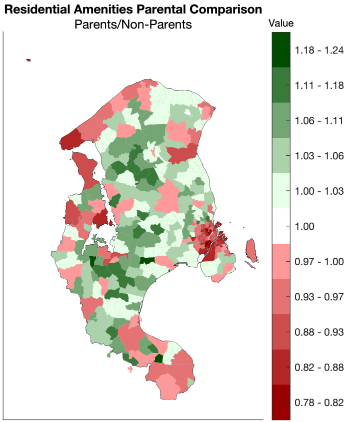
Role of Amenity Differences



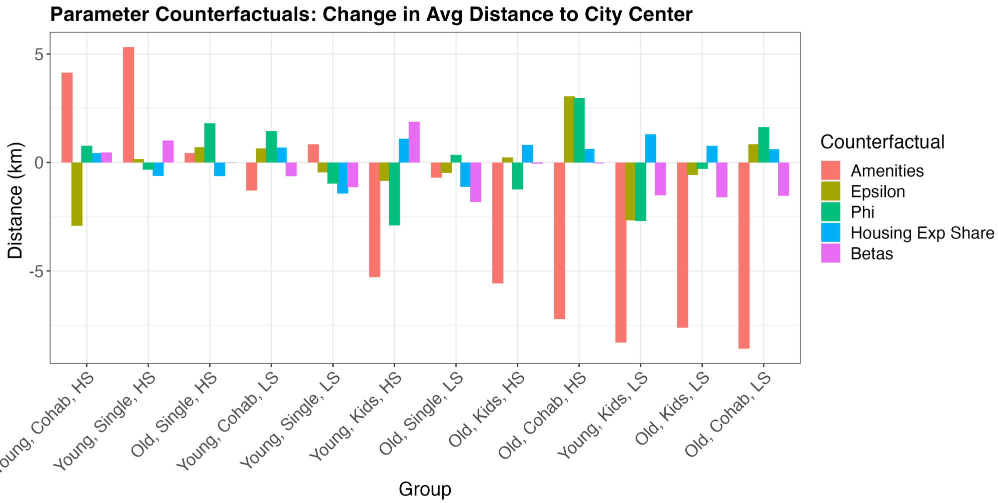
Maps with Amenities by Group







Removing Sorting Mechanisms One at a Time



Model Counterfactuals

The Effect of Demographic Changes on Cities

- How will demographic changes reshape cities?
  - Falling fertility
  - Population aging
  - More single households
- We explore these questions in a series of model counterfactuals that change the relative size of different groups in the city.
- In particular we currently consider three changes:
  - Increase in the share of the old (40+) population by 10%
  - A decrease in number of families with children by half
  - An increase in the share of single households by 10%
- While the counterfactuals explore these trends one at a time, in reality all of these changes are likely correlated.

Aging Counterfactual: Increase in the 40+ Population by 10%

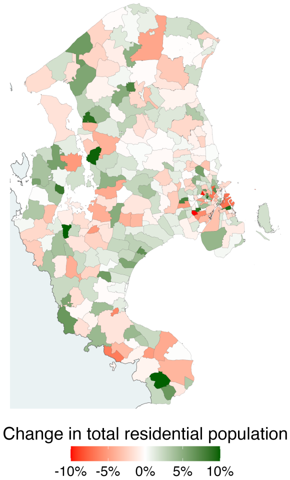


Figure: Residential population

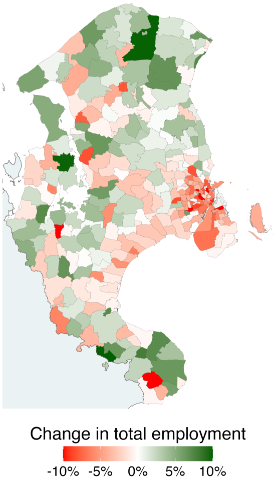


Figure: Employment

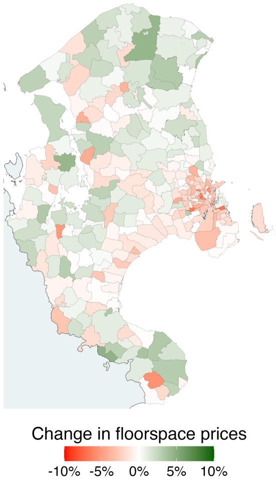
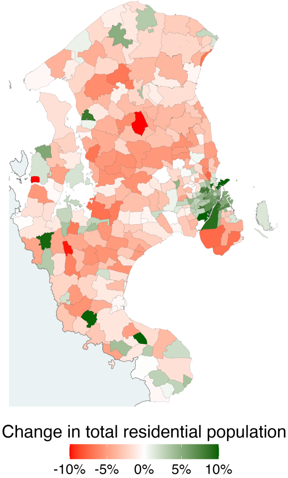


Figure: Residential prices

Lower Fertility Counterfactual: Families with Children halve



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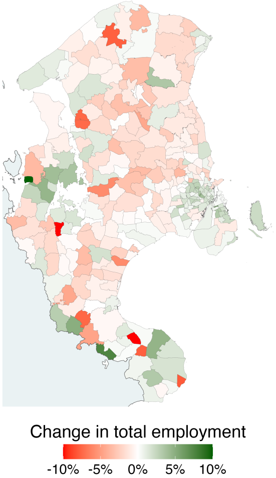


Figure: Employment

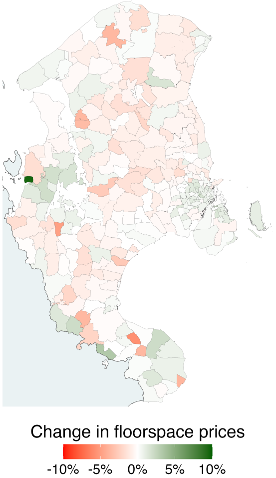


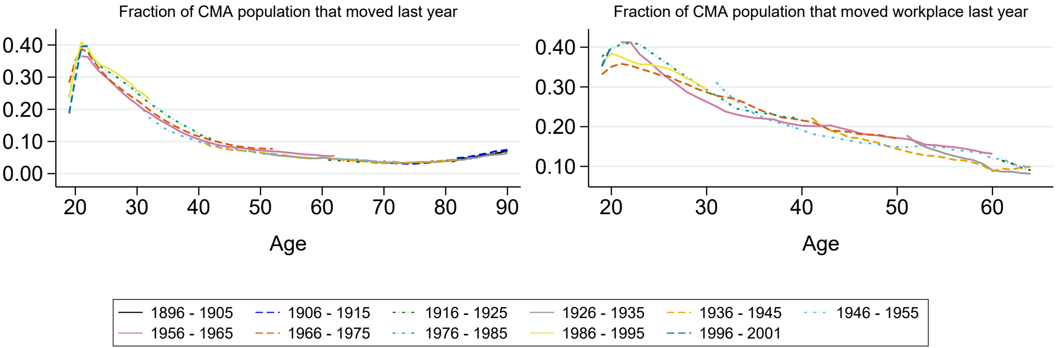
Figure: Residential prices

Conclusion

- We document several new stylized facts how location choices within cities and housing consumption are affected by age and life events.
- We examine the mechanisms behind the striking sorting through the lens of a quantitative spatial model.
- The model points to the central role of residential amenities in explaining location choices across groups.
- We finally use model counterfactuals to explore how demographic trends such as population aging and fertility changes will shape the geography of cities.
- While each of these trends on its own has substantial effects, the combination of these trends will in part neutralise each other.

Appendix

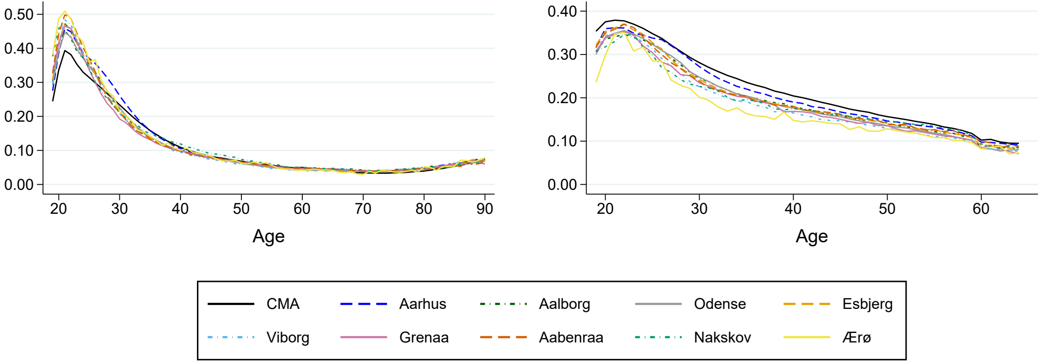
Mobility Over the Life Cycle by Cohort



▸ Mobility

Mobility Over the Life Cycle by Commuting Zone

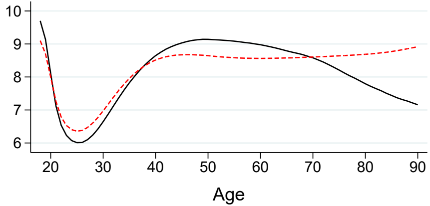
(a) Probability of moving residence by commuting zone (b) Probability of moving workplace by commuting zone



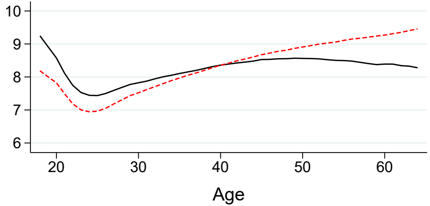
▸ Mobility

Suburbanization in the GCA

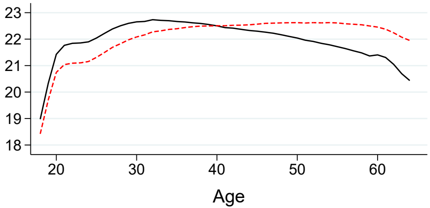
(a) Distance from residence to CBD (km)



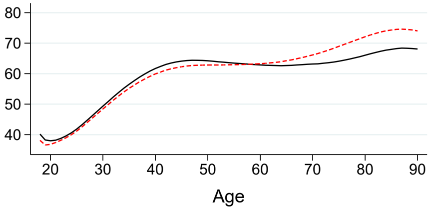
(b) Distance from workplace to CBD (km)



(c) Travel time from residence to workplace (min)

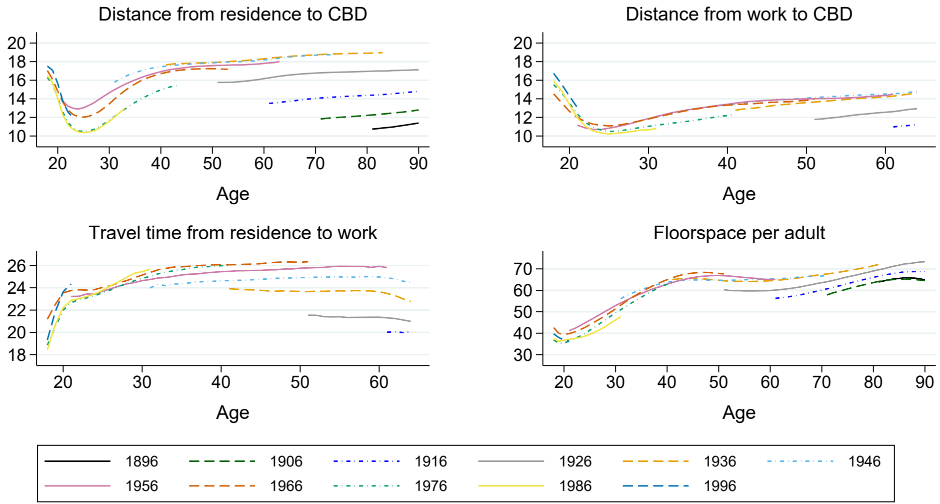


(d) Floor space per adult (m2)



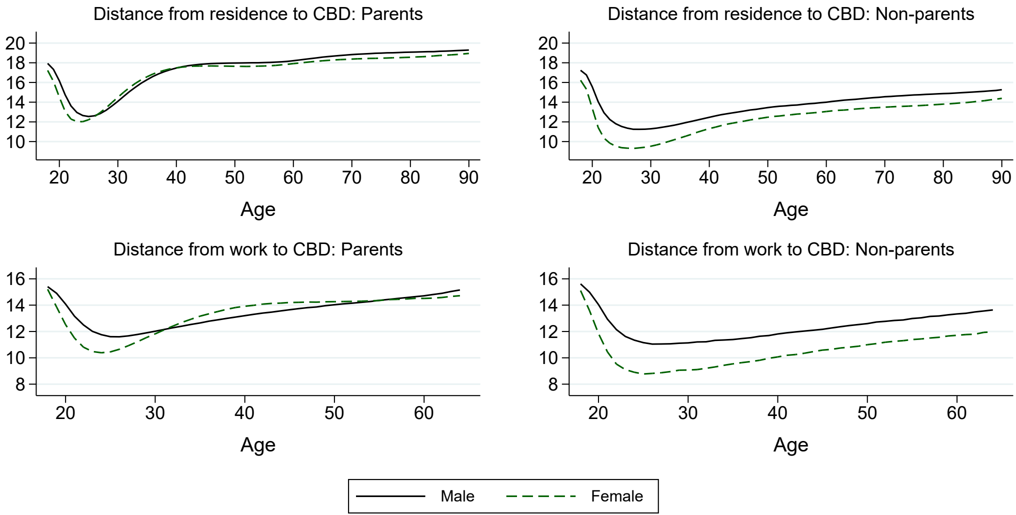
▸ Extended metro area

Life Cycle by Cohort



▸ Back

Parents Versus Non-Parents and Gender Gaps



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Early Life Events

Table: Age Distribution of Early Life Events

Event	p10	p50	p90	Treated Individuals	Share of sample (%)
First Child	23	28	35	465,880	35.20
Second Child	26	31	38	302,950	22.89
Third Child	28	34	40	74,859	5.66
First Cohabitation	20	25	33	700,479	52.93
Second Cohabitation	24	30	41	271,156	20.49
Third Cohabitation	28	34	47	83,531	6.31
First Separation	22	27	40	386,092	29.17
Second Separation	26	33	46	131,732	9.95

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Late Life Events

Table: Age Distribution of Late Life Events

Event	p10	p50	p90	Treated Individuals	Share of sample (%)
Empty Nesting	45	52	60	481,211	20.10
Pension	47	62	67	499,055	20.84
First Widowhood	56	65	79	103,446	4.32

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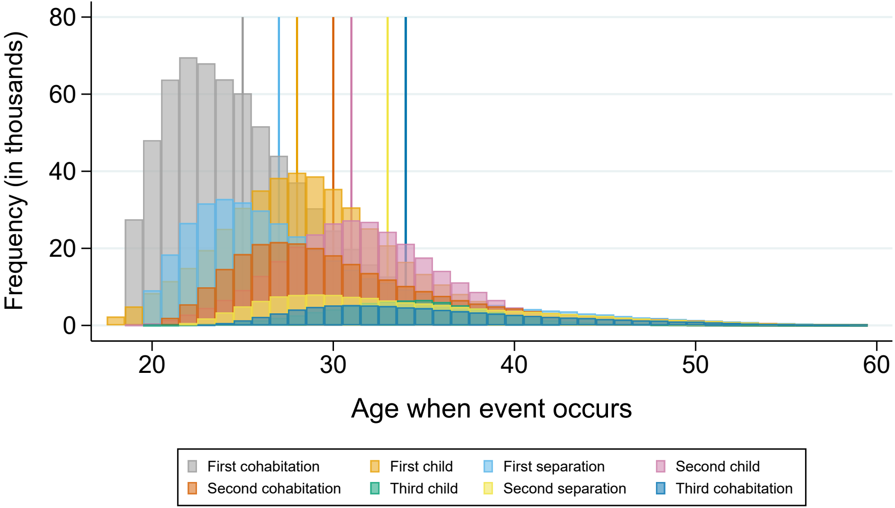
Frequency of Early Life Events by Age



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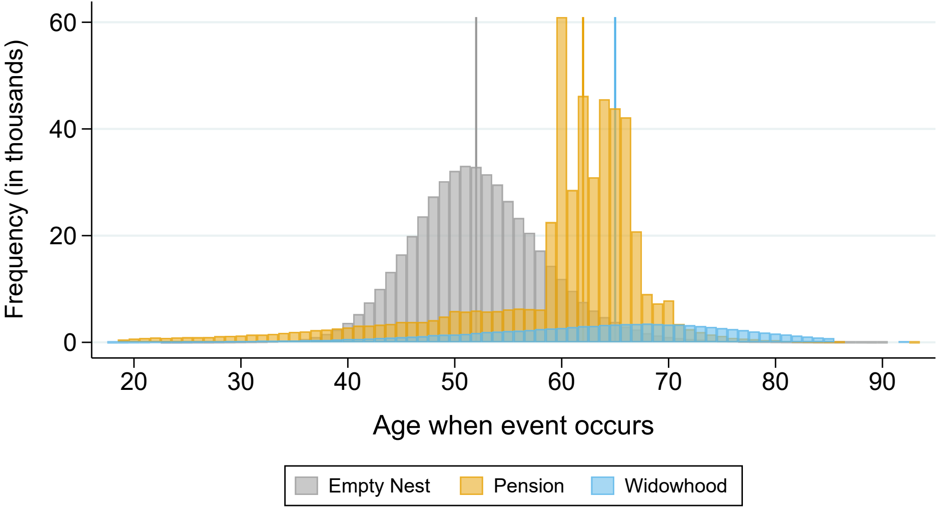
Frequency of Late Life Events by Age



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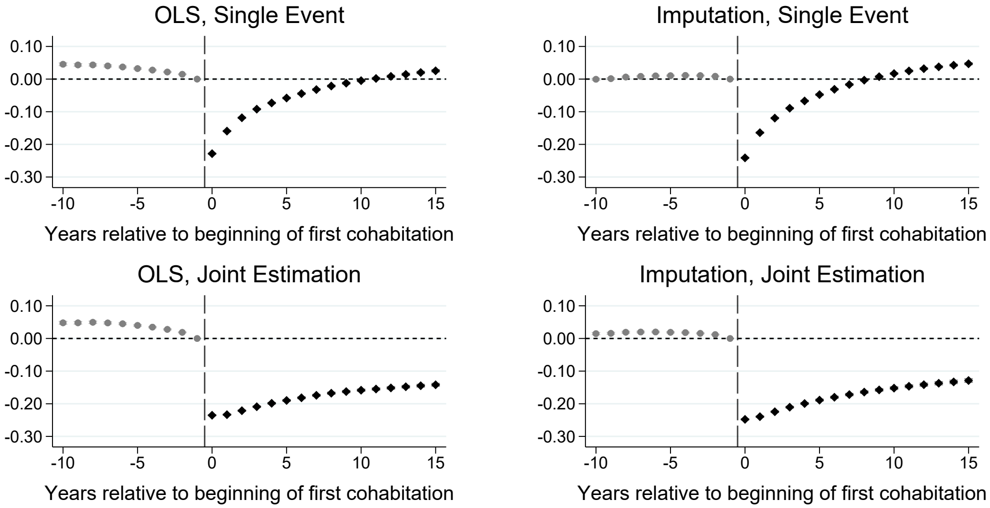
Impact on Floor Space per Adult: Imputation versus OLS



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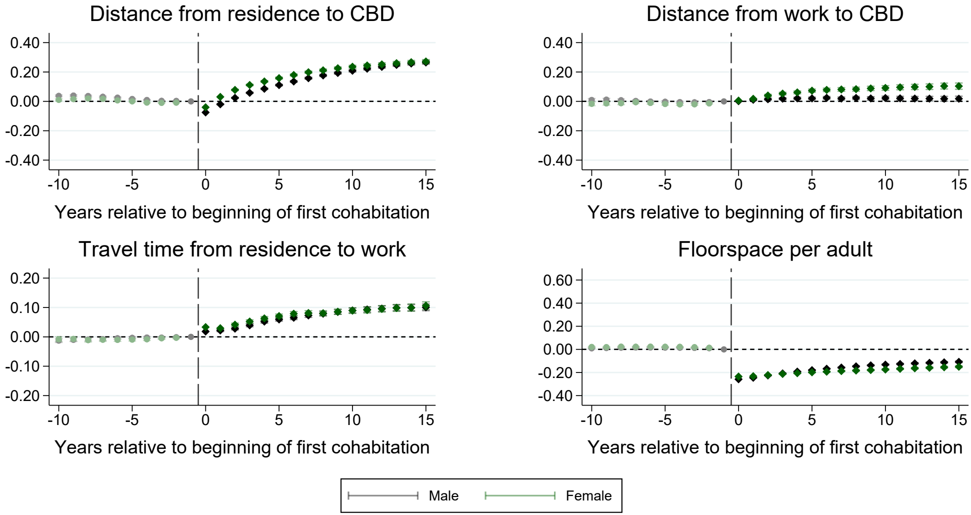
First Cohabitation by Gender



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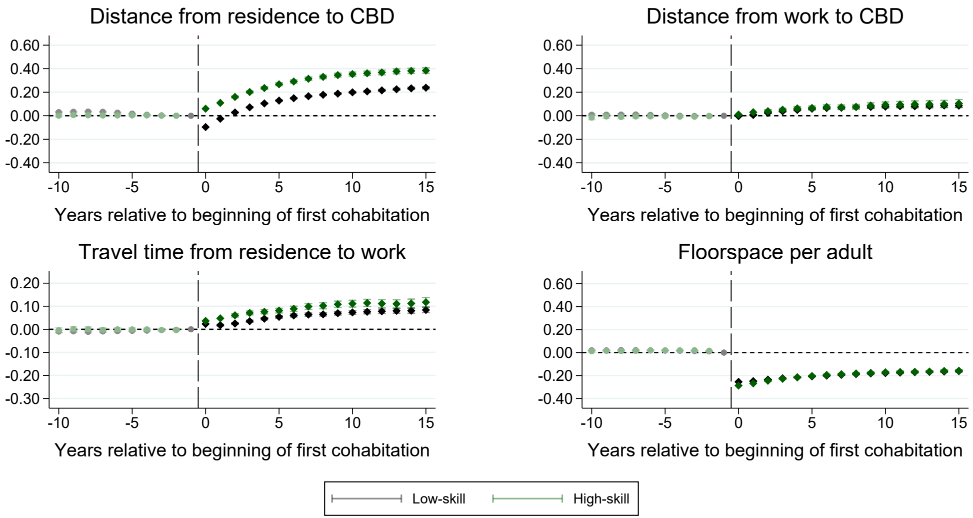
First Cohabitation by Skill



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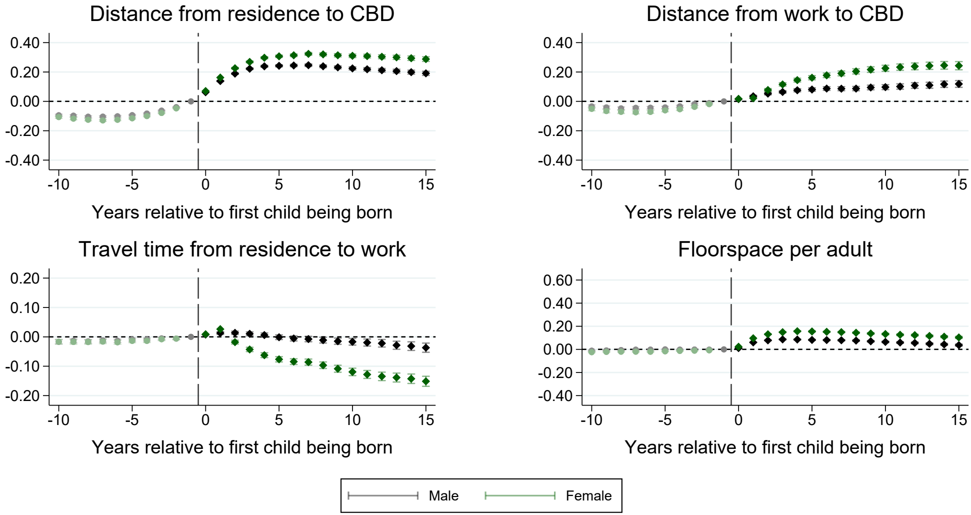
First Child by Gender



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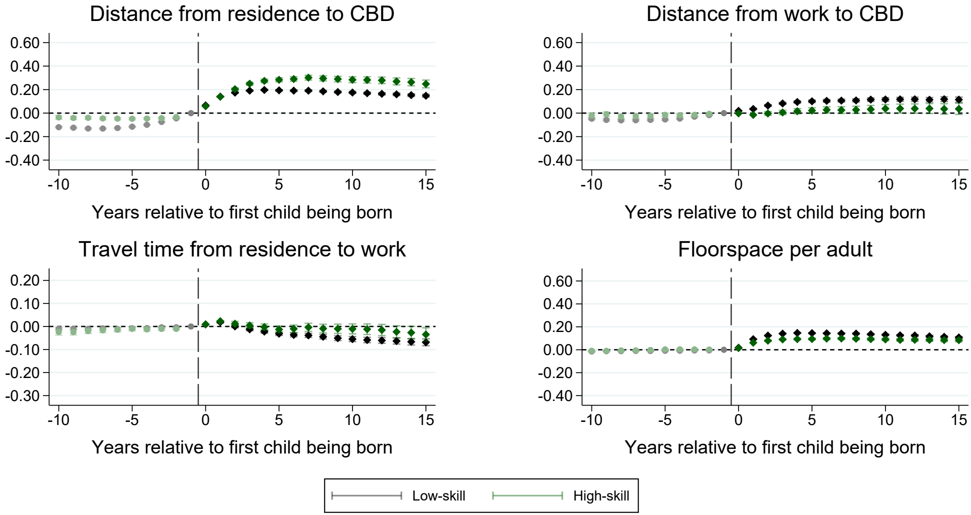
First Child by Skill



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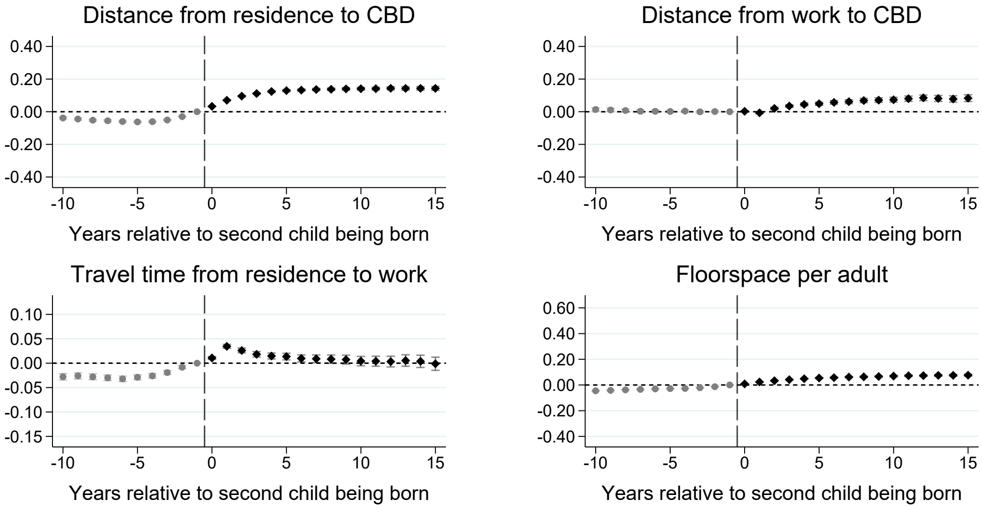
Second Child



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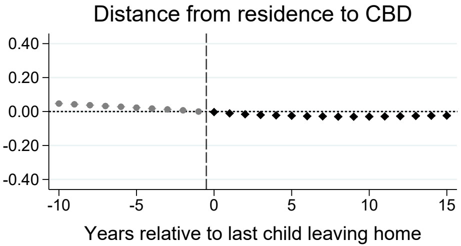
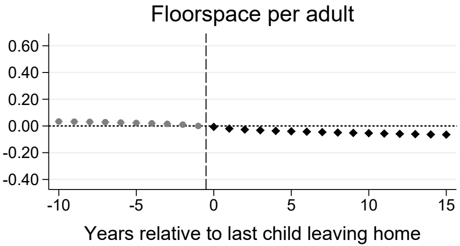
Empty Nest





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Model Groups

Table: Overview of Model Groups

	Age	Skill	Family type
Non-workers	Students	-	Single
	Pensioners	LS, HS	Single, Cohabiting
Workers	Young worker	LS, HS	Single, Cohabiting, Cohabiting with Children
	Senior worker	LS, HS	Single, Cohabiting, Cohabiting with Children

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Equilibrium equations

1. $\lambda_{Rn}^{of} = \frac{L_{Rn}^{of}}{L^{of}} = \frac{\sum_{\ell \in \mathbb{N}} \left(B_{n\ell}^{of} w_\ell^o\right)^{\varepsilon^{of}} \left(\kappa_{n\ell}^{of} (Q_n)^{1-\alpha^{of}}\right)^{-\varepsilon^{of}}}{\sum_{k \in \mathbb{N}} \sum_{\ell \in \mathbb{N}} \left(B_{k\ell}^{of} w_\ell^o\right)^{\varepsilon^{of}} \left(\kappa_{k\ell}^{of} (Q_k)^{1-\alpha^{of}}\right)^{-\varepsilon^{of}}}$

2. $\lambda_{Fi}^{of} = \frac{L_{Fi}^{of}}{\bar{L}^{of}} = \frac{\sum_{n \in \mathbb{N}} \left(B_{ni}^{of} w_i^o\right)^{\varepsilon^{of}} \left(\kappa_{ni}^{of} (Q_n)^{1-\alpha^{of}}\right)^{-\varepsilon^{of}}}{\sum_{k \in \mathbb{N}} \sum \ell \in \mathbb{N} \left(B_{k\ell}^{of} w_\ell^o\right)^{\varepsilon^{of}} \left(\kappa_{k\ell}^{of} (Q_k)^{1-\alpha^{of}}\right)^{-\varepsilon^{of}}}$

3. $\lambda_n^r = \frac{L_{Ri}^r}{L^r} = \frac{(B_n^r \bar{w}^r)^{\varepsilon^r} \left((Q_n)^{1-\alpha^r}\right)^{-\varepsilon^r}}{\sum_{k \in \mathbb{N}} \left(B_k^r \bar{w}^r\right)^{\varepsilon^r} \left(Q_k^{1-\alpha^r}\right)^{-\varepsilon^r}}$

4. $A_i \prod_{o \in \mathbb{O}} \left(\frac{1}{w_i^o}\right)^{\beta_i^o} \left(\frac{1}{q_i}\right)^{\beta^H} = 1$

Equilibrium equations (cont.)

5. $H_{Ri} = \sum_{o \in \mathbb{O}} \sum_{f \in \mathbb{F}} (1 - \alpha^{of}) \frac{v_i^{of} L_{Ri}^{of}}{Q_i} + \sum_{r \in \mathbb{R}} (1 - \alpha^{r}) \frac{\bar{w}^r L_{Ri}^{r}}{Q_i}$
6. $H_{Fi} = \beta_H \left(\frac{A_i}{q_i} \right)^{\frac{1}{1-\beta_H}} \prod_{o \in \mathbb{O}} \left(\frac{L_{Fi}^{o}}{\beta_i^{o}} \right)^{\frac{\beta_i^o}{1-\beta_H}}$

▸ Equilibrium

Housing Expenditure Shares

Table: Estimated Housing Expenditure Shares by Group (α_g)

Group	α_g	Quantity (index)	Price (index)	Net Income (index)
Population	30.0 %	100.0	100.0	100.0
Student	39.4 %	79.7	113.9	64.2
Young, single, low-skill	34.8 %	91.9	100.2	73.9
Young, single, high-skill	33.1 %	102.9	124.6	108.3
Young, cohabiting, low-skill	27.3 %	82.9	94.0	83.6
Young, cohabiting, high-skill	26.3 %	91.6	118.2	120.0
Young, cohabiting with children, low-skill	25.7 %	95.4	84.9	93.4
Young, cohabiting with children, high-skill	25.8 %	108.6	107.2	137.4
Senior, single, low-skill	33.1 %	101.2	100.2	84.5
Senior, single, high-skill	32.8 %	120.9	117.0	129.7
Senior, cohabiting, low-skill	24.8 %	86.6	94.0	101.3
Senior, cohabiting, high-skill	23.7 %	101.3	110.7	149.6
Senior, cohabiting with children, low-skill	24.9 %	93.8	87.8	103.2
Senior, cohabiting with children, high-skill	24.0 %	113.8	108.0	174.3
Pensioner, single, low-skill	35.9 %	118.4	98.3	92.1
Pensioner, single, high-skill	32.4 %	135.4	113.6	147.8
Pensioner, cohabiting, low-skill	31.7 %	89.1	88.8	81.0
Pensioner, cohabiting, high-skill	26.3 %	109.5	107.2	154.3

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Gravity Equations Estimates

Table: Estimated Model Parameters by Group

Group	Zero Flows	PPML	PPML IV	ε	ϕ
Young, single, low-skill	75.03%	−0.080	−0.127	5.594	−0.023
Young, single, high-skill	83.38%	−0.056	−0.097	6.043	−0.016
Young, cohabiting, low-skill	84.49%	−0.064	−0.104	5.817	−0.018
Young, cohabiting, high-skill	86.82%	−0.043	−0.079	7.862	−0.010
Young, cohabiting with children, low-skill	73.80%	−0.077	−0.122	9.749	−0.013
Young, cohabiting with children, high-skill	72.47%	−0.060	−0.103	8.042	−0.013
Senior, single, low-skill	80.99%	−0.081	−0.130	5.308	−0.024
Senior, single, high-skill	84.77%	−0.064	−0.106	6.000	−0.018
Senior, cohabiting, low-skill	74.21%	−0.079	−0.127	5.431	−0.023
Senior, cohabiting, high-skill	79.47%	−0.066	−0.109	5.455	−0.020
Senior, cohabiting with children, low-skill	83.27%	−0.076	−0.121	7.571	−0.016
Senior, cohabiting with children, high-skill	83.18%	−0.062	−0.101	5.853	−0.017

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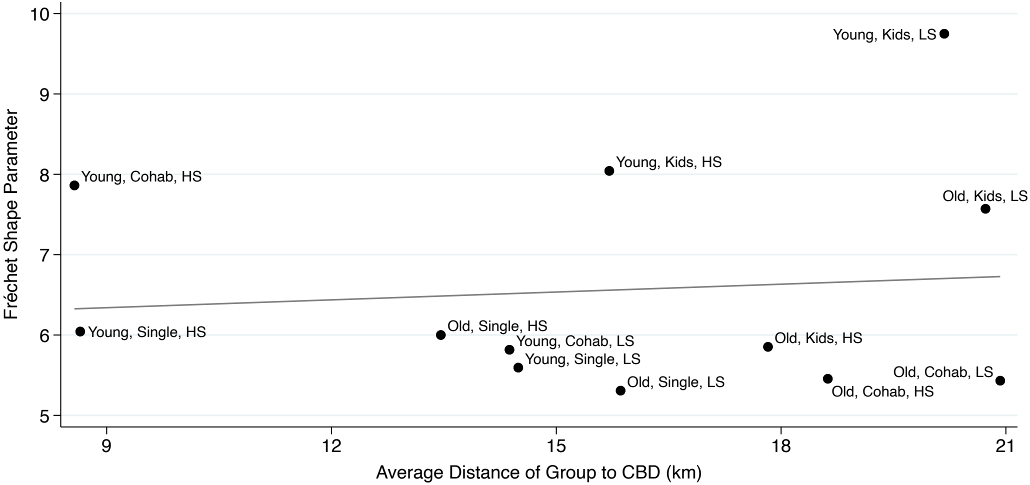
The Role of the Fréchet Shape Parameter



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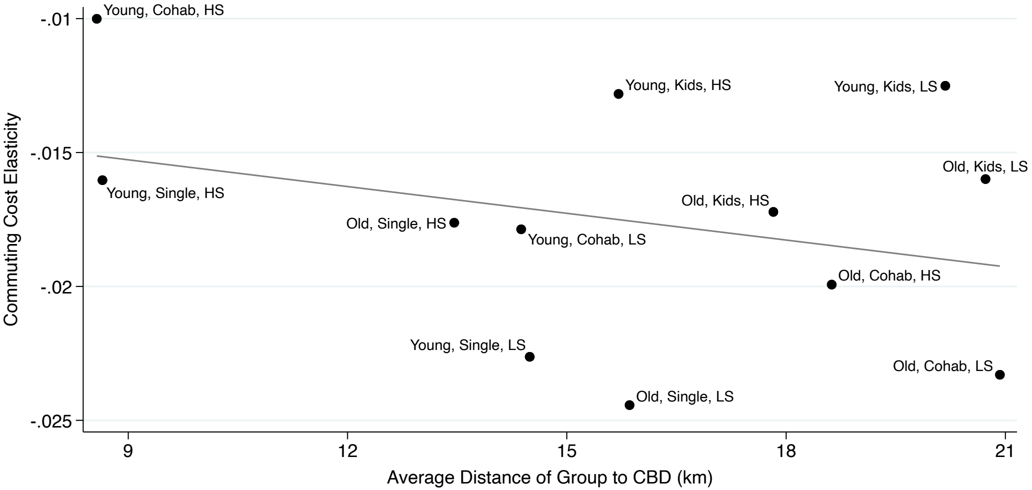
The Role of the Commuting Cost Elasticity



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