Fertility, Housing Costs and City Growth

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Children Across the Urban Space

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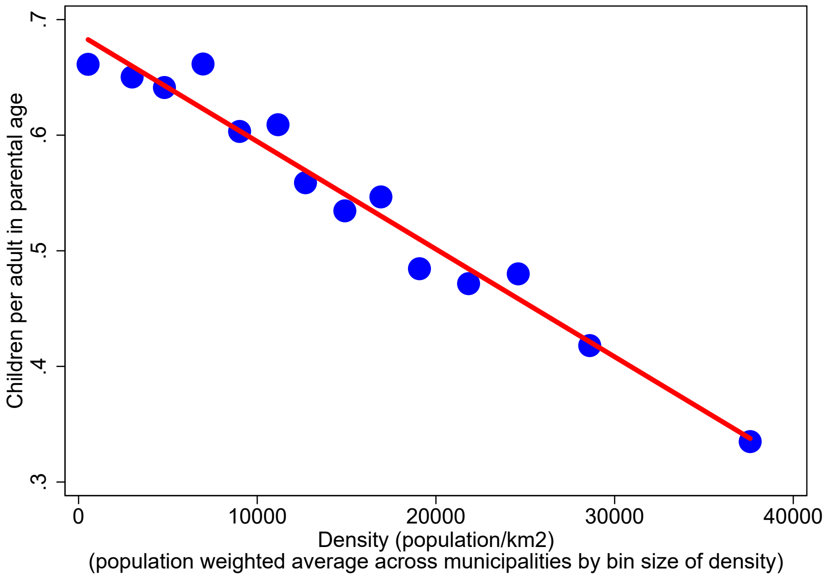
Density-Dependent Fertility

We document *negative density-dependence* of fertility across space in French urban areas.


Children per adult in parental age
.3
.4
.5
.6
.7
0
10000
20000
30000
40000
Density (population/km2)
(population weighted average across municipalities by bin size of density)

The Story

- Housing space is scarce in denser locations (e.g. center of large cities).
- Children are costly in terms of housing space.
  1. **Sorting.** Households with a preference for larger families locate in cheaper (less dense) locations.
  2. **Endogenous fertility choice.** For given fertility preference, households in more expensive (denser) locations have fewer children.
- Generates negative density-dependence of fertility.

This Paper

- Develops a quantitative life-cycle spatial model with endogenous fertility and demographics to account for

  1. Sorting patterns across demographics.
  2. The dynamics of fertility across time and space. The housing market acts as an **automatic stabiliser** of fertility over time.
  3. The **joint** determination of population dynamics and housing prices.

- Structural estimation using French data for counterfactuals since WWII. [not there yet]

Preview of the Main Insights

- **Fertility and distribution of urban population.** A fertility boom fosters suburbanization and vice-versa. The relocation of families towards denser locations and larger cities goes together with a baby-bust.
- **Endogenous aging of urban population.** Aging of baby boomers and their spatial sorting triggers a later baby-bust.
- **Joint dynamics of population and housing prices.** The housing market acts as an endogenous automatic stabilizer of fertility.
  Stable distribution of population across cities in the long-term.

Why do we care?

- Drop in demographic growth threatens welfare states and possibly innovation and productivity growth (Jones (2022)). An empty world going forward?
- Novel trade-off between aggregate productivity and demographic growth.
- Sheds light on land/housing prices across space and time and the consequence of their increase for families. 'Housing Affordability' crisis.

Related Literature

Ecology and Demography

- *Density-dependent population dynamics.* Sibly and Hone (2002), Sinclair (1989, 2003), Mills (2012) for references. Relevance for humans discussed in Lee (1987) and Lutz et al. (2006).
- *Demographic Transition and Urbanization.* Thompson (1916, 1929), Davis (1937) and Notestein (1945). Caldwell(2006) for a survey.

Fertility in Economics

- Becker (1960). References in Hotz et al. (1997), Jones et al. (2008) and Doepke et al.(2022).

Demographics and housing prices

- *Demographics and housing prices (macro).* Starting with Mankiw and Weil (1989).
- *Housing costs and fertility choice (applied micro).* Simon and Tamura (2009), Lovenheim and Mumford (2013) and Dettling and Kearney (2014).

Sorting of individuals across urban space

- *Sorting across skills.* Glaeser & Mare (2001), Combes et al. (2008), Baum-Snow et al. (2011), Eeckhout et al. (2014), Diamond (2016), Roca and Puga (2017), Couture et al. (2019), ...
- *Suburbanisation vs. the revival of cities.* Baum-Snow (2007) and Redding (2021). Couture and Handbury (2020), Moreno-Maldonado and Santamaria (2022).

Outline

1. Empirical Facts from France
   - Motivating evidence on housing consumption and sorting across demographics.
2. Theory
   - A spatial life-cycle model with endogenous fertility and population dynamics.
3. Quantitative Evaluation using French data since WWII [not there yet]
   - Structural estimation and counterfactuals.

Empirical Facts from France

Data

- **Household census data.** SAPHIR dataset of harmonized individual census data (1968-2015). Demographic variables at the municipality level. Fertility measured as children (0-17) per adult in parental age (27-53).
- **Spatial units.** Around 36,000 municipalities. 17,500 urban municipalities across 792 urban reas (UAs). Distance of a given municipality from center of UA.
- **Housing prices.** Notary data on transactions of second-hand dwellings. Price index at the municipality level (2000-2012).
- **Housing consumption.** Household level data from Enquête Nationale Logement (ENL, 1984-2013) on housing consumption and other household characteristics (composition, income, ...).

Housing consumption and demographics

Fact 1: Household housing consumption is increasing with the number of children in a given location.

- Holds for floorspace and housing budget share.
- Holds controlling location. Not driven by sorting of families in cheaper locations.

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$$h_{i,\ell_k,t} = c_{k,t} + f_k\left(d_{\ell_k}\right) + \sum_{m=1}^{N} \beta_m \cdot \mathbf{1}_{\{i \in \mathbb{S}_m\}} + X_{i,\ell_k,t} \cdot \alpha + \nu_{i,t}$$

$$(i, k, \ell_k, t) = (\text{Household}, \text{Urban Area}, \text{Commune in Urban Area}, Y\,\text{ear})$$

$$X_{i,\ell_k,t} = (\text{Age}, \text{Education}, \text{Income}, \text{Owner})$$

Fact 1: Housing Consumption and Demographics ▸ Table

Figure: Housing Consumption

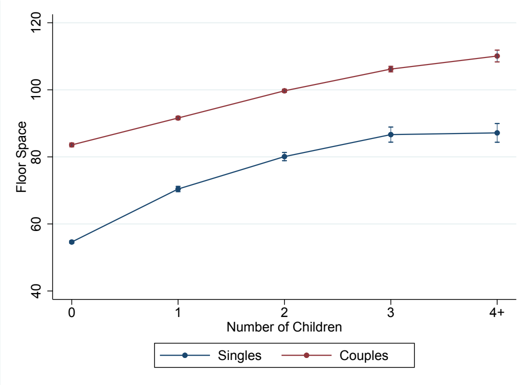
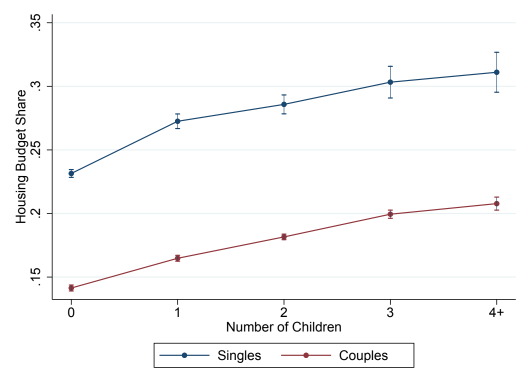


Figure: Housing Budget Share



Urban spatial sorting across demographics

Fertility within Cities

Fact 2: In a *given* urban area, fertility is higher in more suburban locations.

- Fertility higher by about 30% in the most suburban locations.
- Holds across census waves. Drop in fertility over time in all locations.
- Within city, fertility lower in more expensive locations (e.g. central locations)

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At Commune (ℓ_k) Level!

$$y_{\ell_k,t} = c_{k,t} + f_k\left(d_{\ell_k}\right) + X_{\ell_k,t} \cdot \alpha + \nu_{\ell_k,t}$$

Fact 2: Fertility is Higher in Suburbs

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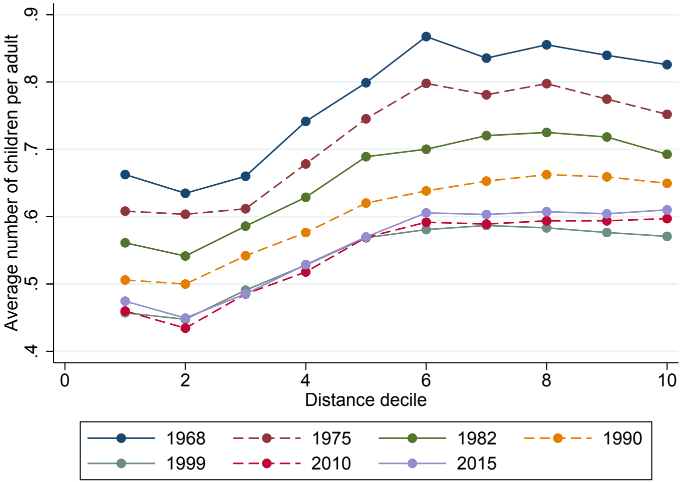
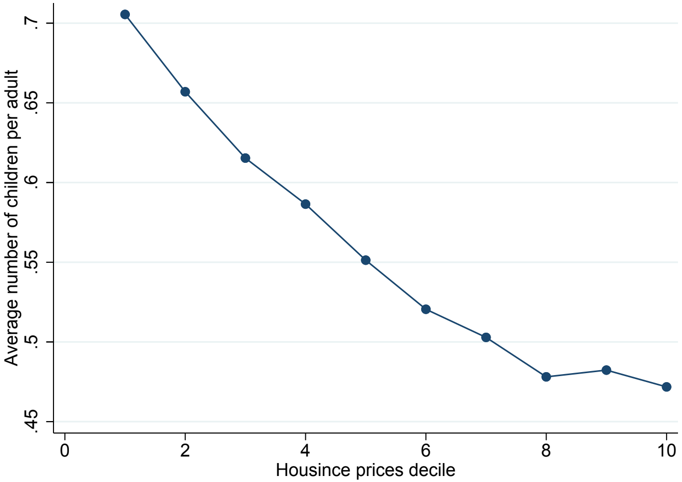


Fact 2: Fertility is Higher in Suburbs

Fertility is lower in more expensive locations



Urban spatial sorting across demographics

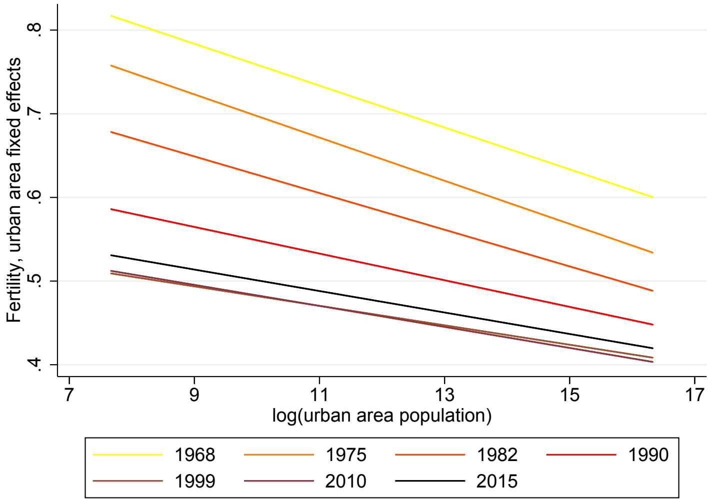
Central Fertility across Cities

Fact 3: *Across* urban areas, **central fertility is higher** in less populated cities.

- Similar magnitude of variations across urban centers.
- Holds across census waves. Drop in fertility over time in all urban centers, more pronounced in smaller cities.
- Across urban centers, fertility lower in more expensive cities (e.g. larger cities).

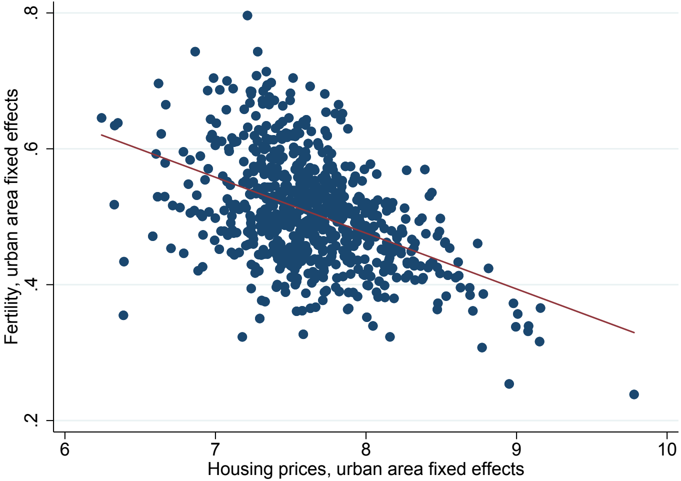
Fact 3: Central Fertility Higher in Smaller Cities

$$y_{\ell_k,t} = {\color{red}c_{k,t}} + f_k\left(d_{\ell_k}\right) + X_{\ell_k,t} \cdot \alpha + \nu_{\ell_k,t}$$



Fact 3: Central Fertility Higher in Smaller Cities

Fertility lower in more expensive cities



Urban spatial sorting across demographics

Average age of urban locations

Fact 4: Average age increases with distance to center.

- In a given urban area, the average age of adults increases as we move towards more suburban locations.
- Across urban areas' centers, the average age of adults is higher in less populated cities.

Fact 4: Average Age is Higher in Suburbs

Within and Across Cities

Figure: Within Cities

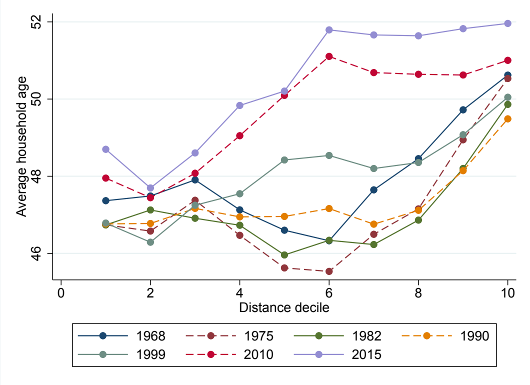
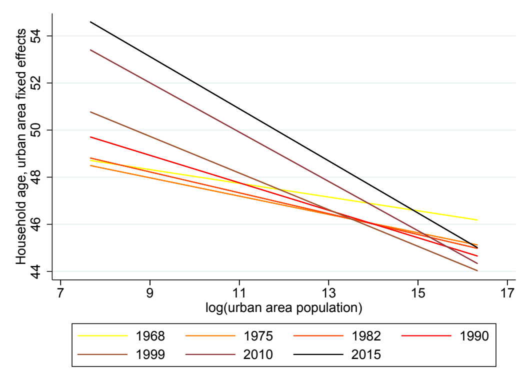


Figure: Across City Centers



Urban spatial sorting across demographics

Fact 5. Sorting of Young vs. Old across urban locations

Fact 5: Within (across) urban areas, young adults sort into central locations (larger cities). Older adults sort into smaller urban areas.

- Driven by the **sorting** of younger households towards the center of large cities and the sorting of older households into smaller cities.
- Aging over time across urban locations—particularly pronounced in smaller cities and in some suburban municipalities where the number of older households increased sharply.

Theory

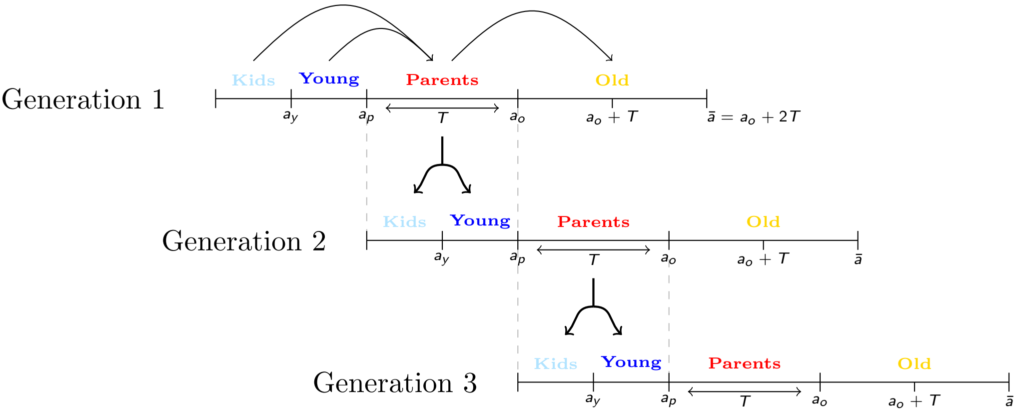
Set-up

- **Overlapping generations.** Focus first on spatial equilibrium at given date t.
- **Stages of life.** Four stages of life, **children** (c), **young** (y), **parents** (p) and **old** (o). Children sheltered by parents making fertility decisions, young and parents work and old retired. Enter each stage at age a_s, $s \in \{y, p, o\}$.
- **Spatial Structure and Household Income.** K cities. City made of a fixed number $\mathcal{L}_k$ of locations, $\ell_k \in \{1, ..., \mathcal{L}_k\}$.
  Household income net of commuting costs in ℓ_k at age $a \geq a_y$,

  $$y(a, \ell_k) = \theta_k \cdot w(a, \ell_k) + b(a),$$

  with wage income net of commuting costs $w(a, \ell_k)$ decreasing with ℓ_k within a city k, retirement benefits $b(a)$ independent of location, θ_k a city-level income fixed effect.

Timing



Generation 1
Kids
Young
Parents
Old
a_y
a_p
T
a_o
$a_o + T$
$\bar{a} = a_o + 2T$
Generation 2
Kids
Young
Parents
Old
a_y
a_p
T
a_o
$a_o + T$
$\bar{a}$
Generation 3
Kids
Young
Parents
Old
a_y
a_p
T
a_o
$a_o + T$
$\bar{a}$

Preferences and budget constraints

- **Budget constraints.** At age a in location ℓ_k,

$$c(a, \ell_k, n) + q_{\ell_k} h(\mathcal{N} + n) = y(a, \ell_k),$$

  with consumption $c(a, \ell_k, n)$, housing space h increasing in the number of sheltered children n ($n = 0$ for young and old) and q_{ℓ_k} the housing price in ℓ_k.

- **Preferences.** Instantaneous utility,

$$U(a, \ell_k, n) = A_k + u\left(c(a, \ell_k, n)\right) + v(n) + \sigma\varepsilon_{n,\ell_k}.$$

  with city amenity A_k, household specific preferences for location at any age and for fertility at age a_p. Preference shock for location (and fertility at age a_p), ε_{n,ℓ_k}, drawn from a type 1 Extreme Value distribution with scale parameter σ.

Spatial Equilibrium

- Assuming no moving costs, and parental stage lasting for one period only: Decisions independent from each other at each age.
- Location decisions at all ages and fertility decisions at age a_p expressed as discrete choice probabilities.
- Given aggregate demographic composition of adult households, this determines the housing demand $H_d(\ell_k)$ in each location ℓ_k.

Spatial Equilibrium

Definition 1:

For a given set of city/location characteristics and a given aggregate demographic composition of adult households, a static spatial equilibrium is a vector of housing costs, $\{q_{\ell_k}\}_{\ell_k \in \mathcal{L}}$, demographic composition, $\{L_{a,\ell_k}\}_{\ell_k \in \mathcal{L}, a_y \leq a \leq \bar{a}}$, and average fertility, $\{n_{\ell_k}\}_{\ell_k \in \mathcal{L}}$, in each location such that:

- Location decisions at each age a and fertility decision at age a_p maximise utility.
- The housing market clears in each and every location $\ell_k \in \mathcal{L}$,

$$H_d(\ell_k) = \delta_{\ell_k}(q_{\ell_k})^{\rho},$$

with ρ the supply elasticity and δ_{ℓ_k} a location-specific supply shifter.

Dynamics across time

Sequence of spatial equilibria with endogenous population dynamics

Definition 2:

For time-varying city/location characteristics, potentially age-specific and a given initial aggregate demographic composition of adult households, $\{L_{a,0}\}_{a_y \leq a \leq \bar{a}}$, a sequence of equilibria for $t \geq 0$ is defined recursively such that:

- The equilibrium at each date t is a static spatial equilibrium according to Definition 1 for a given distribution by age of the aggregate population, $\{L_{a,t}\}_{a_y \leq a \leq \bar{a}}$.
- Aggregate population dynamics by age at each date t, $\{L_{a,t}\}_{a_y \leq a \leq \bar{a}}$ depends on endogenous fertility decisions at each date t and exogenous survival porbabilities into older age.

Quantitative Evaluation using French data since WWII

Numerical illustrations

- Quantitative evaluation using French data since WWII in progress.
- For now, provide numerical illustrations of a calibrated simulated multicity economy aiming at reproducing qualitatively French data since WWII.
- Investigates the response across space and time of cities to
  1. Aggregate demographic changes (e.g. baby-boom and rising longevity)
  2. Aggregate changes in the urban structure (e.g. shifts in commuting costs and housing supply regulations)

Numerical illustrations

Set-up and calibration

- **Timing.** One period = one generation. $t = 0$ corrresponds to 1950. Life-stages: Age $a_y = 18$, $a_p = 27$, $a_o = 54$.
- **Spatial structure.** $K = 5$ cities. $\mathcal{L}_k = 5$ locations in each city.
- **Productivity and amenity.** Cities differ only in their productivity level θ_k and amenity A_k. Positive correlation between productivity and amenity. No change over time for simplicity.
- **Income and commuting costs.** Constant wage within city. Pensions = 80% of average national income in all locations. Commuting costs $\tau_a(\ell_k - 1)$ increasing linearly across locations $\ell_k \in \{1, 2, ..., 5\}$ from center to fringe. Identical for young and parents, **lower for old**.
- **Housing supply.** Constant elasticity of supply of housing $\rho = 2$. No difference in housing supply across locations, $\delta_{\ell_k} = \delta$ constant across locations.

Numerical illustrations

Set-up and calibration

- **Housing space by household size.** Housing space, $h(\mathcal{N} + n) = \underline{h} \cdot (\mathcal{N} + n)^{\alpha}$. $\underline{h}$ set to match aggregate housing spending share. $\alpha = 0.34$ related to scale economies in household size, set to match roughly data of **Fact 1**.

- **Preferences.** Linear consumption. No income effect on fertility.
  Fertility preferences linear in number of children $= \nu n +$ preference shifter for $n = 2$. Set to generate aggregate fertility slightly above 2 at $t = -1$ and reasonable distribution of parental household size.
  Preference shock for location/fertility with scale parameter $\sigma = 0.5$.

- **Mortality and initial demographic composition.** Survival probablity for old in line with data in 1950. Corresponding initial age distribution at $t = -1$.

Numerical illustrations

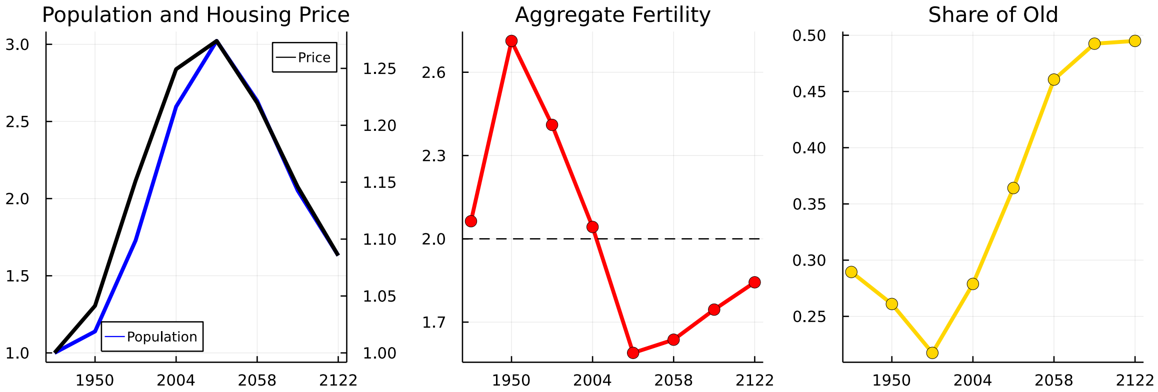
Aggregate demographic changes

- **Baby-boom.** Fertility preference shifter $\Delta_t \nu$ in period $t \in \{0, 1, 2\}$, with $\Delta_0 \nu > \Delta_1 \nu > \Delta_2 \nu > 0$.
  Magnitude to roughly match the increase in fertility during the baby-boom in France. Progressive phasing-out.

- **Rising longevity.** Increase in survival probabilities at older ages in line with data. Probablity to survive into old age, above 54 (resp. very old age, above 81) increases from 0.5 to 0.7 (resp. 0.04 to 0.3) between $t = 0$ and today.

Aggregate demographic changes

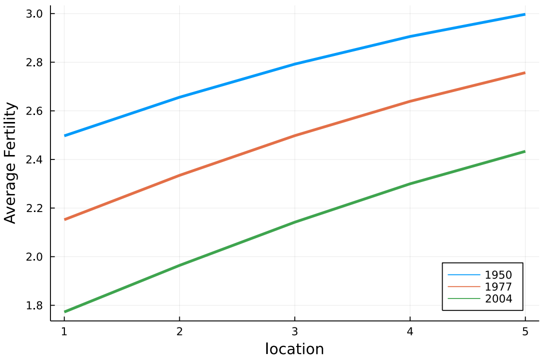
Population dynamics



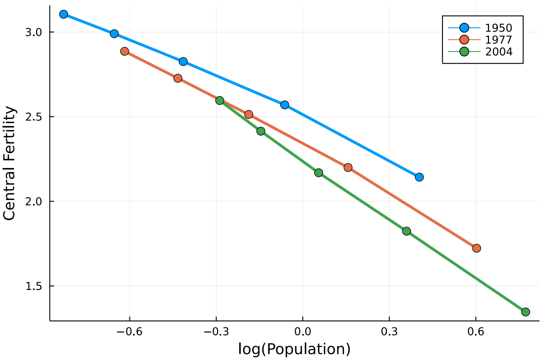
Fertility across urban locations

Facts 2 and 3. Fertility within and across urban areas.

(a) Fact 2: Within city



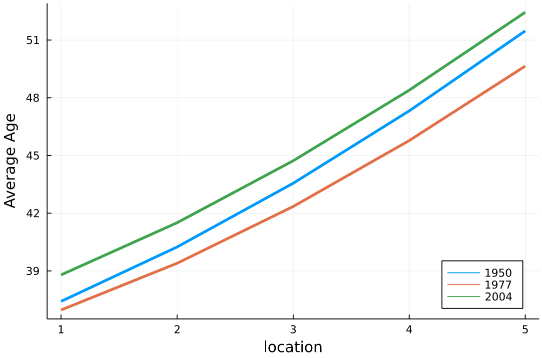
(b) Fact 3: Across cities



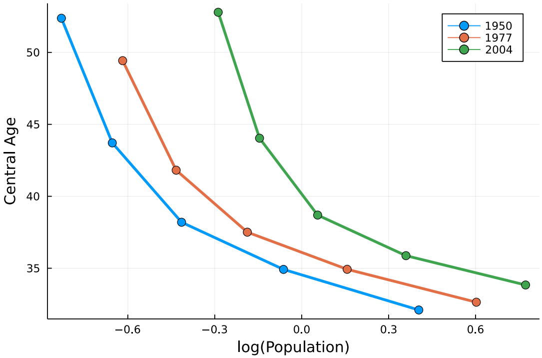
Spatial sorting by age

Fact 4. Average age across urban locations

(a) Fact 4: Within city

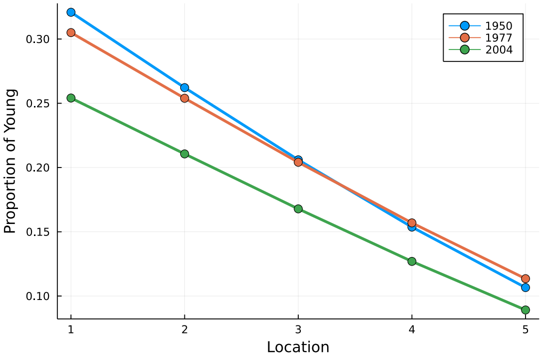


(b) Fact 4: Across cities

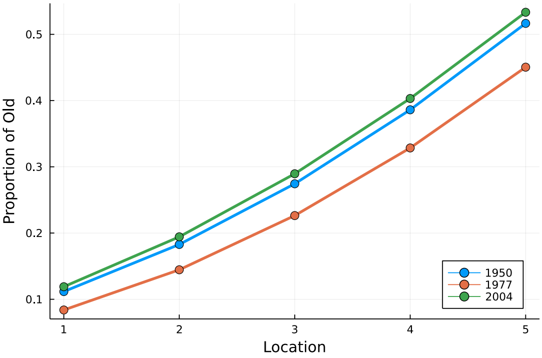


Spatial sorting by age

Fact 5. Young vs. Old across urban locations



(a) Fact 5: Young within city

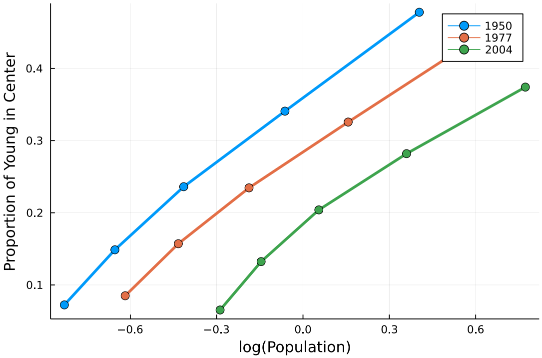


(b) Fact 5: Old within city

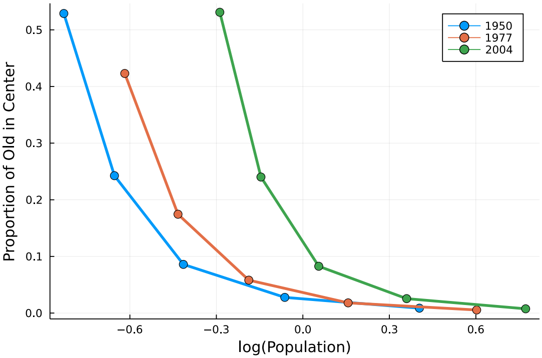
Spatial sorting by age

Fact 5. Young vs. Old across urban locations

(a) Fact 5: Young across cities

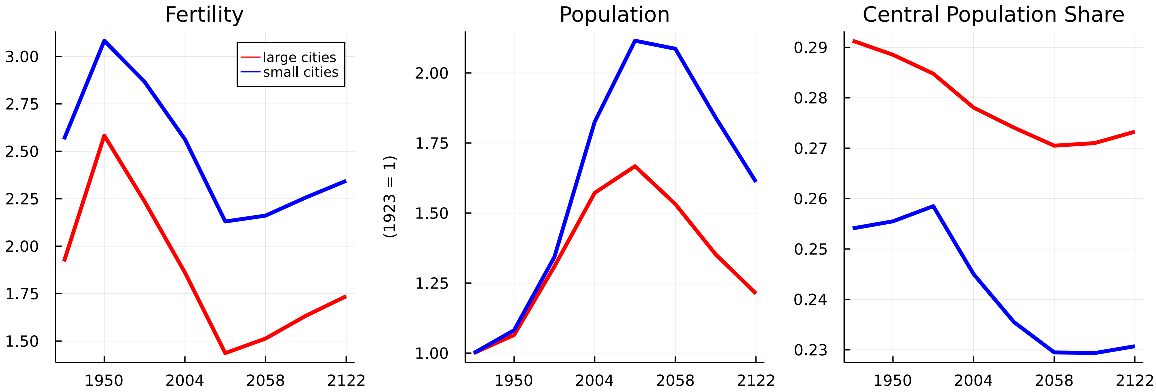


(b) Fact 5: Old across cities



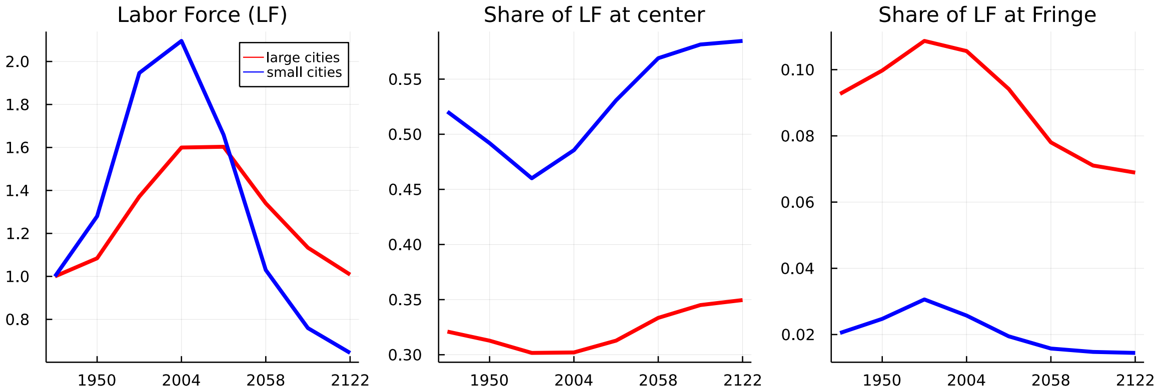
Spatial Distribution of Population

Large vs. Small cities



Spatial Distribution of Population

Large vs. Small cities: Role of Working Population's Residence



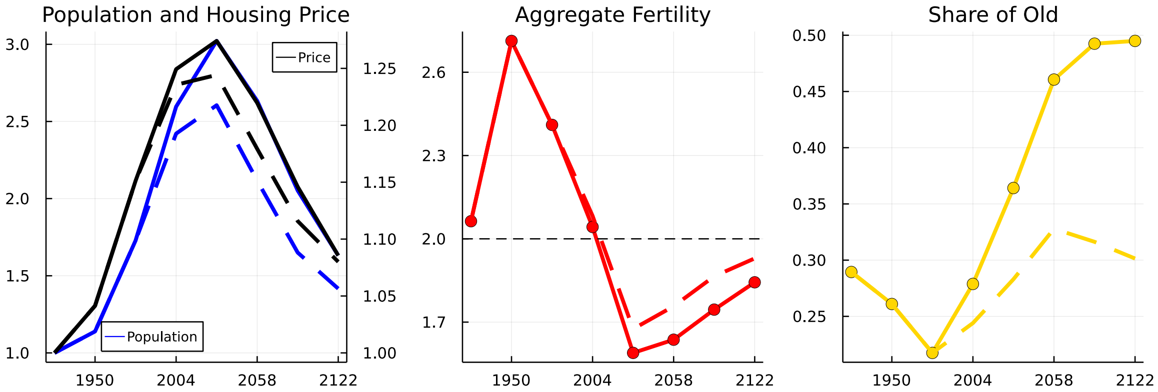
Counterfactuals

The role of rising longevity and of the baby-boom

- Disentangle the role of rising longevity and of the baby-boom for the dynamics of population across time and space.
- **Constant longevity.** Constant survival probabilities, equal to the initial value.
- **No baby-boom.** Constant fertility preferences, equal to the initial value.

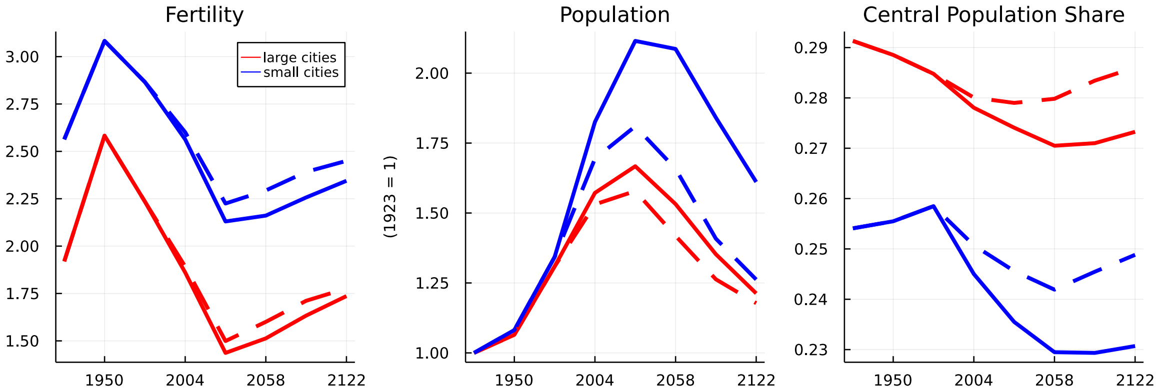
The role of rising longevity and of the baby-boom

Dynamics without increase in longevity



The role of rising longevity and of the baby-boom

Dynamics without increase in longevity



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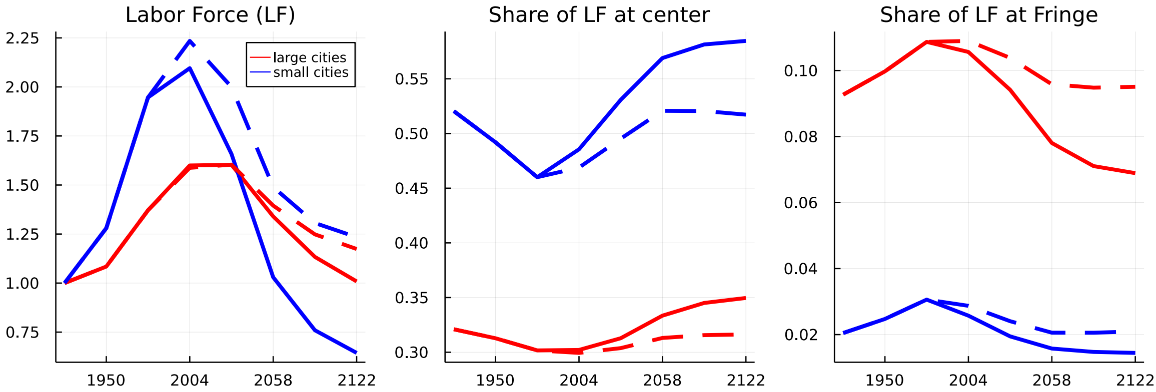
Dynamics without increase in longevity



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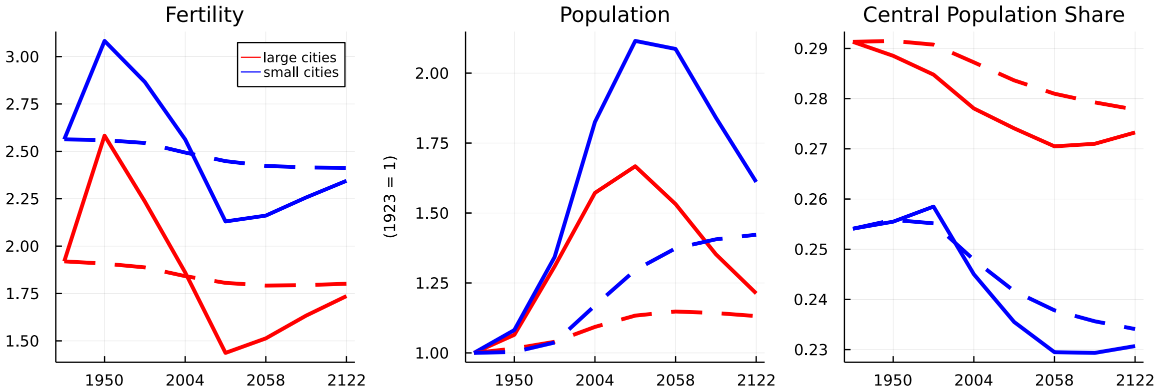

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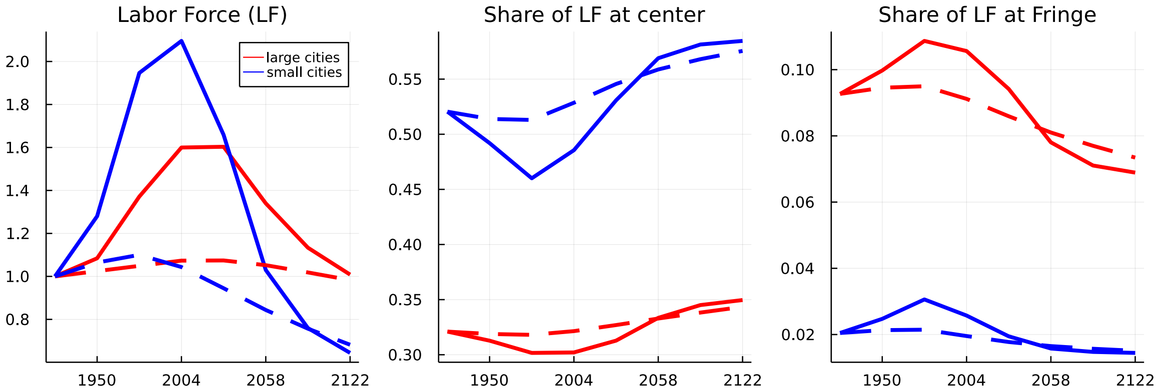
Dynamics without baby-boom



Numerical illustrations

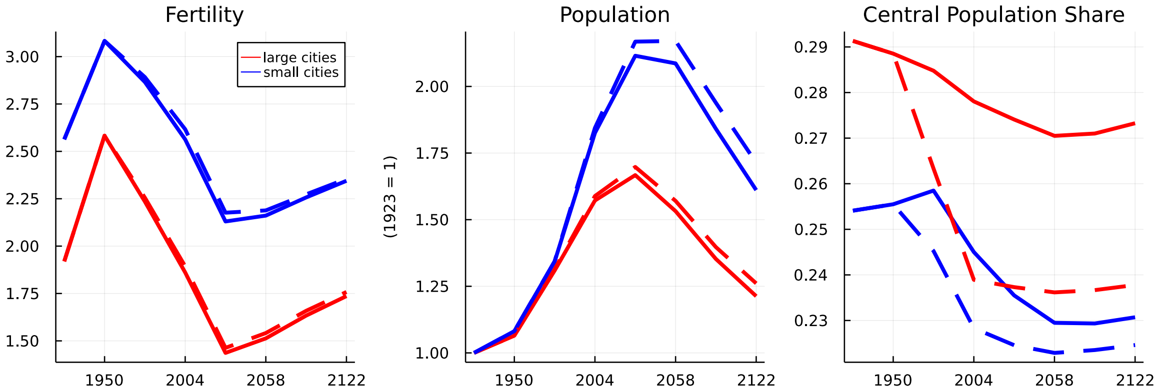
Aggregate changes in the urban structure

- **Drop in commuting costs.** Drop in commuting costs at date $t = 1$, $\tau_t = \tau - \Delta_t \tau$, with $\Delta_t \tau > 0$ for $t \geq 1$ and 0 otherwise.
  Corresponds to better commuting technologies (e.g. automobiles, ...) in the 1960s-1970s.

- **Stricter housing supply regulations.** Tightening of housing supply in the recent period, at date $t \geq 2$, $\delta_t = \delta - \Delta_t \delta$, with $\Delta_t \delta = \Delta \delta > 0$, for $t \geq 2$ and 0 otherwise.
  Corresponds to stricter urban planning in France starting the 1990s. Partly mimic the recent rise in housing prices.

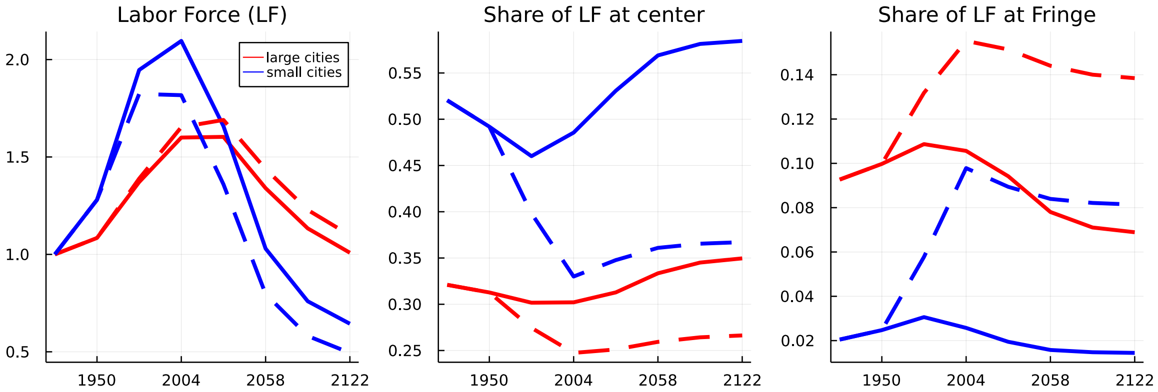
Commuting costs, fertility and suburbanisation

Drop in commuting costs



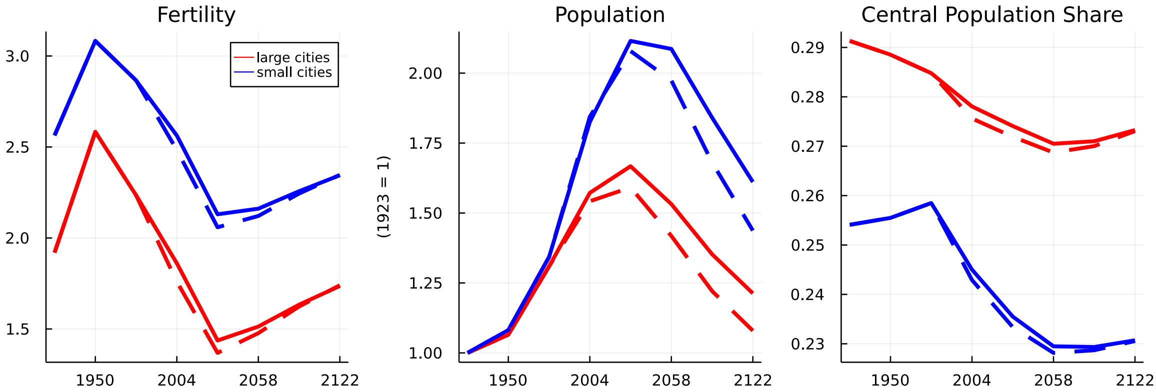
Commuting costs, fertility and suburbanisation

Drop in commuting costs



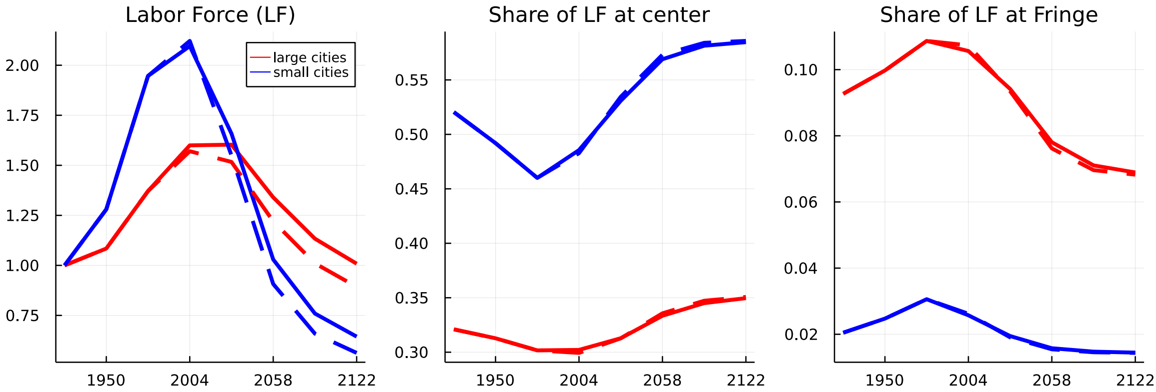
Housing supply regulations, fertility and city growth

Stricter housing supply regulations



Housing supply regulations, fertility and city growth

Stricter housing supply regulations



Conclusion

- Novel facts about fertility and demographic sorting across urban locations in France.
- Spatial overlapping generations equilibrium model with endogenous population dynamics reproduces these stylized facts (qualitatively).
- Quantitative estimation (in progress) to identify through a variety of counterfactuals
  - the role of demographic shifts in explaining the spatial distribution of population.
  - the role of changes in commuting technologies and/or housing supply regulations for the population dynamics of cities.
  - the side-effects of family policies for the distribution of population and economic activity across space.
- With agglomeration forces, fertility and population dynamics matter for aggregate productivity.

Fact 1: Housing Consumption

back

	singles1	couples1	singles2	couples2	singles3	couples3	singles4	couples4	singles5	couples5	singles6	couples6	singles7	couples7	singles8	couples8	singles9	couples9
en0i	52.73^a	77.94^a			53.52^a	79.64^a			53.48^a	80.20^a	54.60^a	83.57^a			54.56^a	83.84^a	55.17^a	85.11^a
	(0.23)	(0.33)			(0.21)	(0.31)			(0.23)	(0.31)	(0.21)	(0.29)			(0.21)	(0.29)	(0.20)	(0.28)
en1i	74.53^a	92.56^a			73.32^a	92.45^a			70.46^a	90.67^a	70.41^a	91.59^a			69.53^a	91.26^a	69.82^a	91.84^a
	(0.44)	(0.31)			(0.43)	(0.28)			(0.43)	(0.29)	(0.40)	(0.25)			(0.39)	(0.26)	(0.38)	(0.25)
en2i	86.16^a	104.5^a			83.84^a	103.5^a			81.18^a	99.90^a	80.08^a	99.70^a			78.34^a	98.14^a	78.48^a	98.75^a
	(0.66)	(0.28)			(0.65)	(0.27)			(0.63)	(0.26)	(0.62)	(0.24)			(0.57)	(0.24)	(0.59)	(0.24)
en3i	93.13^a	111.4^a			90.32^a	110.3^a			88.62^a	106.5^a	86.64^a	106.2^a			84.80^a	105.0^a	84.54^a	105.6^a
	(1.31)	(0.49)			(1.21)	(0.48)			(1.29)	(0.44)	(1.15)	(0.42)			(1.17)	(0.42)	(1.07)	(0.41)
en4i	93.57^a	112.3^a			91.09^a	112.8^a			87.96^a	108.1^a	87.15^a	110.1^a			87.36^a	111.9^a	87.03^a	112.3^a
	(1.80)	(1.01)			(1.81)	(0.97)			(1.48)	(0.95)	(1.42)	(0.90)			(1.35)	(0.93)	(1.35)	(0.90)
wldim			10.24^a	10.18^a	8.171^a	8.590^a					7.405^a	8.568^a					3.440^a	3.987^a
			(0.62)	(0.54)	(0.27)	(0.20)					(0.26)	(0.18)					(0.24)	(0.20)
wlagei							23.59^a	17.02^a	30.73^a	35.71^a	27.48^a	30.71^a	14.52^a	5.484^a	23.16^a	25.36^a	22.34^a	24.20^a
							(1.66)	(1.83)	(0.73)	(0.68)	(0.71)	(0.65)	(1.65)	(1.88)	(0.66)	(0.63)	(0.66)	(0.62)
wedmi							-4.939^a	-3.393^a	2.876^a	7.917^a	4.013^a	8.628^a	-4.725^a	-3.281^b	2.638^a	7.624^a	2.977^a	7.674^a
							(1.21)	(1.31)	(0.53)	(0.49)	(0.49)	(0.47)	(1.20)	(1.30)	(0.47)	(0.45)	(0.46)	(0.45)
wedsi							-11.25^a	-7.598^a	2.835^a	12.96^a	6.204^a	15.06^a	-9.764^a	-5.960^a	3.711^a	14.84^a	5.037^a	14.67^a
							(1.05)	(1.12)	(0.49)	(0.48)	(0.49)	(0.47)	(1.04)	(1.13)	(0.44)	(0.45)	(0.45)	(0.45)
wowni							-6.296^a	-14.95^a	-1.855^a	-12.23^a	-1.236^b	-9.965^a	-5.010^a	-10.47^a	-0.727	-7.146^a	-0.723	-7.201^a
							(1.26)	(1.07)	(0.55)	(0.37)	(0.51)	(0.34)	(1.23)	(1.08)	(0.50)	(0.34)	(0.49)	(0.33)
wlrevi							22.69^a	50.78^a	3.434^a	12.48^a	6.886^a	18.54^a	21.90^a	48.84^a	2.616^a	9.320^a	5.672^a	14.85^a
							(0.52)	(0.82)	(0.23)	(0.31)	(0.40)	(0.41)	(0.50)	(0.82)	(0.20)	(0.29)	(0.36)	(0.39)
wna1i													-6.728^b	-2.852	-7.073^a	-7.745^a	-5.793^a	-4.650^a
													(3.16)	(2.18)	(1.22)	(0.80)	(1.19)	(0.76)
wna2i													-6.315^a	9.707^a	-13.61^a	-13.96^a	-9.612^a	-8.797^a
													(2.39)	(2.23)	(0.83)	(0.63)	(0.83)	(0.64)
wna3i													-10.73^b	4.831	-14.24^a	-10.30^a	-8.773^a	-4.384^a
													(4.77)	(3.98)	(1.68)	(1.15)	(1.69)	(1.09)
whoui													30.49^a	25.03^a	29.34^a	27.87^a	24.44^a	21.27^a
													(1.06)	(0.85)	(0.56)	(0.29)	(0.61)	(0.35)
N	33716	83797	33716	83797	33716	83797	32630	82687	32630	82687	32630	82687	32630	82687	32630	82687	32630	82687
R^2	0.82	0.86	0.04	0.02	0.85	0.88	0.16	0.12	0.84	0.88	0.88	0.90	0.19	0.14	0.88	0.90	0.89	0.91