Structural Change, Land Use and Urban Expansion

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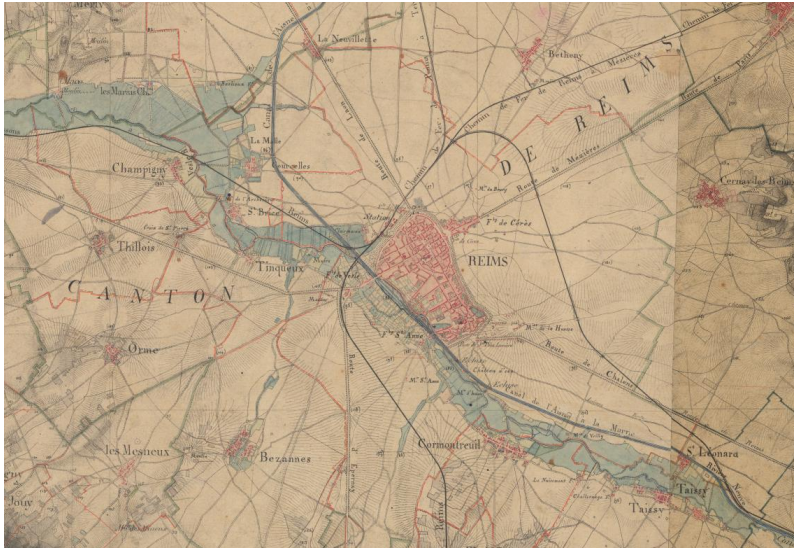
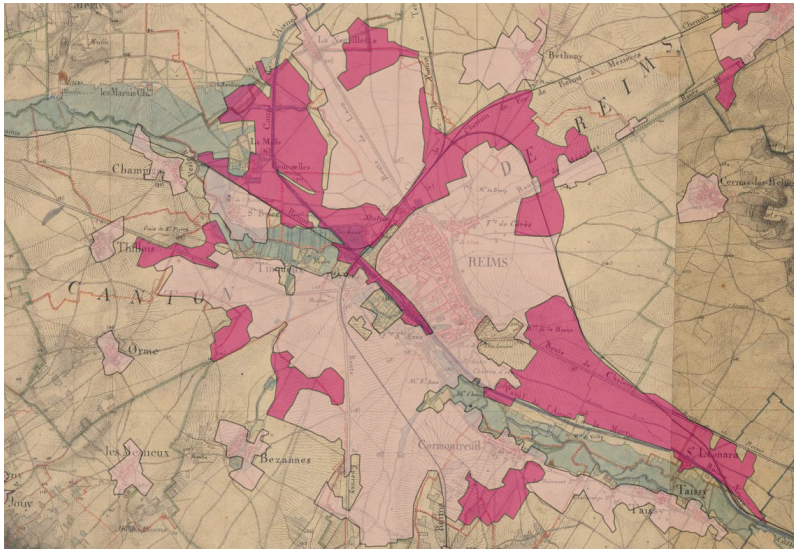
Motivation: Reims in 1866

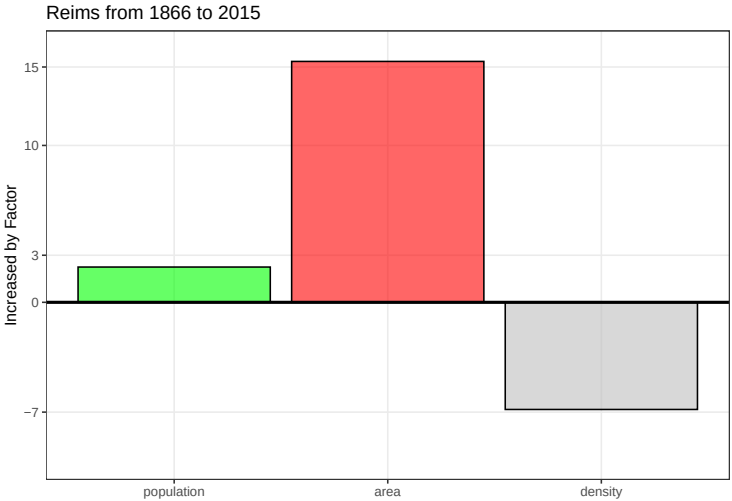


Motivation: Reims in 1866 vs IGN *Buildings* in 2017



Motivation: Reims in 1950 vs IGN *Buildings* in 2017

Motivation: Fall in Urban Density



- 50% work in Agriculture in 1866, 2% in 2015.
- Expansion at expense of Agricultural Land.

This paper

Spatial general equilibrium model of structural change and land use.

- Three sectors/goods: rural, urban, and housing.
  - Different intensity in the use of land as input.
  - Rival Land Use: Agricultural or Housing.
  - Fixed Supply of Land.
- Drivers of structural change:
  - Non-homothetic preferences for the rural good.
  - Transitory dynamics with rising productivity.
- Land reallocation.
  - City expands as rural employment falls.
  - Urban good produced at city center.
  - Commuting costs for urban workers.

Preview of Main Mechanisms

Transitory Dynamics with Rising Productivity and Falling Commuting Costs

- **In Year 1866:** Land is scarce. High values of farmland with respect to income due to low productivity ('food problem'). Very small and dense, *walkable* cities.

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- **From 1970 on** Reallocation of factors/land use slows down. Cities expand less and land prices increase more with rising productivity. Land particularly scarce in some locations.

Why Do We Care?

- Understanding land/housing prices across space and time in the long-run.
  - Housing Affordability crisis.
- Understanding sprawling and soil artificialization.
  - Environmental impact (IPCC (2019)).
- Implications for welfare and aggregate productivity of land use restrictions. [not there yet]
  - Is sprawling 'excessive'? Benefits of compact cities?
  - General equilibrium implications of lowering commuting costs.

Related literature

(Traditional) Macro and Land Values

- Ricardo (1817), Nichols (1970), Grossman and Steger (2016). Measurement. Morris and Heathcote (2007), Piketty and Zucman (2014), Knoll, Schularick and Steger (2017).

(Macro) Structural Change

- Survey: Herrendorf, Rogerson and Valentinyi (2014). Theory: Kongsamut et al. (2001), Gollin et al. (2002), Boppart (2014), Acemoglu and Guerrieri (2008), Ngai and Pissarides (2007)...
  Structural change and urbanization. Lewis (1954), Michaels et al. (2012). Eckert and Peters (2018).
- Agricultural Productivity Gap. Gollin et al. (2014), Lagakos and Waugh (2013), Young (2013), Restuccia et al. (2008).

Urban — Size and Expansion of Cities

- Theory. Alonso-Mills-Muth. Surveys by Duranton and Puga (2014, 2015). Brueckner (1990), Brueckner and Lall (2014), ...
  Quantitative Spatial Economics. Redding and Rossi-Hansberg (2017). Sprawl/Density. Glaeser et al., Ahlfeldt et al. (2015), Angel et al. (2010)
- Land Prices and Rents. Combes et al. (forthcoming), Albouy (et al.) (2016, 2018), Glaeser et al. (2005).

Urban Expansion in France: Facts

Urban Expansion in France 1866–2016

Data description

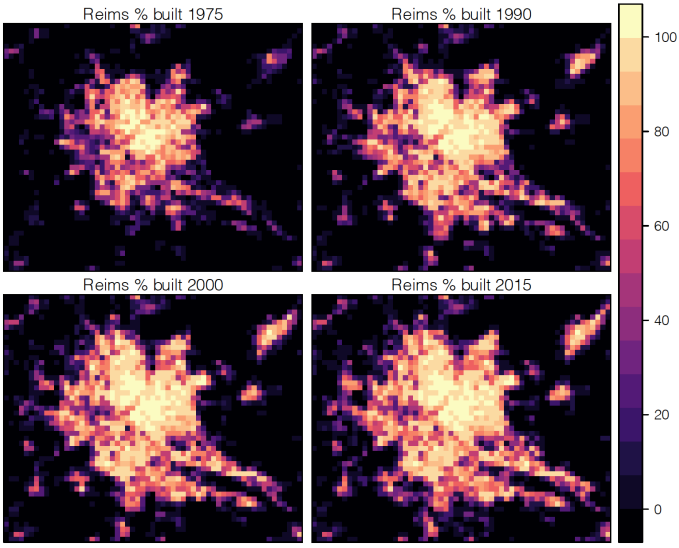
- Land use and employment in agriculture across French regions
  - Historical: mostly from Toutain (1993) based on Recensement Agricole. Post-1950, Ministry of Agriculture.
- Employment and spending across sectors
  - Insee, Toutain (1993), Villa (1996), Herrendorf et al. (2014).
- The expansion of cities
  - Carte Etat-Major (1866), IGN (1950), Satellite Data post-1975 (GHSL data). Census for Population.
- Housing and Land Prices [in progress]
  - Aggregate Historical: Piketty et al. (2014), Knoll et al. (2017). Farmland across regions: Ministère de l'Agriculture since 1950. Housing/Farmland Transactions: Base des Notaires.

Land and labor reallocation: Aggregate France

Sources:

1. Toutain (1993)
2. Recensement Agricole (Ministry of Agriculture)
3. INSEE
4. Villa (1996)

City Area and Population Measurement

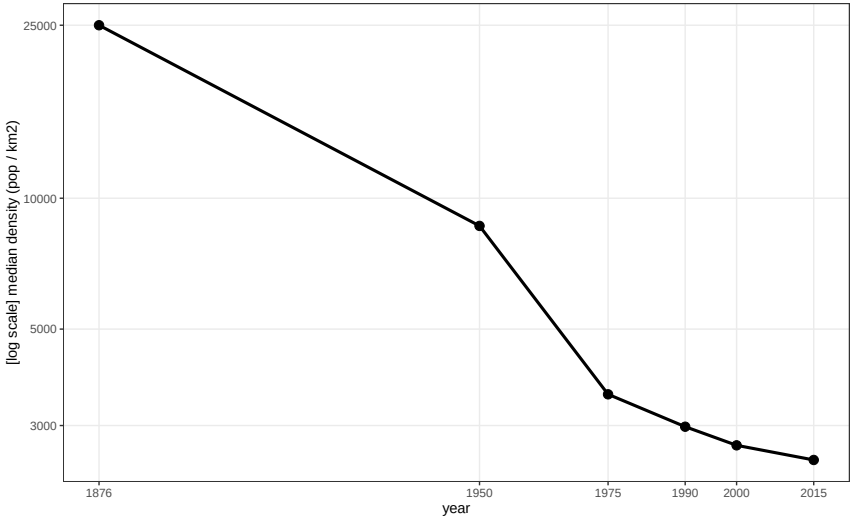


- 1866: Manual + Census
- 1950: Manual + Census
- 1975, 1990, 2000, 2015: GHSL

The Historical Fall in Urban Density

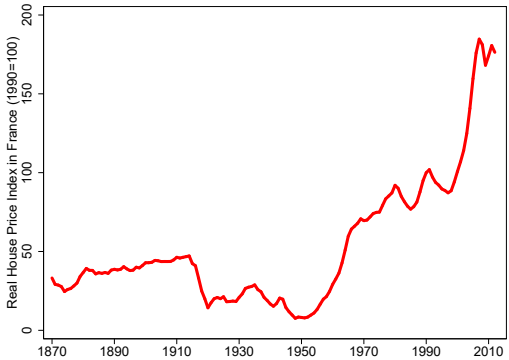
Median Urban Density in France fell by Factor 10

Top 100 French cities

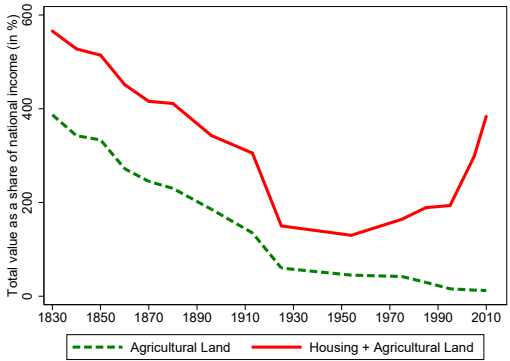


- Paris
- Distribution
- Top 5
- World

Hockey-stick in housing prices and Fall in Agricultural Value Share



(a) Hockey Stick: Knoll et al. (2017)



(b) Picketty and Zucman (2014)

Model

A general equilibrium model of land use

Set-up

- Economy endowed with a fixed amount of land and L ex-ante identical workers supplying one unit of labour.
- Three sectors/goods: rural (r), urban (u) and housing (h).
- Goods and factor markets perfectly competitive. Labor mobile.
- Goods (u) and (r) perfectly tradable.

Technology

Urban and Rural good

- For the urban good, only labor for simplicity,

$$Y_u = \theta_u L_u.$$

- For the rural good,

$$Y_r = \theta_r \left(\alpha (L_r)^{\frac{\sigma-1}{\sigma}} + (1-\alpha)(S_r)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}},$$

- θ_i = TFP in sector i, L_i = labor used in i, S_r = land used in r.
- Rural good more intensive in land.
- Stronger decreasing returns to labor in (r).

Preferences and budget constraint

- Non-homothetic preferences for an individual in location ℓ

$$C(\ell) = (c_r(\ell) - \underline{c})^{\nu(1-\gamma)} (c_u(\ell) + \underline{s})^{(1-\nu)(1-\gamma)} h(\ell)^{\gamma},$$

$c_i(\ell)$ = consumption of $i = \{r, u\}$, housing consumption $h(\ell)$.
$\underline{c}, \underline{s}$ subsistence consumption and initial endowment of urban good.

- Budget constraint,

$$pc_r(\ell) + c_u(\ell) + q(\ell)h(\ell) = w(\ell) + \mathbf{r},$$

$q(\ell)$ the rental price per unit of housing in location ℓ.
$\mathbf{r}$ land rents per capita, equally distributed.

Spatial Structure: Wage Function $w(\ell)$

Wages Net Of Commuting Costs in Spatial Equilibrium: $C(\ell) = \bar{U}$

1. Space $\ell \in [0, 1]$

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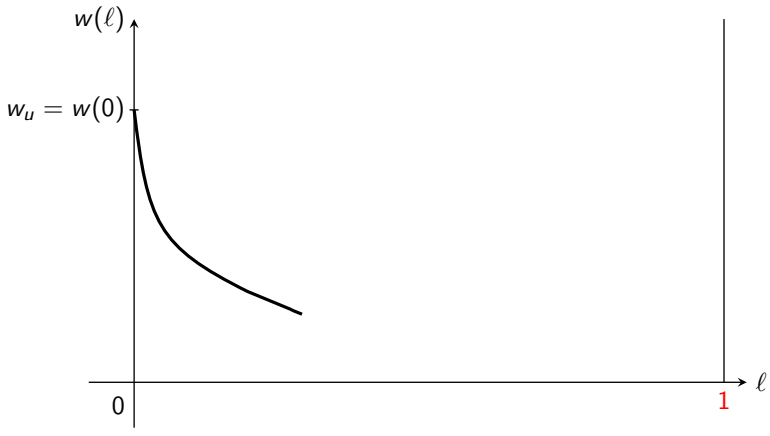

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4. $\tau(\ell)$: commuting cost from ℓ
5. $w_u - \tau(\ell)$ urban wage

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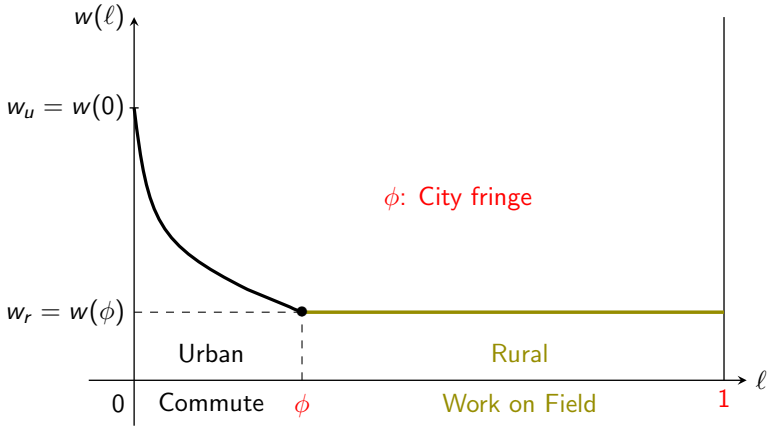

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6. ϕ denotes urban fringe.

Commuting Costs in units of numeraire good

Based on DeSalvo and Huq (JUE 1996)

- $\tau(\ell)$ is composed of a fixed operating cost f and time cost $t(\ell)$

$$\tau(\ell) = f + \zeta w_u t(\ell)$$

- Operating cost $f(\ell, m)$ is s.t. longer ($\uparrow \ell$) and faster ($\uparrow m$) commutes are more expensive.
- (e.g. Train line vs horse-drawn carriage.)

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- Allows closed form optimal mode choice:
  1. Faster commutes for people further away.
  2. Speed increases with wage (opp. cost of time).
  3. Elasticity of $\tau(\ell)$ wrt wage is strictly less than unity
- Menu of transport modes m is fixed throughout. Higher incomes allow faster mode choices.

Housing Market Equilibrium

Housing market clearing in the city

- Housing market clearing, $H(\ell) = D(\ell)h(\ell)$, leads to density

$$D(\ell) = \frac{\rho_r}{\gamma_\ell}(w(\phi) + \mathbf{r} - p\underline{c} + \underline{s})^{-1/\gamma_\ell}(w(\ell) + \mathbf{r} - p\underline{c} + \underline{s})^{1/\gamma_\ell - 1},$$

  with $\gamma_\ell = \frac{\gamma}{1+\epsilon_\ell}$ = supply-adjusted housing spending share.

- Total urban population

$$L_u = \int_0^\phi D(\ell)d\ell \tag{1}$$

- Pins down the city size ϕ for a given sectoral allocation of workers (and for given prices), $\phi(L_u, w_u, \rho_r, p\underline{c})$.

Land and Labor Market Clearing

- Land market clearing

$$\phi + S_{hr} + S_r = 1,$$

with S_{hr} = the land demand for housing in the rural area.

$$S_{hr} = \frac{L_r \gamma_r \left(w_r + \mathbf{r} - p\underline{c} + \underline{s} \right)}{\rho_r}$$

with $\gamma_r = \gamma_\phi$ (homogenous rural housing supply conditions).

- Labor market clearing

$$L_u + L_r = L.$$

- Land Rents

$$\mathbf{r}L = \int_0^\phi \rho(\ell) d\ell + \rho_r \times (1 - \phi). \tag{2}$$

Equilibrium Allocation

Definition of the Equilibrium

For technology parameters $(\theta_u, \theta_r, \alpha, \sigma)$, spatial frictions $\{\tau(\ell)\}_\ell$, housing supply conditions $\{\epsilon_\ell\}_\ell$, and preference parameters, $(\nu, \gamma, \underline{c}, \underline{s})$, an equilibrium is a sectoral labor allocation (L_u, L_r), a city fringe (ϕ) and rural land for production (S_r), factors and goods prices (w_u, w_r, ρ_r, p) and land rents $(\mathbf{r})$, such that:

- *Factors are paid their marginal productivity.*
- *Workers are indifferent across locations.*
- *The demand for urban land (or city fringe ϕ) satisfies the city size Eq. 1.*
- *Land and labor markets clear.*
- *Rural and urban goods markets clear.*
- *Land rents satisfy Eq. 2.*

Results

Parameterization

Productivity Series $\{\theta_{u,t}\}, \{\theta_{r,t}\}$

- We feed the model series $\{\theta_{u,t}\}, \{\theta_{r,t}\}$
- We measure value added for rural and urban production in French Data.
- Applying our production functions, we can back out $\{\theta_{u,t}\}, \{\theta_{r,t}\}$

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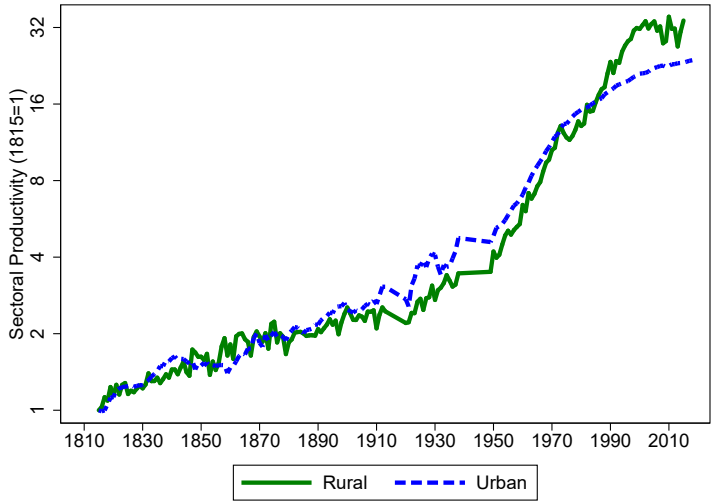


Main Parameter Values

Technology. $\alpha = 0.75$, $\sigma = 1$.

Preferences. Housing weight, $\gamma = 25\%$. Rural weight, $\nu = 1.5\%$.
Subsistence level $\underline{c}$ such that given initial θ, slightly more than 50% of workers in (r), $\underline{s} << \underline{c}$.

Commuting costs. $\eta_\ell = 0, \eta_m = 1.3$, $\zeta = 0.5$.

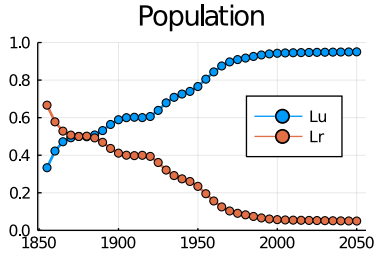
Housing supply elasticity. Baseline with $\epsilon_\ell = \epsilon_r = 4$. Version with lower ϵ_ℓ at CBD.

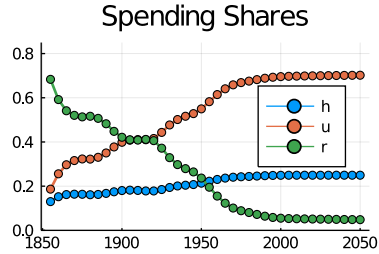
Population. Baseline. $L = 1$.
Alternative. Rising population since 1860, roughly doubles.

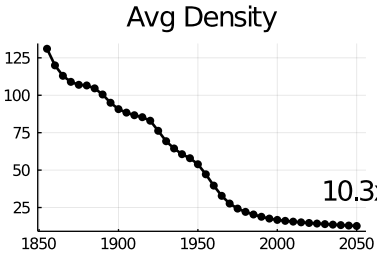
Results

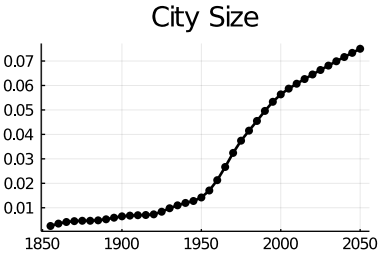
Baseline Model

1. Rural population: 66% $\rightarrow$ 5%
2. Rural spending share: 68% $\rightarrow$ 5%
3. Urban Density: Falls by factor of 10.
4. City size increases substantially: 0.002 $\rightarrow$ 0.075.



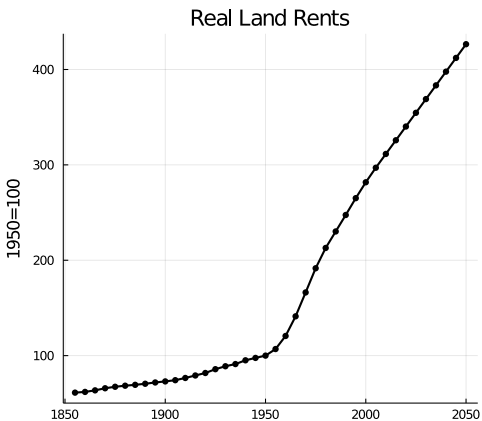


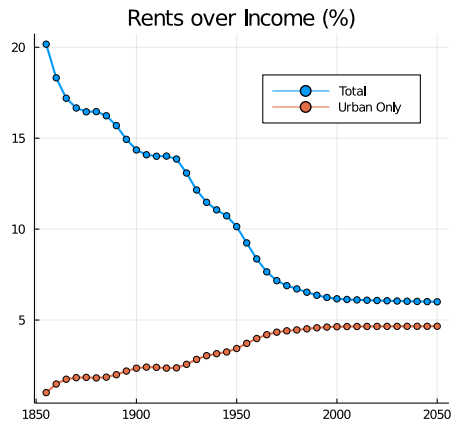




Results

Baseline Model: Hockey Stick and Falling Value Share

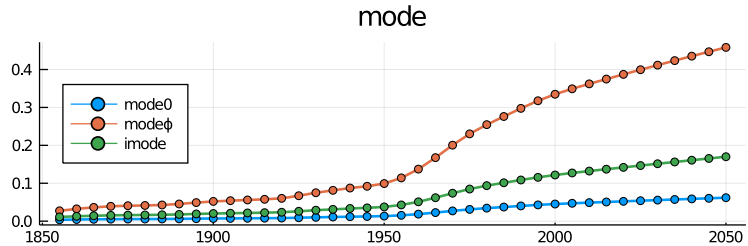


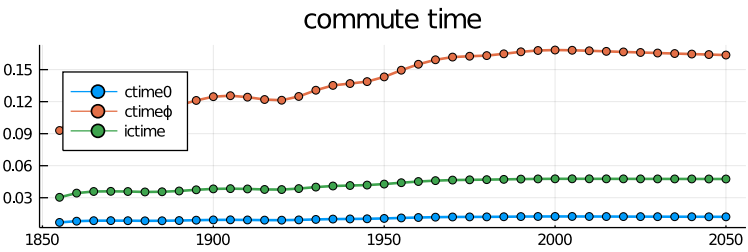


Results

Baseline Model Commuting Patterns

1. People at fringe choose fastest commute.
2. People in center ($\ell = 0$) walk.
3. Shorter commute in center ($\ell = 0$).
4. Longer commutes at fringe ($\ell = \phi$).

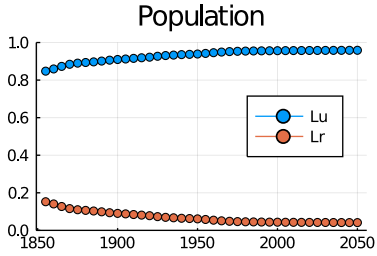


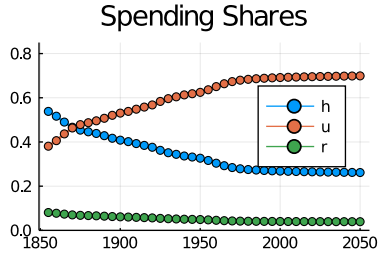


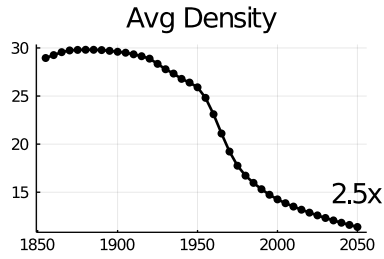
Results

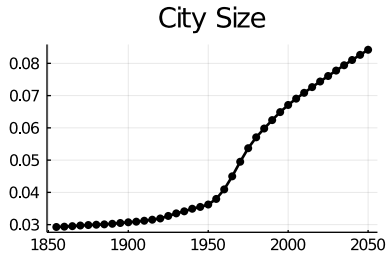
Counterfactual 1: Low $\underline{c}$, high $\underline{s}$. Too little reallocation!

- High preference for urban good does not deliver.
- Too little population reallocation.
- Spending shares are wrong.





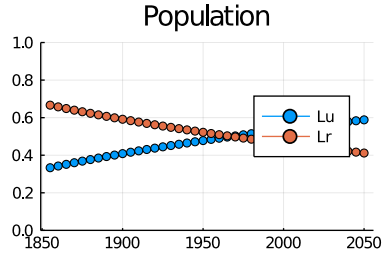


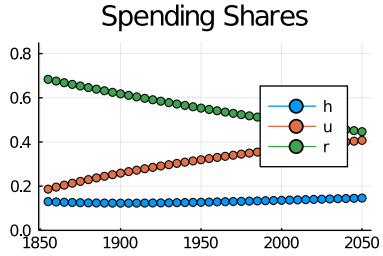


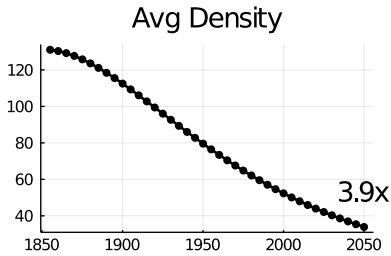
Results

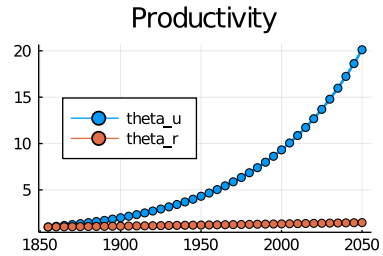
Counterfactual 2: High Urban Productivity Growth

- Population reallocation is too slow.
- Spending shares evolution dampened.
- Huge fall in urban density.





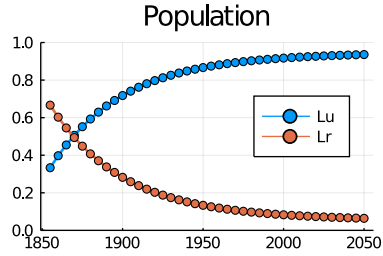


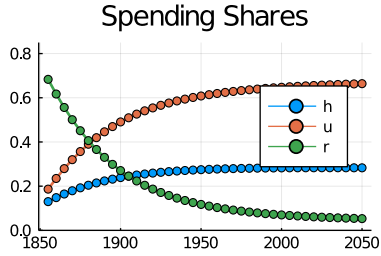


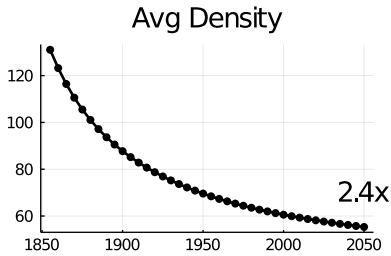
Results

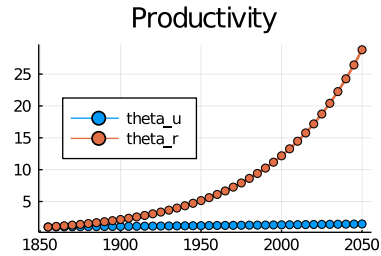
Counterfactual 3: High Rural Productivity Growth

- Qualitatively correct implications.
- Rural productivity growth is key.









Possible Extensions

- Multiple cities/regions
  - Sectoral technological comparative advantages.
    Potentially additional heterogeneity across cities (housing supply conditions, commuting technologies).
  - Similar aggregate outcomes with a distribution of city size/land use across regions.

- Dynamic Model
  - Pins down a path for the real interest rate.
    Housing/Land values beyond rents.
  - Relatively simple without capital, perfect mobility and ex-ante homogenous households.

- Frictions
  - Quantitative investigation of commuting frictions. Congestion.
  - Additional Frictions: Land Use Restrictions.

Conclusion

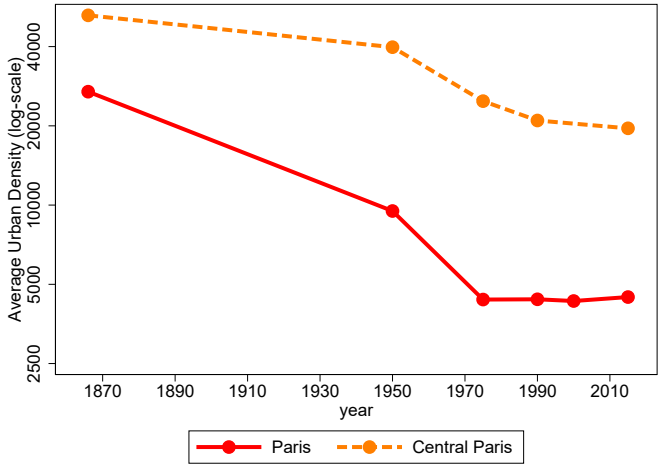
- Spatial general equilibrium of land use to explain
  - The evolution of the sectoral allocation of economic activity across space.
  - The evolution of the density of settlements.
  - The evolution of the distribution of land values.

- Beyond positive implications, a potentially useful tool to evaluate the welfare effects of land use restrictions.

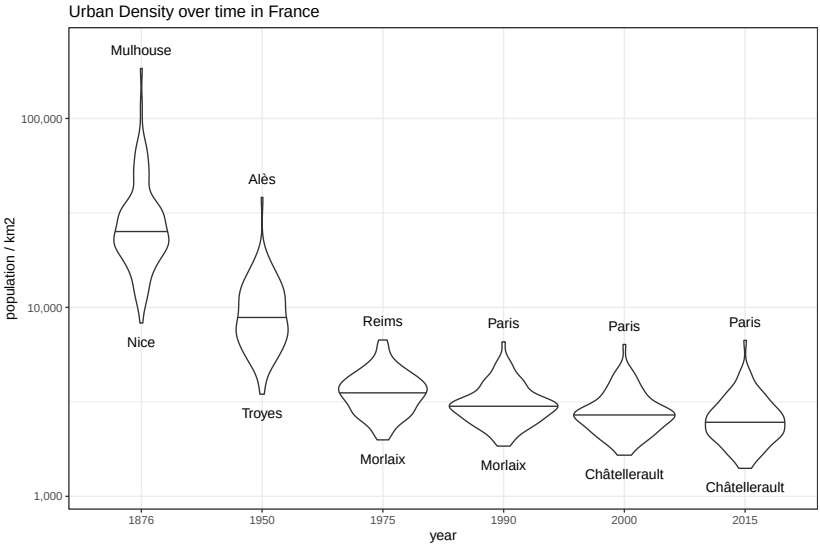
THANK YOU!

The historical fall in urban density

Paris



The historical fall in urban density



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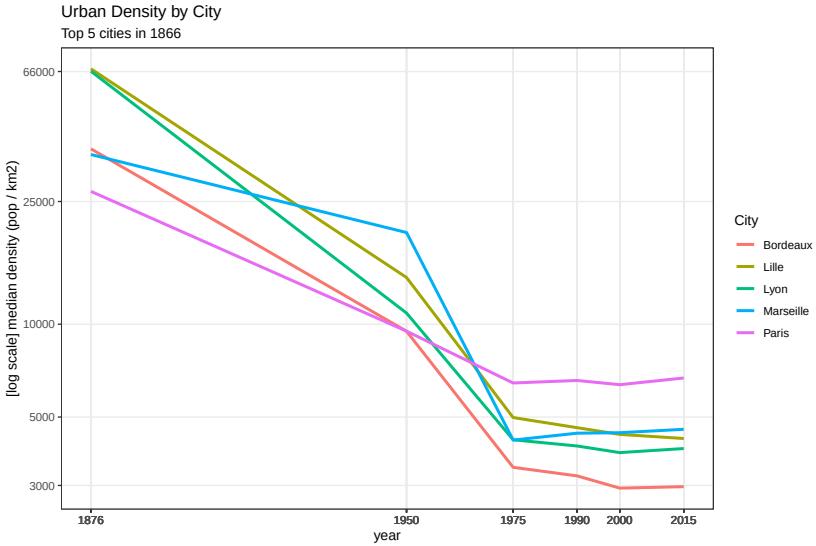
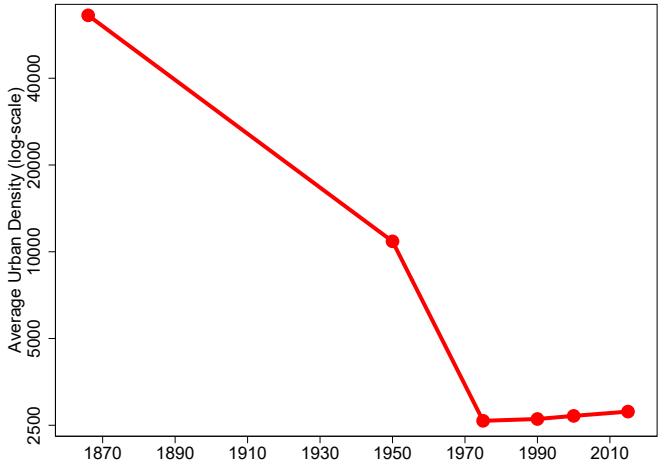
The historical fall in urban density



The historical fall in urban density

Lyon



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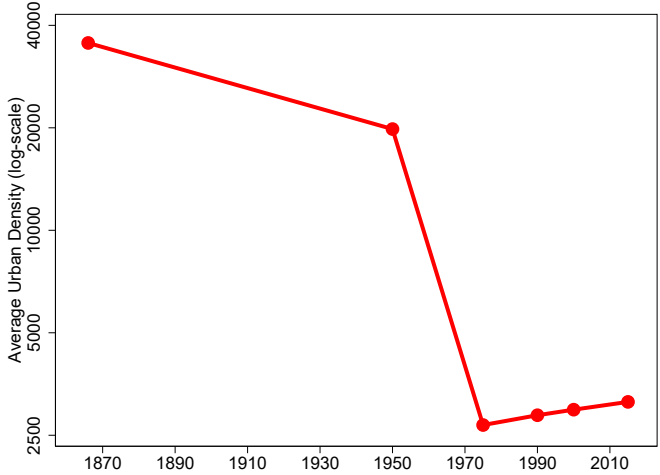
Marseille



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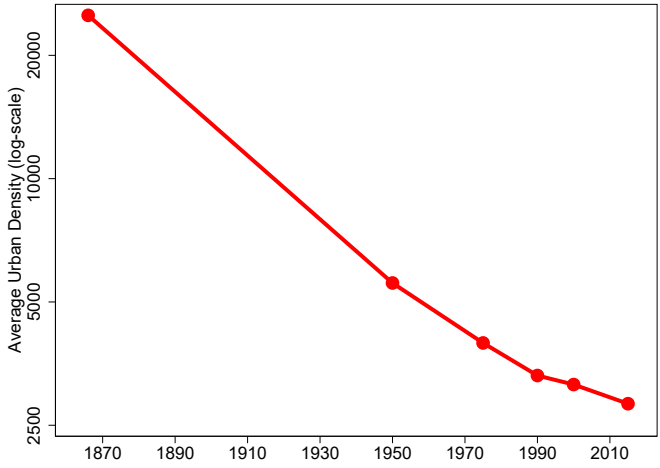
The historical fall in urban density

Reims



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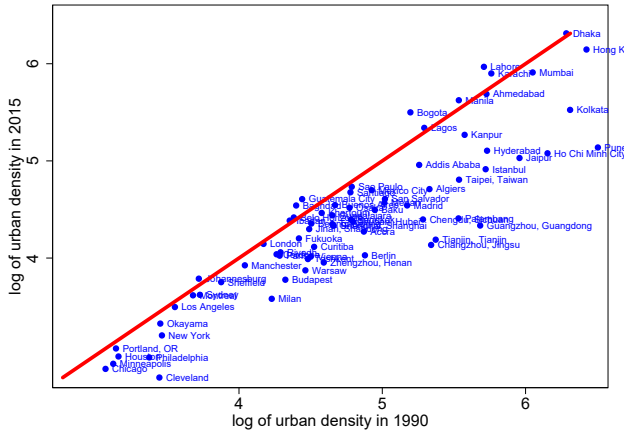
The fall in urban density across the globe, 1990-2015

World sample of large cities



Source: Atlas of Urban Expansion. Sample of 73 cities above 1 000 000 people. Details in Angel et al. (2010).

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