The Geography of Life: Evidence from Copenhagen

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Motivation

- We have plenty of evidence for large spatial differences in outcomes such as income, skills, the average age of residents, fertility, and marriage rates.
- Such differences exist both between cities and also across neighborhoods within urban areas, such as between downtown areas and suburbs.
- Using cross-sectional data, these differences in outcomes could be due to:
  - Heterogeneity in preferences across individuals or cohorts.
  - Location decisions changing when individuals are at different points of their lives.
- We know little about the relative importance of these two explanations.
- We know even less what mechanisms cause this sorting, such as why many young people live downtown and families in suburbs.

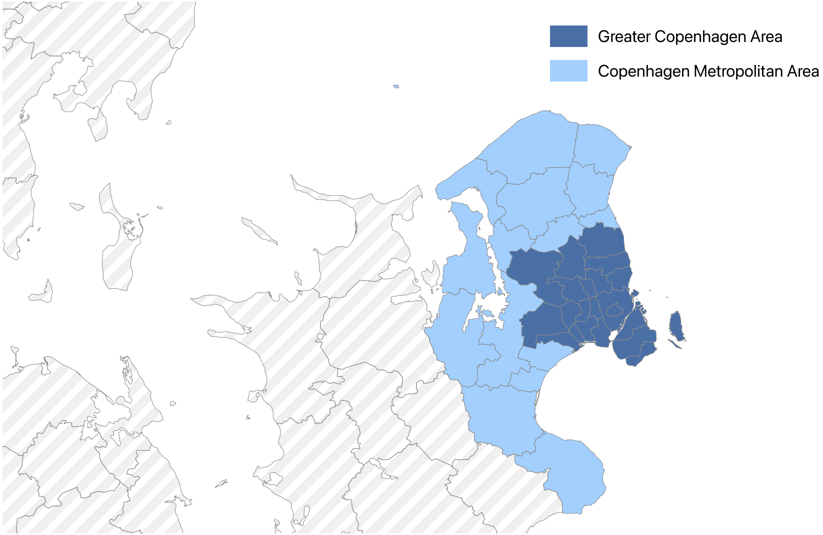
This Paper

- We use new employer-employee-property-family panel data for Copenhagen from 1986 to 2019 to look at the mechanisms behind spatial sorting.
- We first show that residential and workplace choices follow a u-shaped pattern in age with respect to distance to center.
- This pattern is robust to including person fixed effects, suggeting that people make different choices at different ages.
- Using event study estimates we show that part of this pattern can be accounted for by life events such as children and marriage.
- Using a quantitative spatial model we show that residential amenities are central in explaining location choices across different population groups.
- Finally, we use the estimated model to explore the effects of demographic change, such as aging and lower fertility, on the future of cities.

Related Literature

- **Sorting and Gentrification:** Couture and Handbury (2020), Baum-Snow and Hartley (2020), Su (2022), Couture et al. (2023), Almagro and Domínguez-Iino (2025), Diamond and Gaubert (2022).
- **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)
- **Effect of age on wages, income and savings:** Modigliani (1966), Mincer (1974), Meghir and Pistaferri (2011)
- **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)

Copenhagen Metro Area (CMA)



Data

- Individual yearly panel data, matched with property, employer and family status from 1986 to 2019 for all residents in Denmark.
  - Residence and workplace (if working) location in 100 x 100 m grid cells.
  - Wage and non-wage income, education level, employment sector.
  - Family status, with number and age of children, and marital status.
  - Residence property size and type, with estimates of square meter price.
- Computed travel times across Copenhagen by several transport modes.
- Our main sample: adults residing in the Copenhagen Metropolitan Area.

Stylized Facts

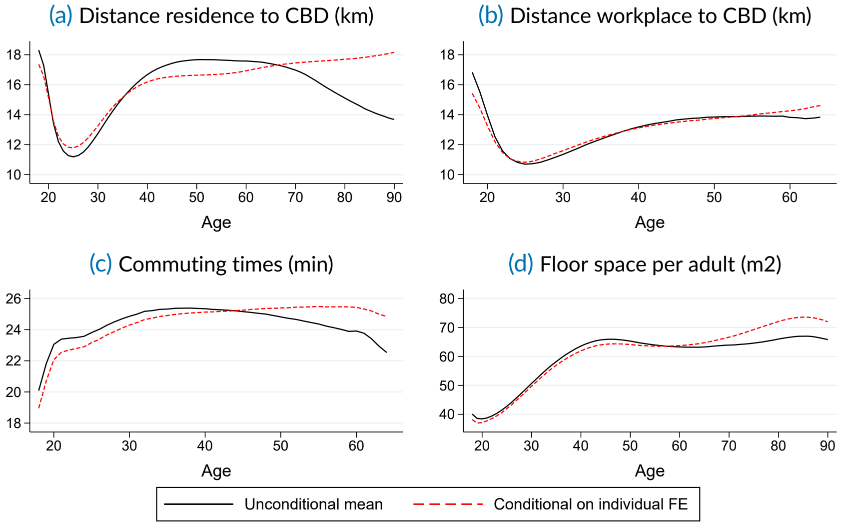
Mobility Over the Life Cycle

(a) Probability of moving residence or workplace

(b) Conditional probability of moving within CMA

▸ Different Cohorts
▸ Commuting Zones Outside Copenhagen

The Life Cycle in the City



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

Event-Study Estimates of Life Events

- An obvious question is whether observable life events can account for some of the pronounced life cycle in location choices.

- To explore this we estimate event-study regressions for 11 life events:

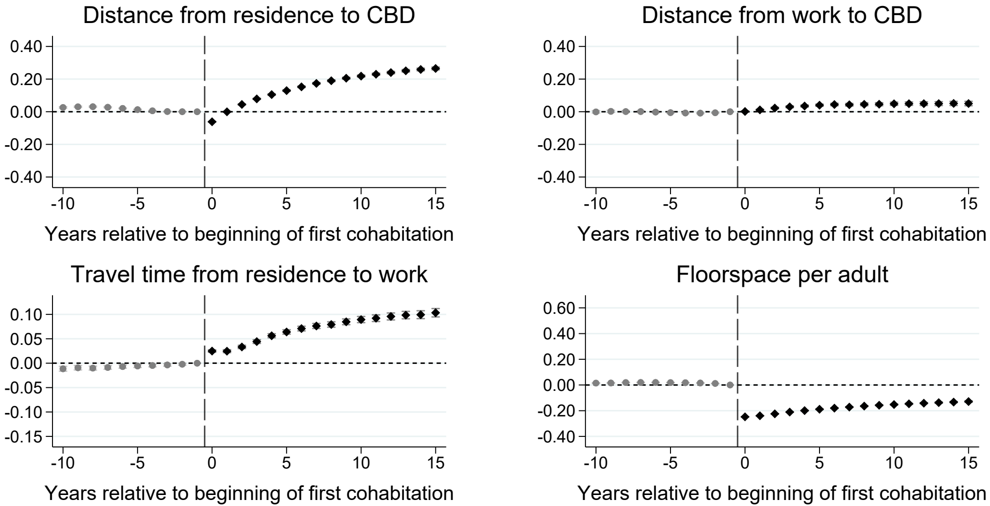
$$\ln\left(y_{it}\right) = \hat{\theta}_i + \hat{\eta}_a + \sum_{e \in \mathbb{E}} \sum_{\substack{h=-m \\ h \neq -1}}^{n} \beta_h^e \mathbb{1}[K_{it}^e = h] + \varepsilon_{i,t}$$

  where $\hat{\theta}_i$ and $\hat{\eta}_a$ are imputed individual and age fixed effects (Borusyak et al. 2024) and β_h^e is the treatment effect of event e at event time h.

- We jointly estimate the effect of early and late life events. ▸ Early Events ▸ Late Events

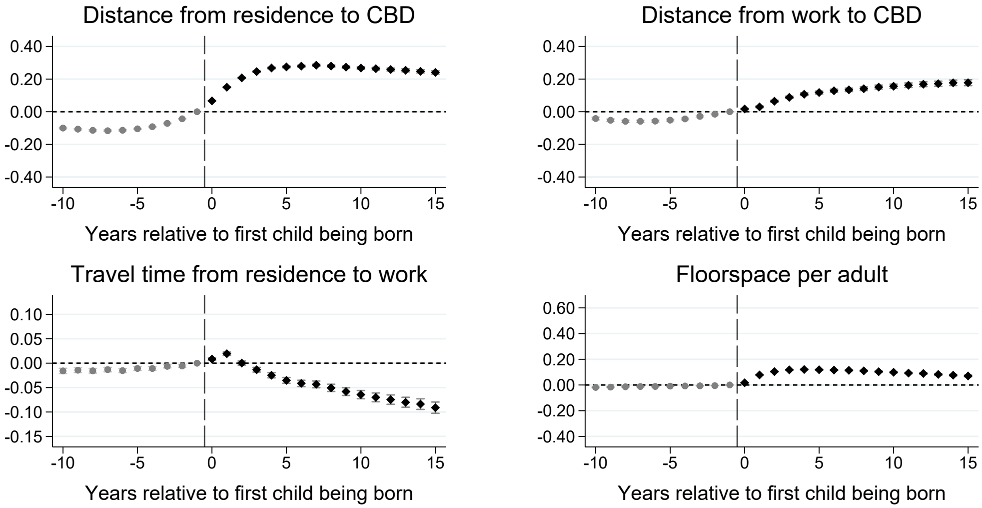
- The timing and sequence of life events varies substantially. ▸ Distribution Early Events ▸ Distribution Late Events

First Cohabitation



▸ By Gender ▸ OLS Robustness

First Child



▸ By Gender ▸ Second Child ▸ First Separation ▸ Widowhood ▸ Pension ▸ Empty Nest ▸ Decomposition

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 two main ways:
  - Several different worker types: young/old and low/high skilled.
  - Workers can have different family types (single/couple and children), which affect commuting costs, housing expenditure and preferences over amenities.
- The worker and family types are chosen to reflect the rich heterogeneity in behavior that we see in the reduced form evidence.
- We use the model for two purposes:
  - To shed light on the mechanisms that drive the strikingly different location choices at different ages.
  - To examine the effect of demographic changes, such population aging or lower birth rates, on the geography of cities.

Preferences and Production

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

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

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

$$Y_i = A_i \prod_{o \in \mathbb{O}} \left(\frac{L_{Fi}^o}{\beta_i^o}\right)^{\beta_i^o} \left(\frac{H_{Fi}}{\beta^H}\right)^{\beta^H}, \quad 0 < \beta_i^o, \beta^H < 1, \quad \sum_{o \in \mathbb{O}} \beta_i^o + \beta^H = 1, \tag{2}$$

▸ Sorting ▸ Equilibrium ▸ Parameter Estimation

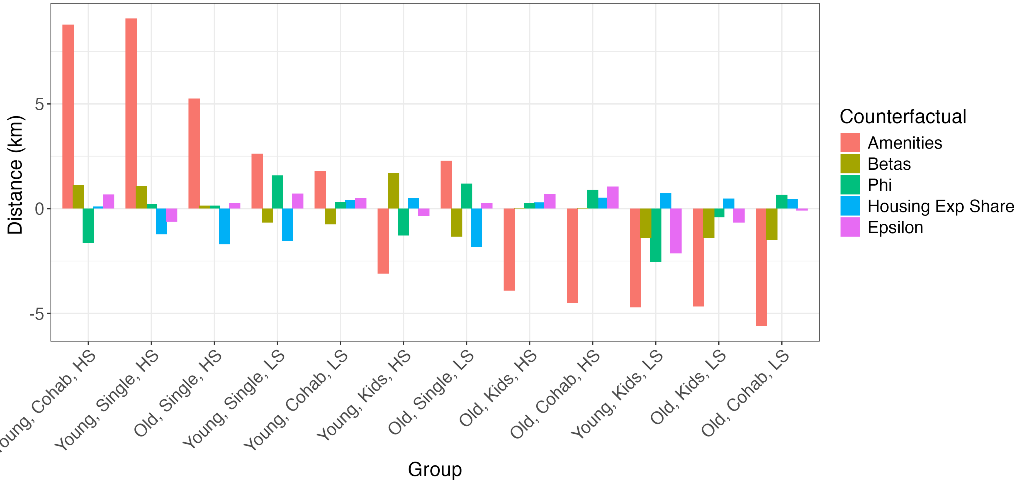
Quantification of Mechanisms

What Explains Sorting in the Model?

- In the model, some of the mechanisms that could explain residential sorting:
  - Groups with higher housing expenditure shares should (all else equal) prefer locations with lower house prices.
  - Groups with higher commuting costs should favor central locations with better commuter market access.
  - Different groups attach different amenity values to a location.
- We examine the importance of each of these mechanisms (and others) through model counterfactuals that eliminate each mechanism.

▸ Housing Exp Share ▸ Gravity Coefficient ▸ Residential Amenities

Full Model Counterfactuals: Mechanisms Behind Sorting



Model amenities and real-world amenities

Table: Relative Amenity Preferences by Groups

Interaction effects	Senior	Couples	Parents	High-skill
Consumption amenity index	-0.0213^{***}	-0.0293^{***}	-0.0133^{***}	0.0183^{***}
	(0.0014)	(0.0017)	(0.0017)	(0.0014)
Natural amenity index	0.0332^{***}	0.0124^{***}	0.0100^{***}	-0.0099^{***}
	(0.0026)	(0.0031)	(0.0031)	(0.0026)
School quality index	0.0018^{**}	0.0013	0.0023^{**}	0.0009
	(0.0008)	(0.0010)	(0.0010)	(0.0008)
Observations	3,421			
Group FE	Yes			
Parish FE	Yes			
R-squared	0.7658			

▸ Relative Amenities

Demographic Change in Cities

The Effect of Demographic Change on Cities

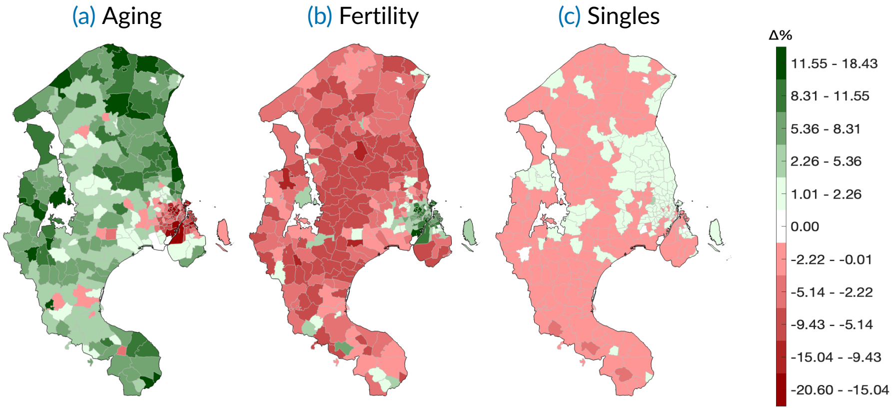
- How will demographic change reshape cities?
  - Falling fertility
  - Population aging
  - Lower marriage rates
- Tokyo experience as benchmark for model counterfactuals of demographic changes.

Table: Demographic Change in the Greater Tokyo Area

	Age		Couples		Parents	
Year	18-44	45-64	Single	Couple	Parents	Non-Parents
1980	69%	31%	32%	68%	43%	57%
2020	54%	46%	40%	60%	19%	81%

Counterfactual Changes in the Residential Population

Figure: Counterfactual Changes in the Residential Population

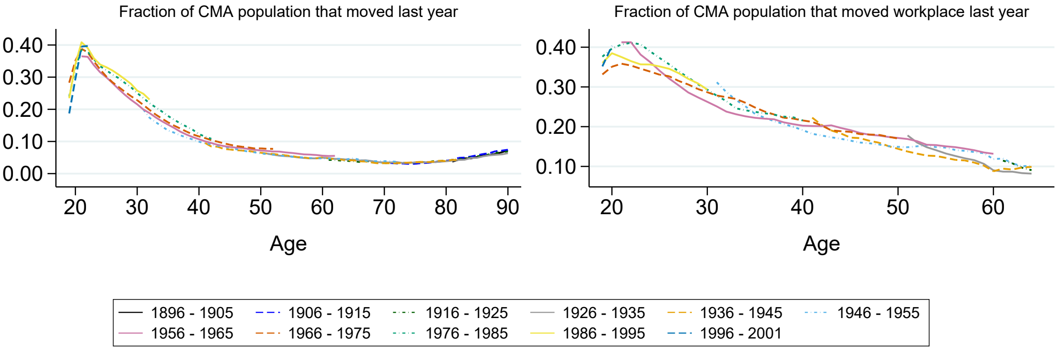


Conclusion

- 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

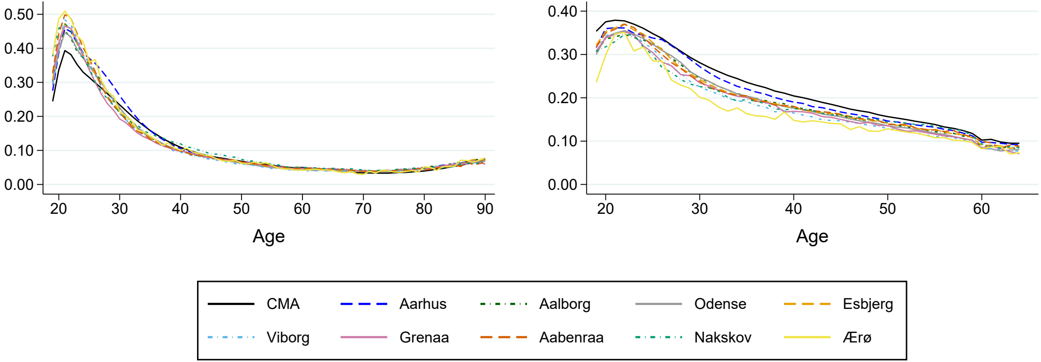


▸ Mobility

Mobility Over the Life Cycle by Commuting Zone

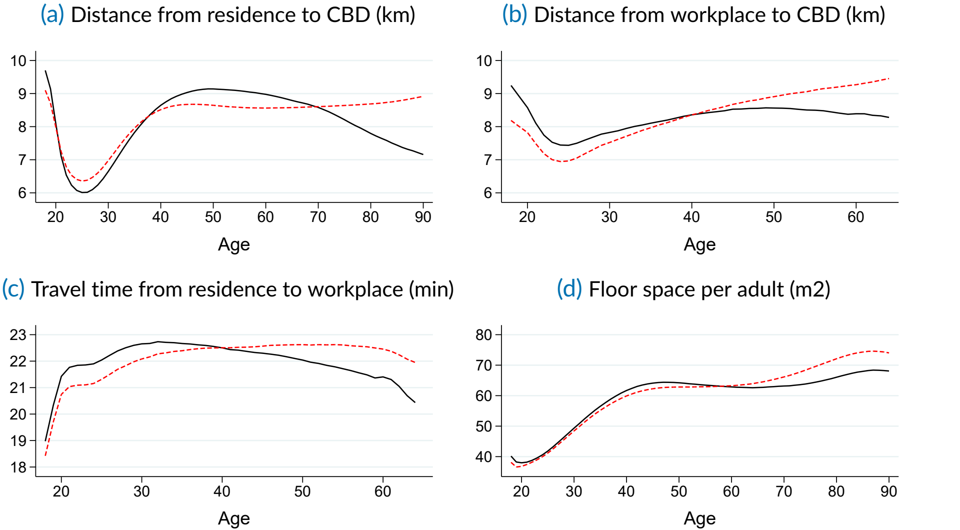
(a) Probability of moving residence by commuting zone

(b) Probability of moving workplace by commuting zone



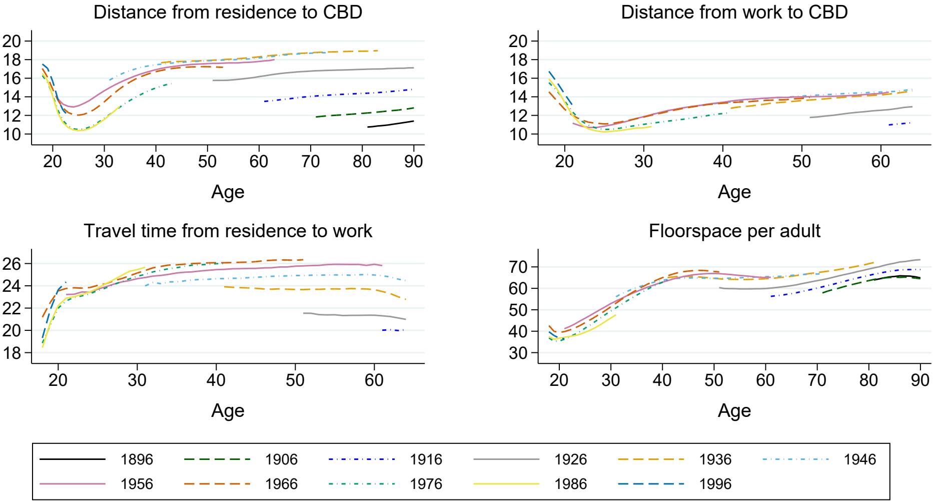
▸ Mobility

Suburbanization in the GCA



▸ Extended metro area

Life Cycle by Cohort



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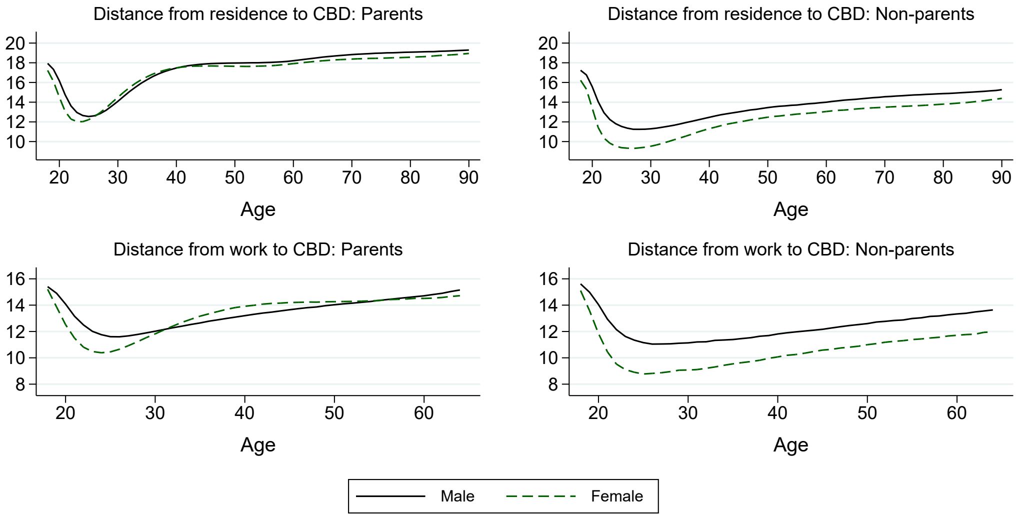
Parents Versus Non-Parents and Gender Gaps



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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	29	36	660,503	22.31
Second Child	25	31	38	517,545	17.48
Third Child	28	34	41	172,159	5.81
First Cohabitation	21	26	41	870,719	29.41
Second Cohabitation	25	32	51	498,638	16.84
Third Cohabitation	28	37	54	145,563	4.92
First Separation	22	31	55	804,221	27.16
Second Separation	26	36	54	241,615	8.16

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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	42	52	62	630,665	21.30
Pension	49	62	67	671,887	22.69
First Widowhood	52	70	84	201,439	6.80

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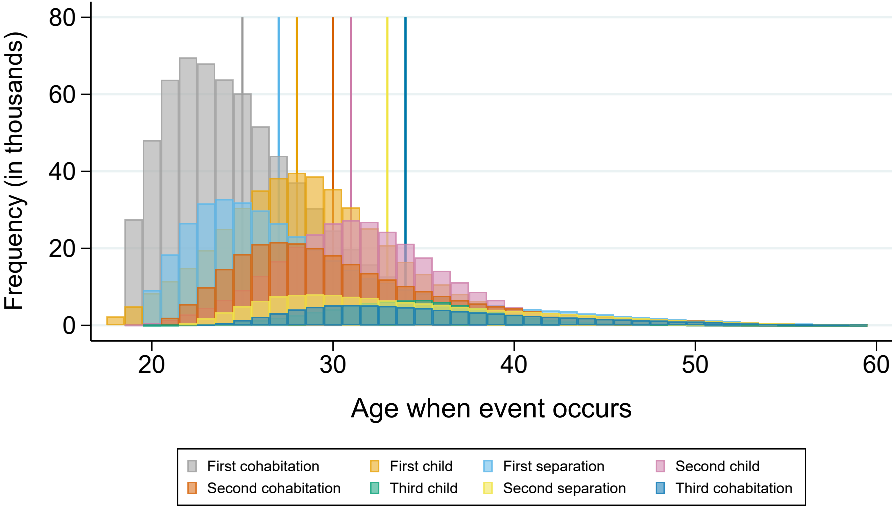
Frequency of Early Life Events by Age



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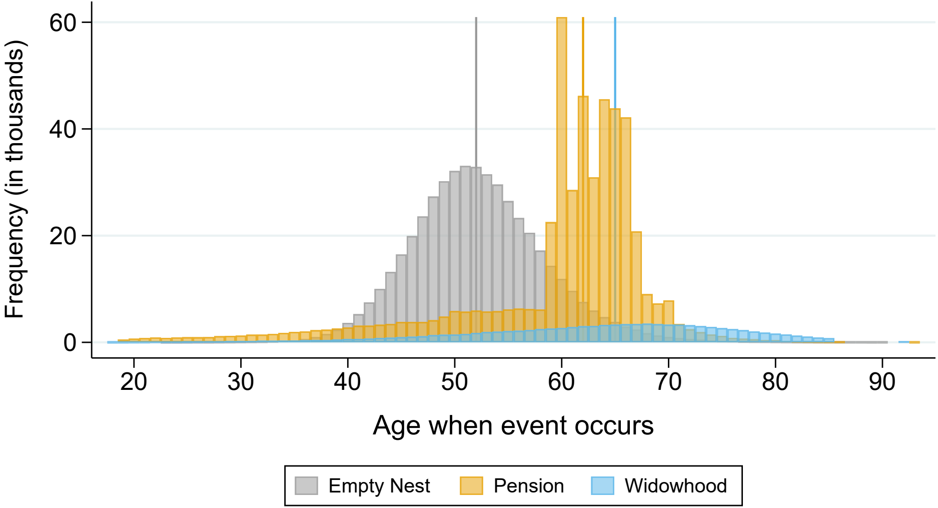
Frequency of Late Life Events by Age



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Regression Specification

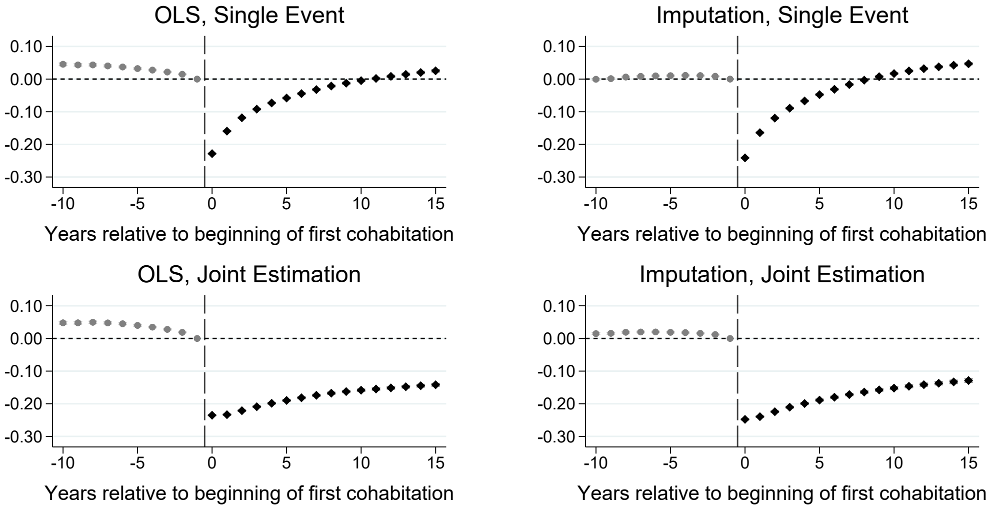
- We estimate the following event-study regressions for outcome y_{it} of person i in year t using a variant of the imputation method (Borusyak et al. 2024):

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

  - $\hat{\theta}_i$ 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

▸ Empirical Strategy

Impact on Floor Space per Adult: Imputation versus OLS



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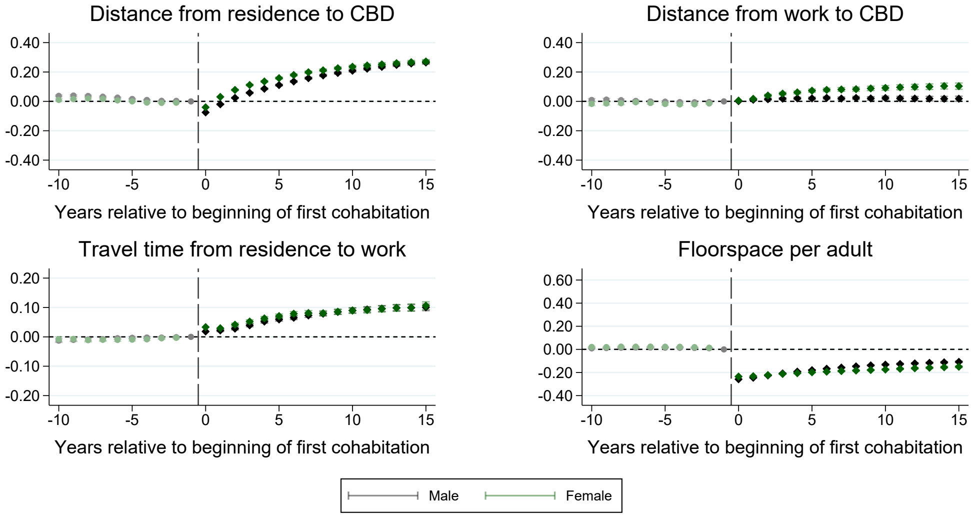
First Cohabitation by Gender



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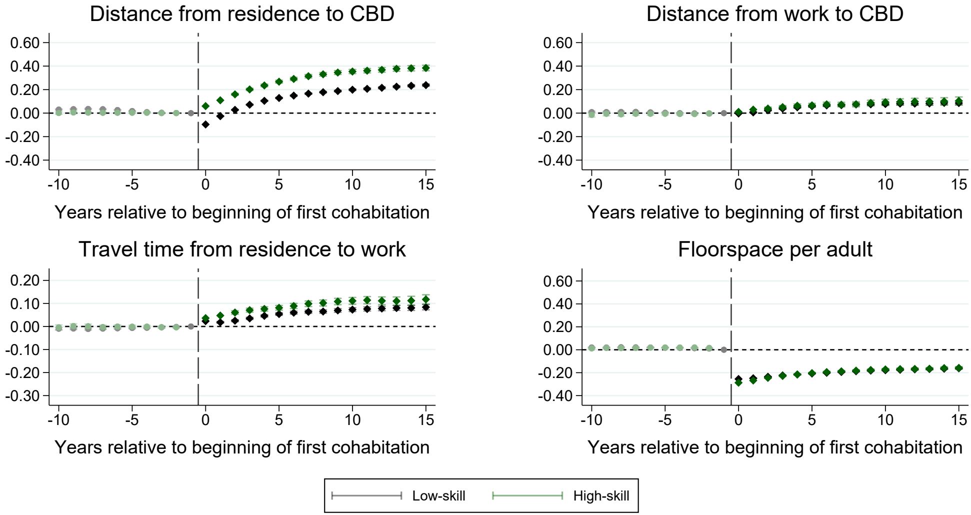
First Cohabitation by Skill



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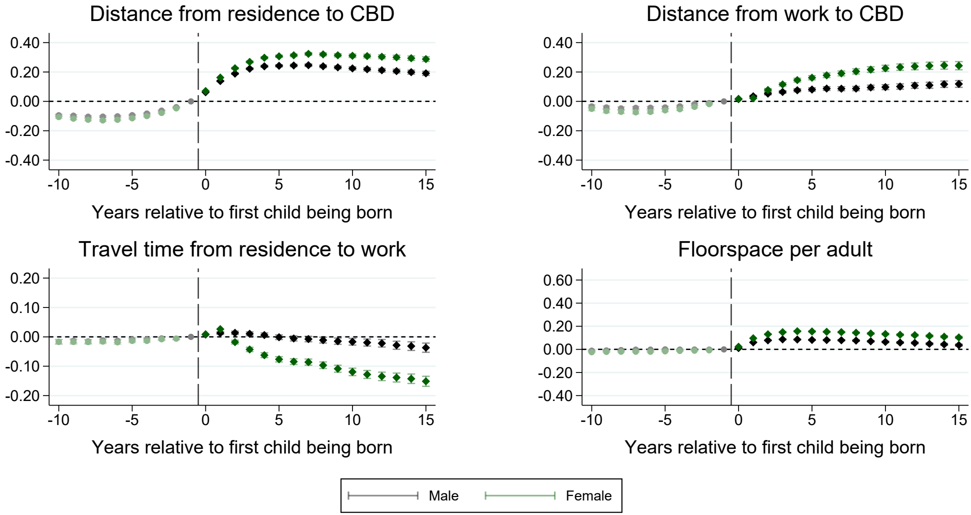
First Child by Gender



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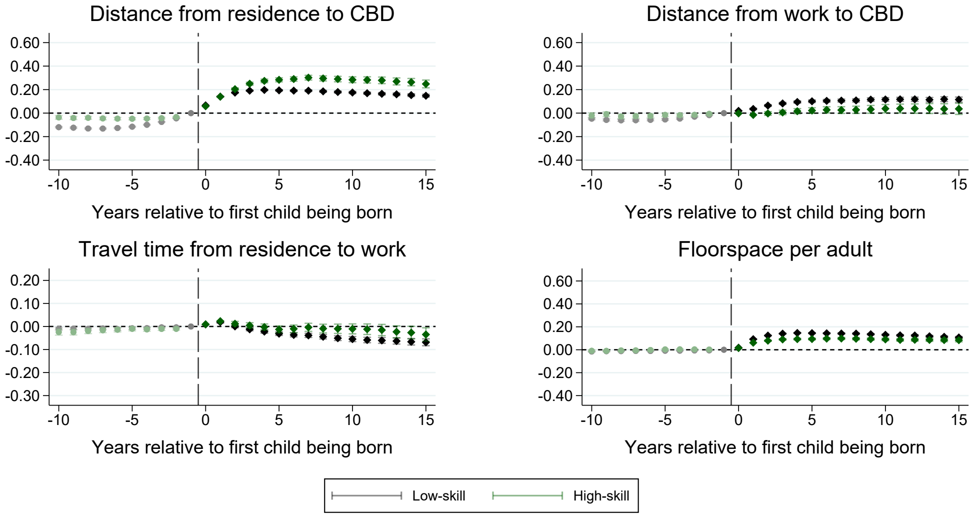
First Child by Skill



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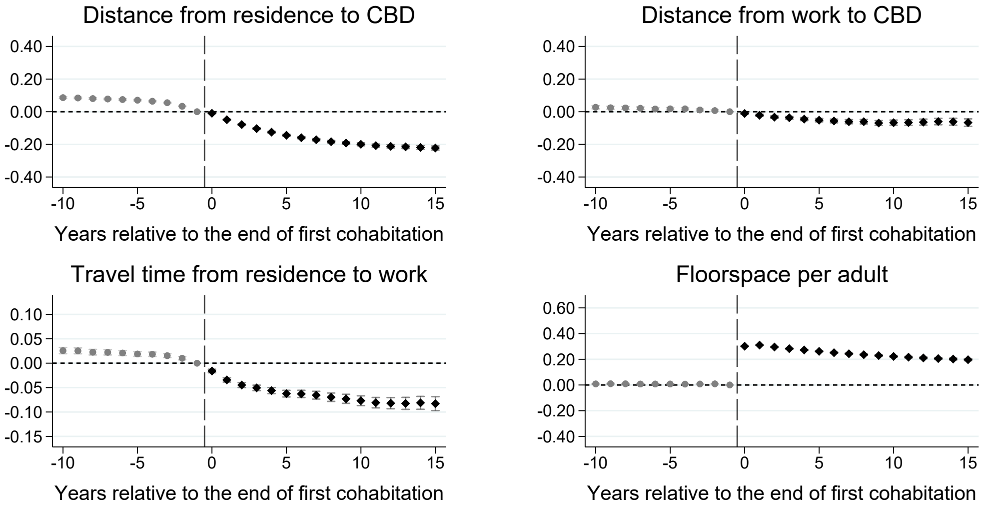
First Separation



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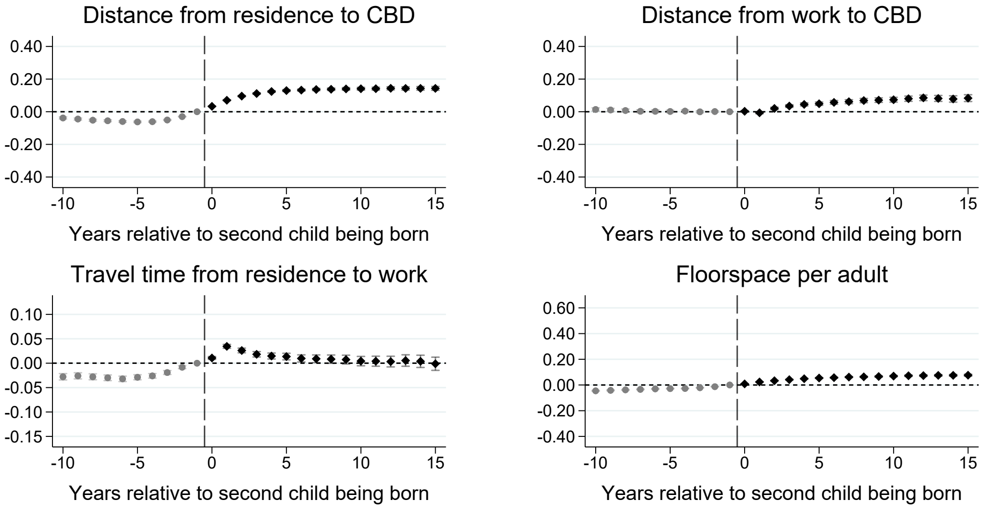
Second Child



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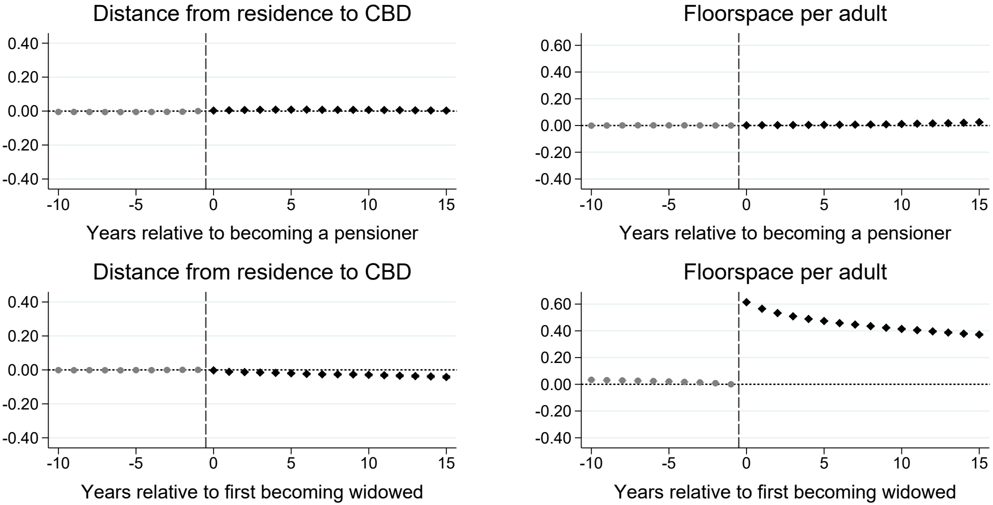
Retirement and Death of Spouse



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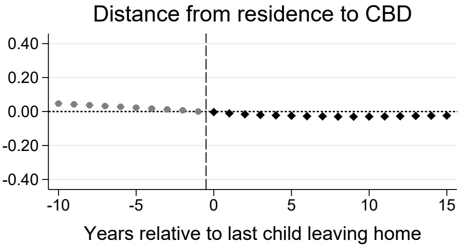
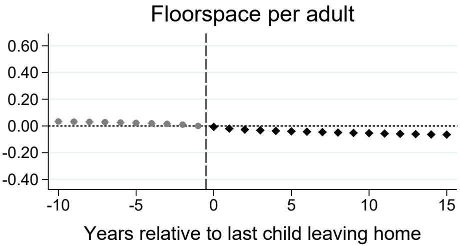
Empty Nest





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

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

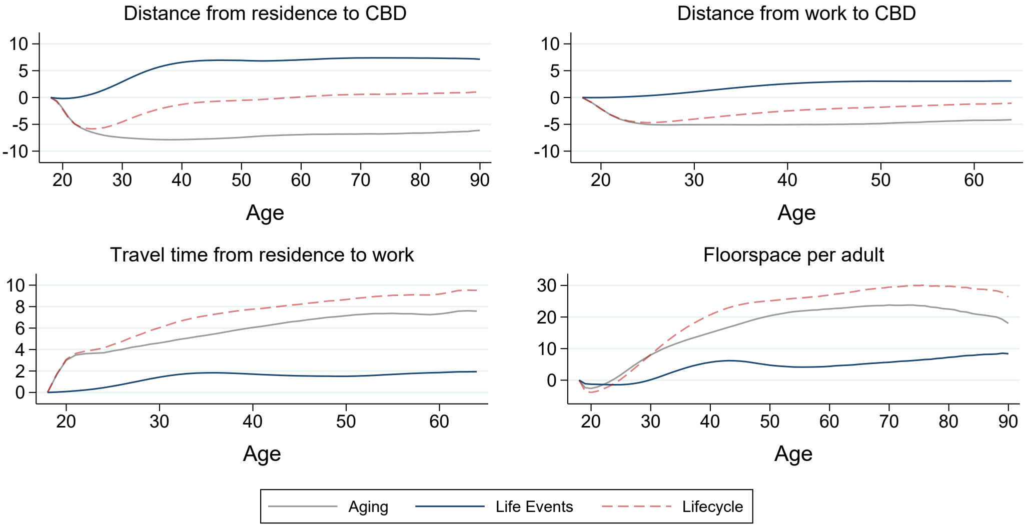
- We average the treatment effect of life events for each age bin

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

- 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 Back

Life Events versus Aging



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Residential sorting

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

$$\lambda_{Rn}^{of} = \frac{L_{Rn}^{of}}{L^{of}} = \frac{\sum_{\ell \in \mathbb{N}} \left(B_{n\ell}^{of} w_{\ell}^{o}\right)^{\varepsilon^{of}} \left(\kappa_{n\ell}^{of} \left(Q_n\right)^{1-\alpha^{of}}\right)^{-\varepsilon^{of}}}{\sum_{k \in \mathbb{N}} \sum_{\ell \in \mathbb{N}} \left(B_{k\ell}^{of} w_{\ell}^{o}\right)^{\varepsilon^{of}} \left(\kappa_{k\ell}^{of} \left(Q_k\right)^{1-\alpha^{of}}\right)^{-\varepsilon^{of}}} = \frac{\Phi_n^{of}}{\Phi^{of}} \tag{3}$$

- 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:

$$\frac{L_{Rn}^{of}}{L^{of}} = \frac{\left(\mathcal{B}_n^{of} / Q_n^{1-\alpha^{of}}\right)^{\epsilon^{of}} \sum_{\ell \in \mathbb{N}} \left(w_{\ell}^{of} / t_{n\ell}^{\phi^{of}}\right)^{\varepsilon^{of}}}{\Phi^{of}} \tag{4}$$

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

$$\lambda_n^{r} = \frac{L_{Rn}^{r}}{L^{r}} = \frac{\left(B_n^{r} / Q_n^{1-\alpha^{r}}\right)^{-\varepsilon^{r}}}{\sum_{k \in \mathbb{N}} \left(B_k^{r}\right)^{\varepsilon^{r}} \left(Q_k^{1-\alpha^{r}}\right)^{-\varepsilon^{r}}} \tag{5}$$

▸ Back

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) $\{A_i, B^{of}_{ni}, B^{r}_{n}, H_{Fi}, H_{Ri}\}$, the general equilibrium of the model is referenced by the vector of six variables $\{L^{of}_{Ri}, L^{r}_{Ri}, w^{o}_{i}, L^{of}_{Fi}, Q_i, q_i\}$
- We solve for these six variables using these equations:
  1. Residential choice probabilities for workers (λ^{of}_{Rn})
  2. Non-worker residential choice probabilities (λ^{r}_{n})
  3. Zero profit condition (w^{o}_{i})
  4. Worker workplace choice probabilities (λ^{of}_{Fi})
  5. Residential floor space market clearing (Q_i)
  6. Commercial floor space market clearing (q_i)

Full Equations Back

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

Overview Estimation of 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
- 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
  - the share of floor space in costs (β^{H}) is set to 0.15

▸ Back

Model Parameter Estimates

Table: Estimated Model Parameters by Group

Group	Housing Expenditure Share	PPML	PPML IV	ε	ϕ
Young, single, low-skill	34.7%	−0.080	−0.126	6.009	−0.021
Young, single, high-skill	35.7%	−0.056	−0.097	6.046	−0.016
Young, cohabiting, low-skill	24.4%	−0.064	−0.104	5.924	−0.018
Young, cohabiting, high-skill	25.0%	−0.043	−0.079	7.886	−0.010
Young, cohabiting with children, low-skill	24.2%	−0.077	−0.122	9.854	−0.012
Young, cohabiting with children, high-skill	23.7%	−0.060	−0.103	8.045	−0.013
Senior, single, low-skill	34.7%	−0.081	−0.129	6.674	−0.019
Senior, single, high-skill	35.4%	−0.064	−0.106	6.221	−0.017
Senior, cohabiting, low-skill	24.1%	−0.079	−0.126	7.021	−0.018
Senior, cohabiting, high-skill	23.3%	−0.066	−0.109	5.822	−0.019
Senior, cohabiting with children, low-skill	24.1%	−0.076	−0.121	7.683	−0.016
Senior, cohabiting with children, high-skill	24.4%	−0.062	−0.101	5.873	−0.017

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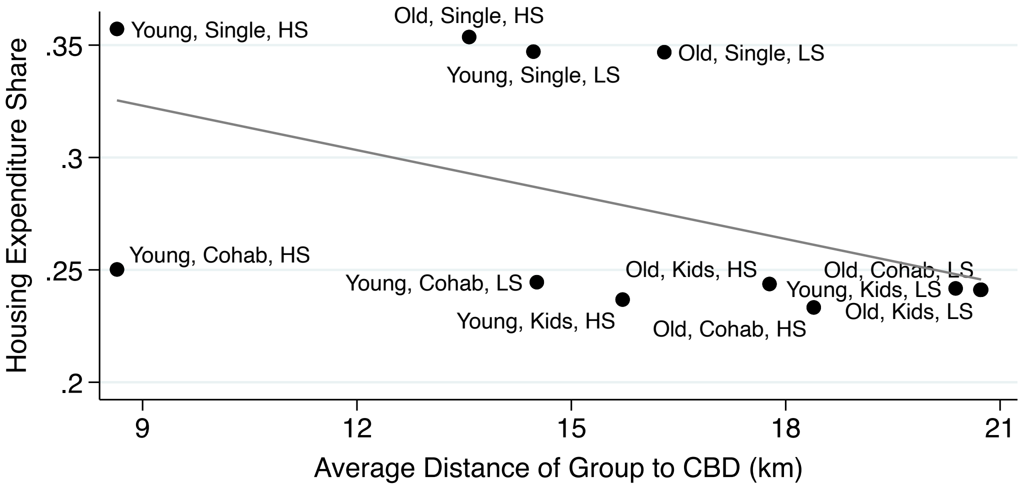
Role of Housing Expenditure Shares



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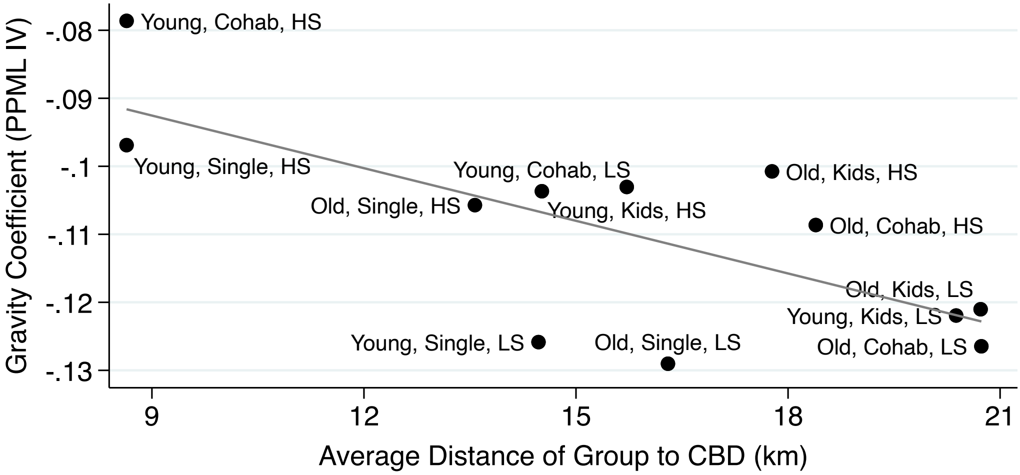
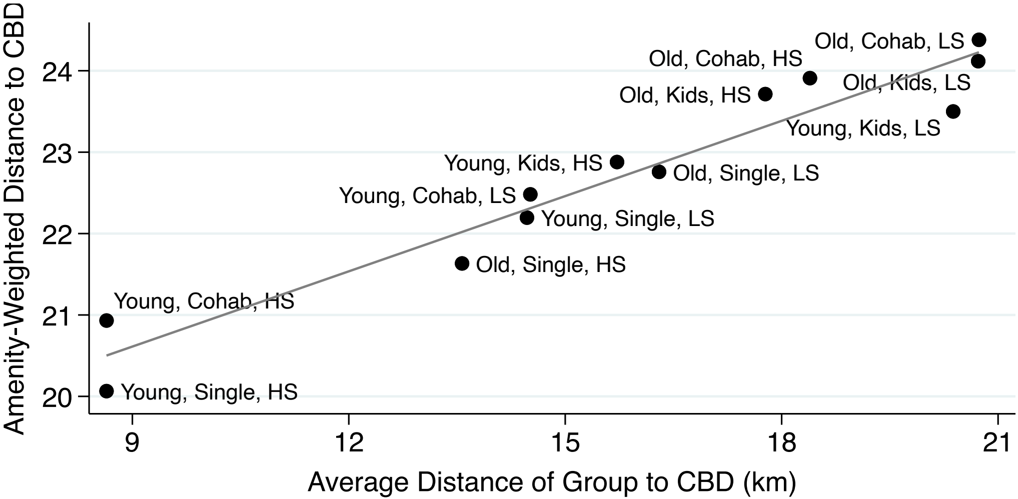
Role of Commuting Costs



Full Gravity Estimates   Back

Role of Amenity Differences



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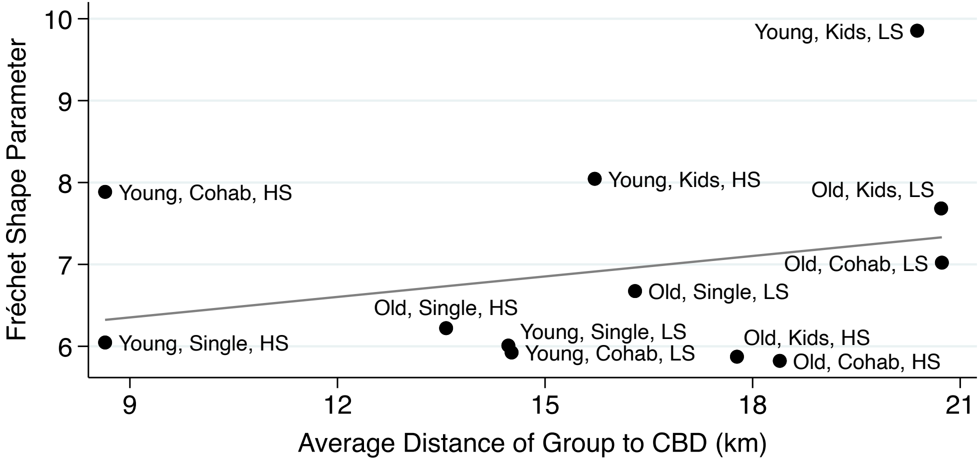
The Role of the Fréchet Shape Parameter



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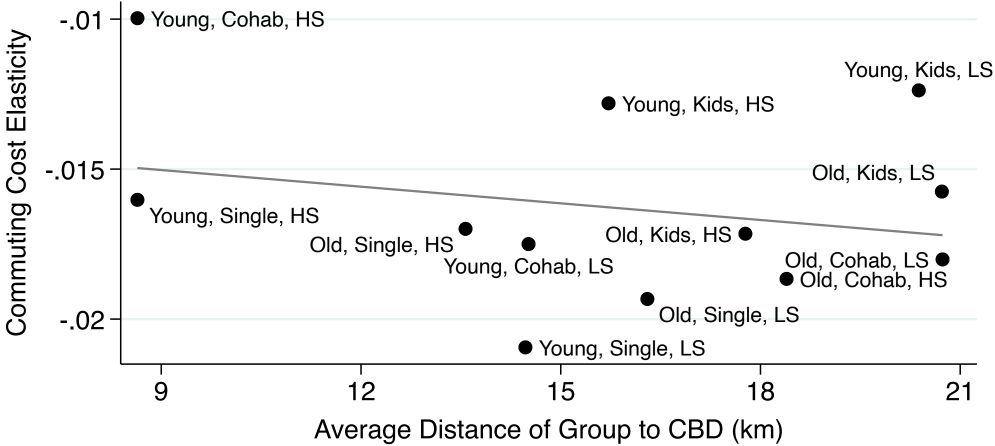
The Role of the Commuting Cost Elasticity



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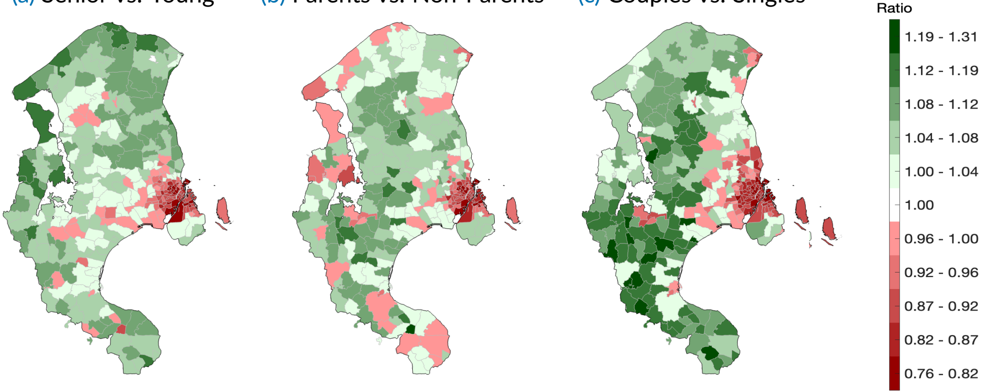
Relative Amenities by Group

Figure: Residential Amenity Comparisons

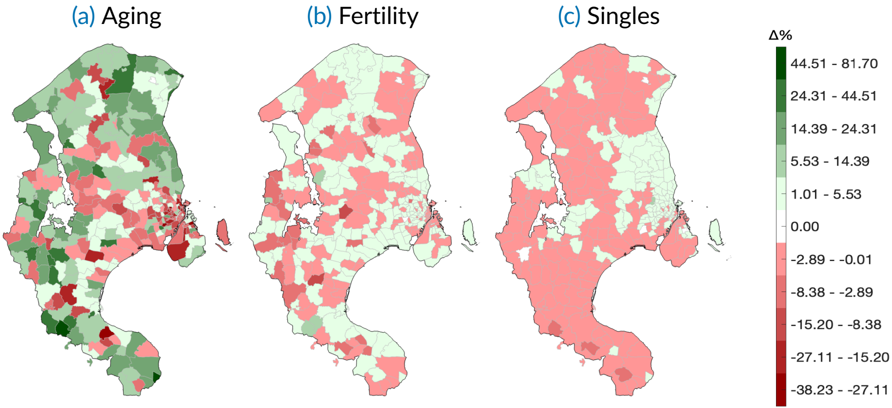
(a) Senior vs. Young (b) Parents vs. Non-Parents (c) Couples vs. Singles



▸ Amenity Regression

Counterfactual Changes in the Employment Population

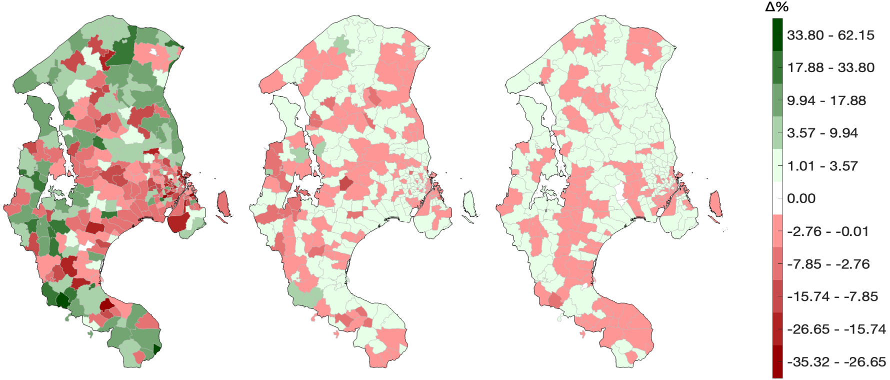
Figure: Counterfactual Changes in the Workplace Population



Counterfactual Changes on Commercial Prices

Figure: Counterfactual Changes Commercial Prices

(a) Aging (b) Fertility (c) Singles



Counterfactual Changes on Residential Prices

Figure: Counterfactual Changes in the Workplace Population

(a) Aging (b) Fertility (c) Singles