Structural Change, Land Use and Urban Expansion

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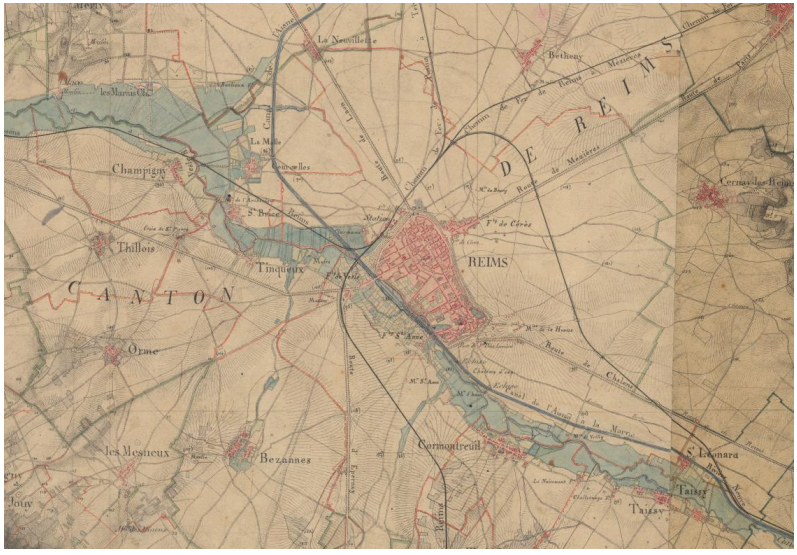
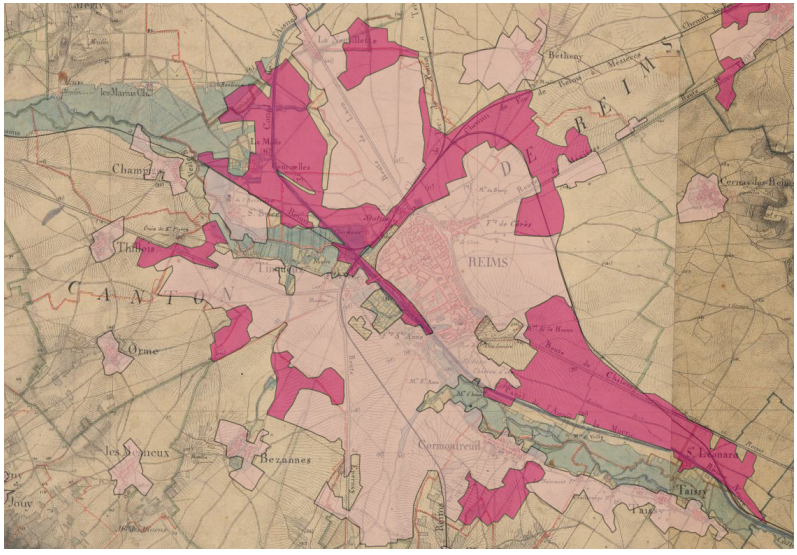
Motivation: Reims in 1866

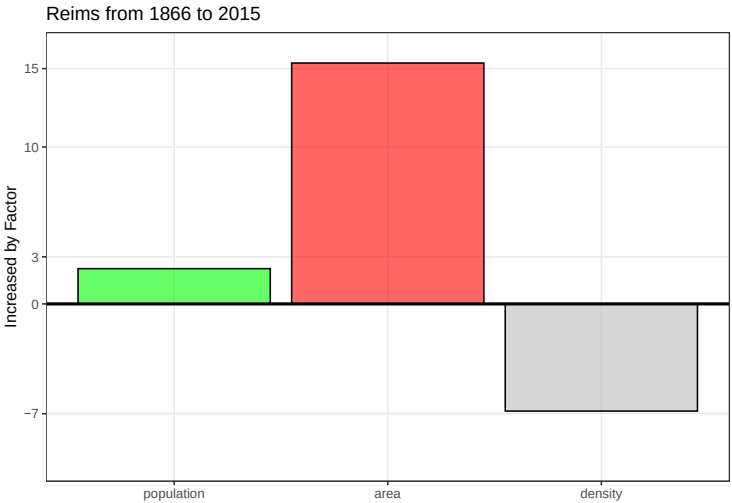


Motivation: Reims in 1866 vs IGN *Buildings* in 2017



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

Motivation: Fall in Urban Density



- 50% work in Agriculture in 1866, 2% in 2015.
- Urban Surface increased about 15 fold.
- Density fell about 7 fold.
- Why?

Urban Expansion: Different Views

1. Urban Economics:
   - Decline in commuting cost over time allows residing further away from city centre.
   - New technologies (🚗 🚋 🚆) enable suburbanisation. 🏘

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This paper: Try to reconcile 🤝 both views in a unified framework.

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), Miles and Sefton (2020)

(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. (2021), Combes et al. (mimeo 2021), Albouy (et al.) (2016, 2018), Glaeser et al. (2005).

Urban Expansion in France: Facts

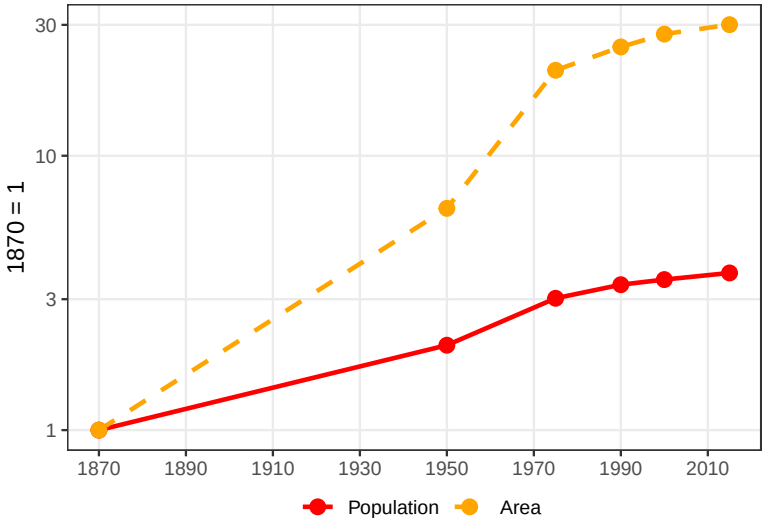
Land *and* labor reallocation: Aggregate France

Sources:

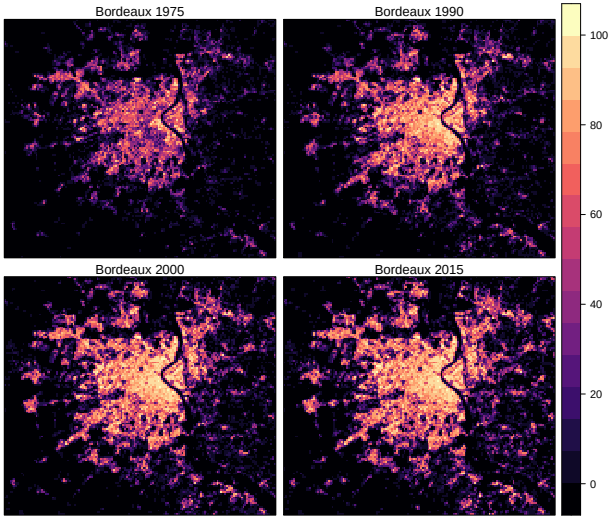
1. Toutain (1993)
2. Recensement Agricole (Ministry of Agriculture)
3. INSEE
4. Villa (1996)

Urban Expansion

Top 100 Cities in France

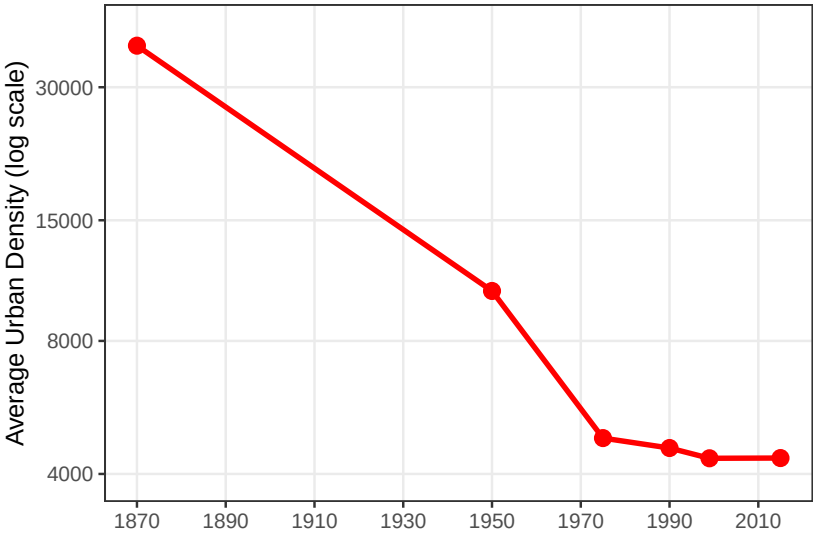


City Area and Population Measurement

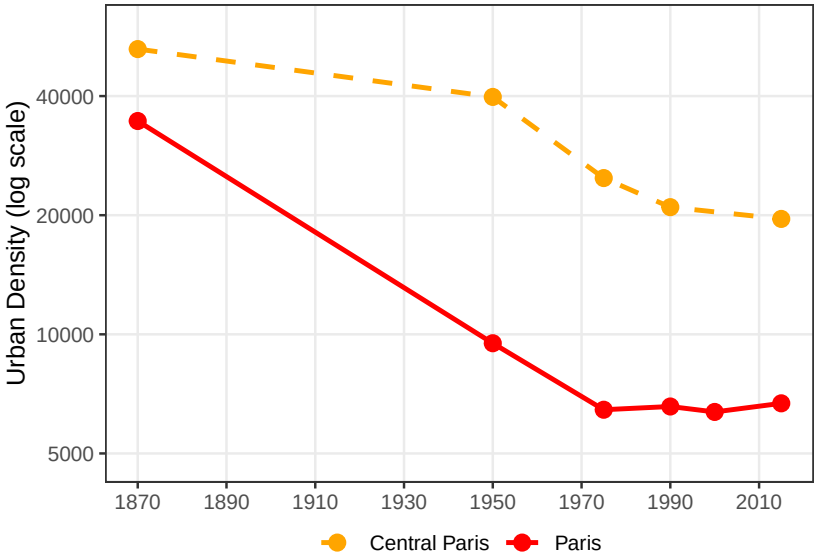


- 1866: Manual + Census
- 1950: Manual + Census
- 1975, 1990, 2000, 2015: GHSL
- ▸ More details please!

The Historical Fall in French Urban Density

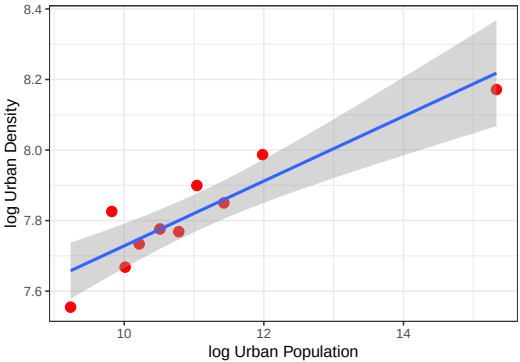


The Historical Fall in Urban Density: Within Paris



Distribution
Top 5
World

Urban Density vs Farmland Price and Population (year 2000)



Well known: More populated cities are denser on average.

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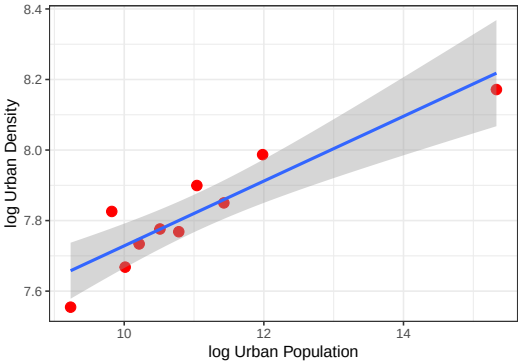

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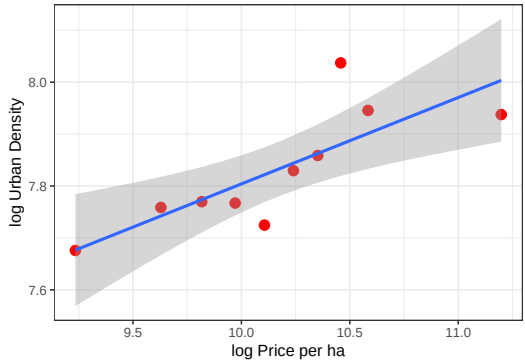
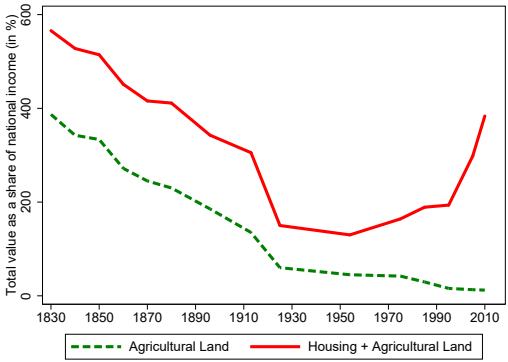


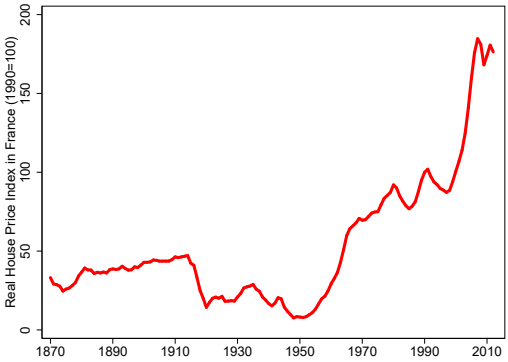
Less known: surrounding farmland and density are positively correlated.

▸ Fringe Land Use?

Fall in Agricultural Value Share and *Hockey-stick* in Housing Prices



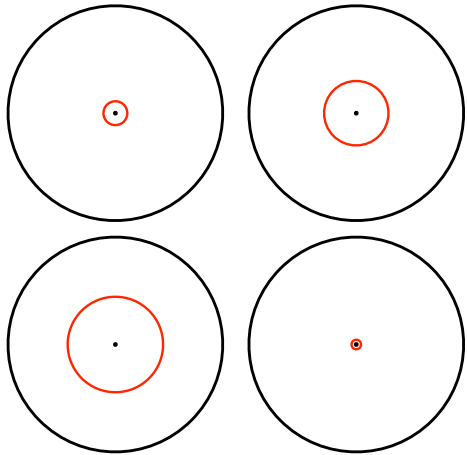
(a) Picketty and Zucman (2014)



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

Model

Model: Spatial Setup



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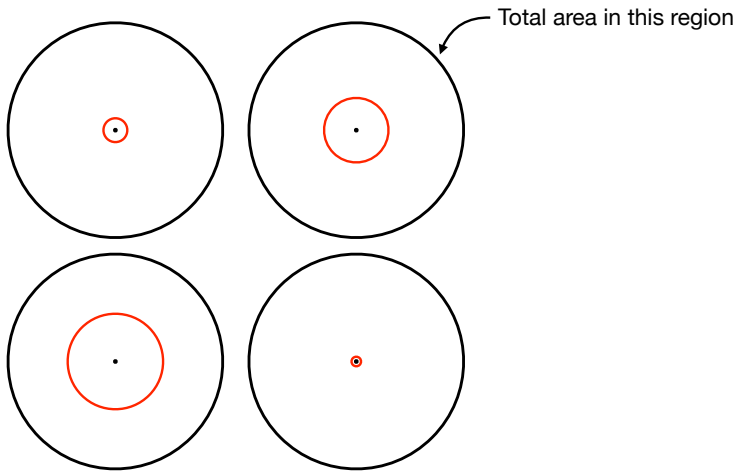

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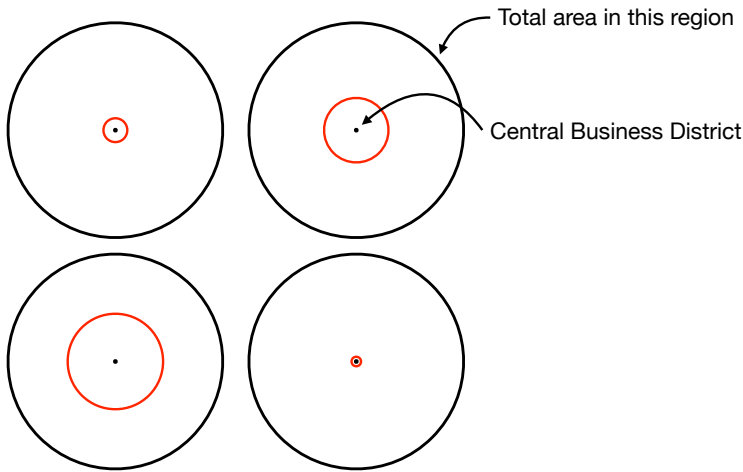

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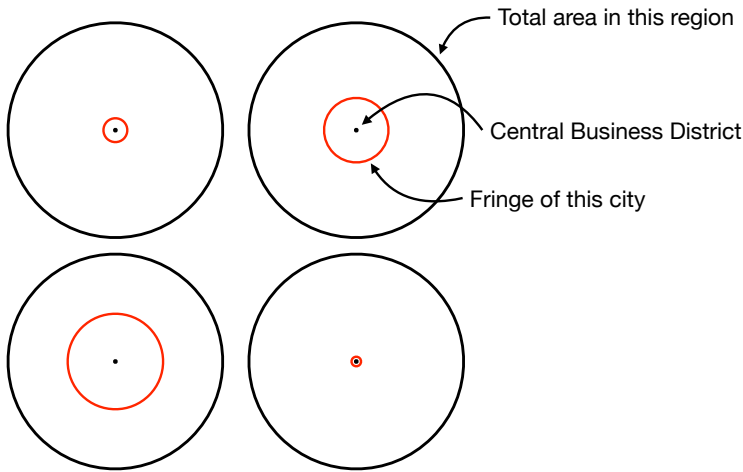

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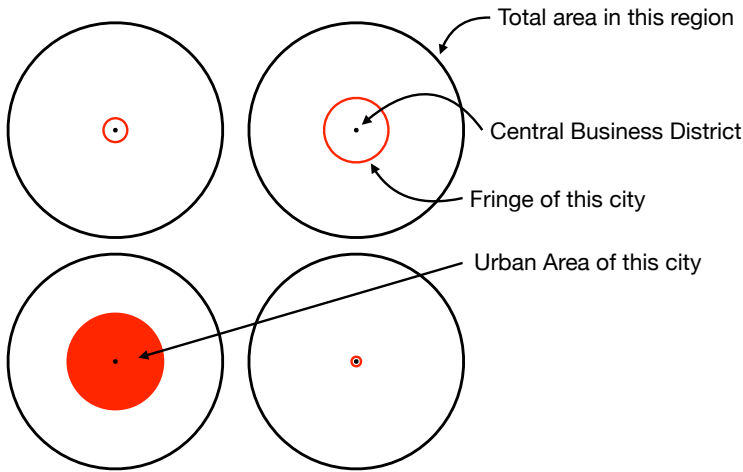

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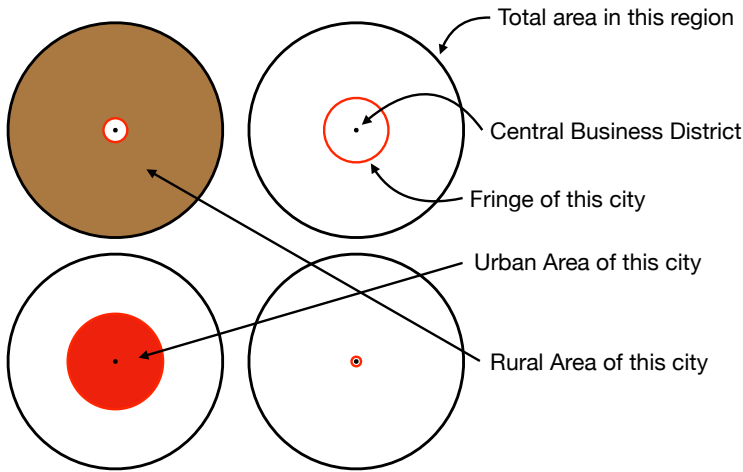

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- Economy consists of K regions of identical circular shape, but different productivities in their rural (r) and urban (u) sectors. At the center of each region k lies a single city.

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- Urban versus Rural Land: (Endogenous) commuting costs for urban workers.
- Drivers of Structural Change
  - Non-homothetic preferences for the rural good.
  - Increases in productivity during transition.

Technology

Urban, Rural goods and Housing Production

- For the urban good, only labor for simplicity,

$$Y_{u,k} = \theta_{u,k} L_{u,k}.$$

- For the rural good,

$$Y_{r,k} = \theta_{r,k} \left(L_{r,k}^{\alpha} \cdot S_{r,k}^{1-\alpha} \right).$$

- $\theta_{i,k}$ = TFP in sector i, $L_{i,k}$ = labor used in i, $S_{r,k}$ = land used in r in region k.
- Rural good more intensive in land, stronger decreasing returns to labor in (r).
- Land developers produce $H(\ell_k)$ units of housing space per unit of land.

Preferences and budget constraint

- Preferences for an individual in location ℓ are

$$C(\ell_k) = \mathcal{C}\left(c_r(\ell), c_u(\ell)\right)^{1-\gamma} h(\ell_k)^{\gamma}$$

where non-homotheticity between rural and urban good is in $\mathcal{C}$:

$$\mathcal{C}\left(c_r(\ell), c_u(\ell)\right) = \left[\nu^{1/\sigma}\left(c_r(\ell) - \underline{c}\right)^{\frac{\sigma-1}{\sigma}} + (1-\nu)^{1/\sigma}\left(c_u(\ell) + \underline{s}\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$$

- Budget constraint,

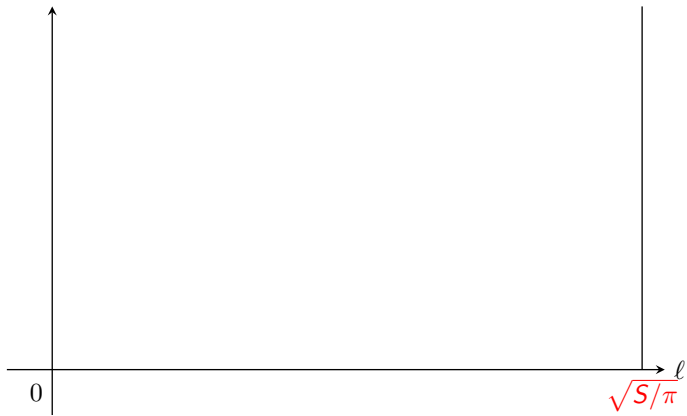
$$pc_r(\ell) + c_u(\ell) + q(\ell)h(\ell) = w(\ell) + r,$$

$q(\ell)$ the (rental) price of one unit of housing in location ℓ.
r rental income per capita, equally distributed.

Spatial Structure: Spatial Equilibrium! $C(\ell_k) = \overline{U}$

Illustrating net wages along a single radius

1. Space $\ell \in [0, \sqrt{S/\pi}]$



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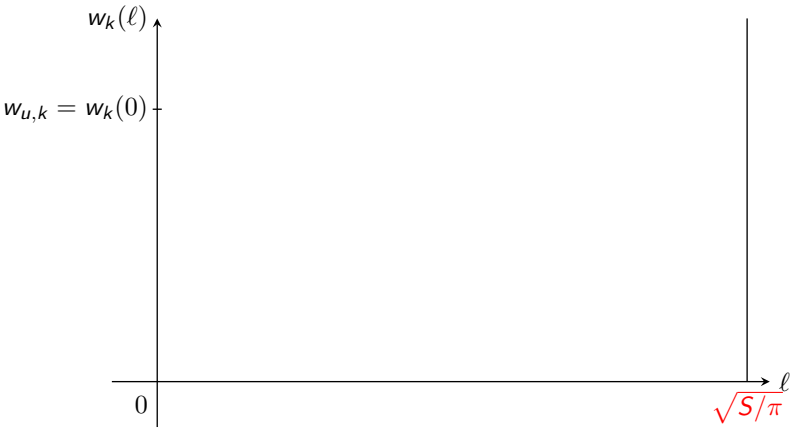

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2. Urban production at $\ell = 0$
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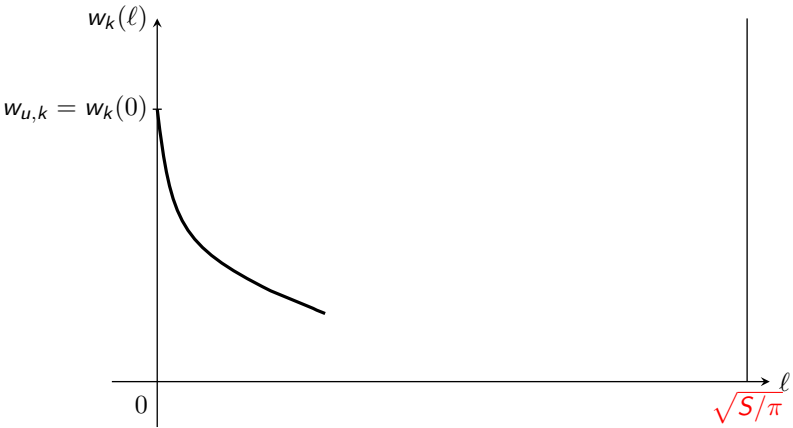

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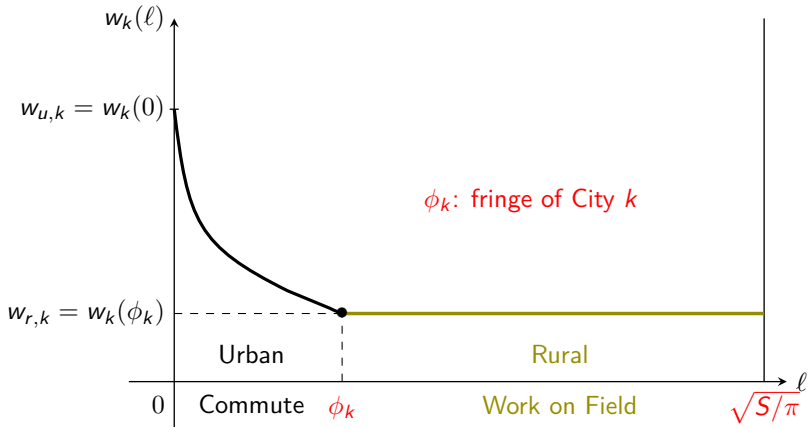

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6. ϕ_k denotes urban fringe of city k.

Commuting Costs in units of Numeraire Good

Based on DeSalvo and Huq (JUE 1996)

Our commuting cost function is:

$$\tau(\ell_k) = a \cdot (w_{u,k})^{\xi_w} (\ell_k)^{\xi_\ell}$$

- We have a micro-foundation for this model.
- Substantive points: $a > 0$ must decrease over time, and costs concave: $\xi_w, \xi_\ell \in (0, 1)$.
- $\xi_w < 1$ is key: commuting costs rise less than proportional with increasing wages.

Equilibrium

- Land developers buy land and numeraire good to provide residential floorspace.
  Details!

- Arbitrage across land use at the fringe pins down land values and house prices:

$$\rho_{r,k} = \frac{q_{r,k}^{1+\epsilon}}{1+\epsilon} = (1-\alpha) p \theta_{r,k} \left(\frac{L_{r,k}}{S_{r,k}} \right)^{\alpha}$$

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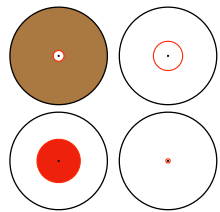
- Land Market Clearing: each city k is big enough to host $L_{r,k}$ workers, enough $S_{r,k}$ land left to produce food.
- Labour Market Clearing.
- Land Rents consistently defined.



Results:

1. **Intuition: Artificial Economy with $K = 4$**
2. **Full Quantitative Model**

Sectoral and Regional Productivities

For the productivity processes, we posit that

$$\theta_{s,k,t} = \theta_{s,t} \cdot \theta^k_{s,t}$$

We denote for sector s in period t:

- an aggregate component: $\theta_{s,t}$,
- a shifter for region k: $\theta^k_{s,t}$ with weighted mean equal to 1.

👉 Aggregating over all K cities recovers the *average* city (i.e the one following $\theta_{s,t}$ only)

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In Artificial setting ($K = 4$): fix constant growth of $\theta_{s,t}$, and pick $\theta^k_{s,t}$ *high/low*. Full model: estimate $\theta^k_{s,t}$ to match size and land price distributions.

Artificial Model. $K = 4$, constant agg. growth and shifters $\theta^k_{s,t}$

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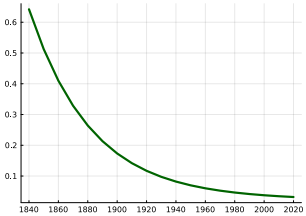

(a) Rural Labor Share.

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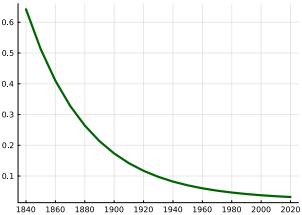

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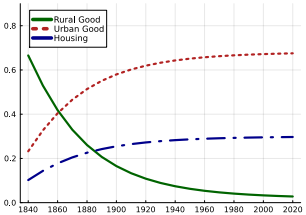

(b) Spending Shares.

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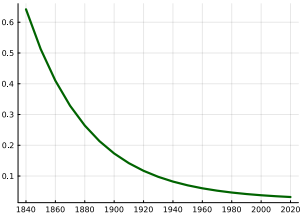

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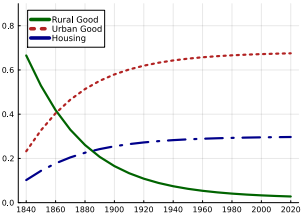

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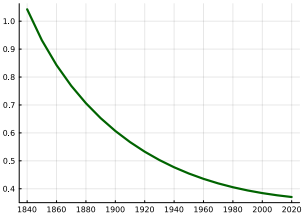

(c) Relative price p.

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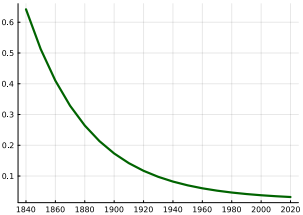

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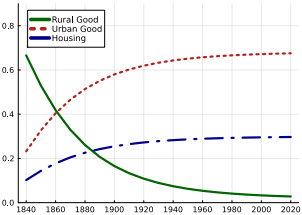

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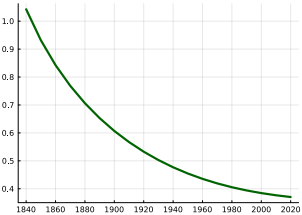

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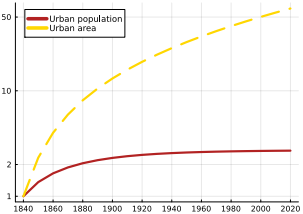

(d) Area and Population.

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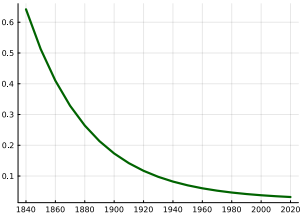

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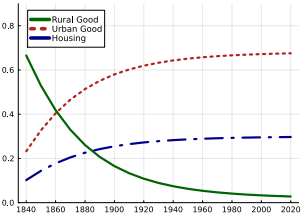

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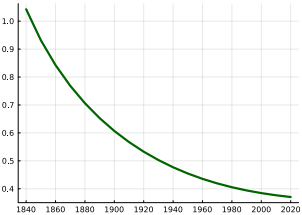
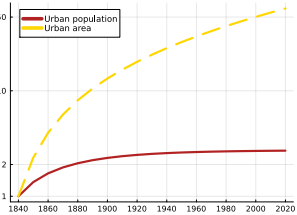
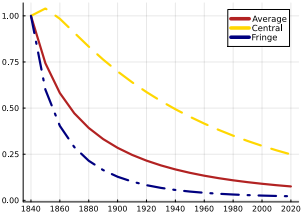


(c) Relative price p.

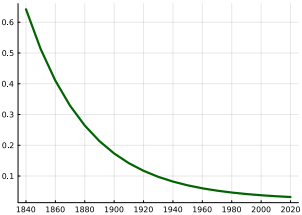


(d) Area and Population.

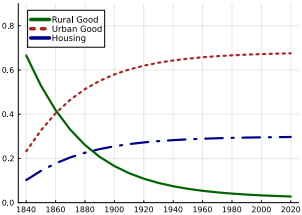


(e) Average Urban Densities.

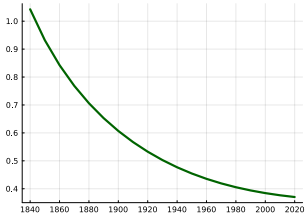
Artificial Model. $K = 4$, constant agg. growth and shifters $\theta^k_{s,t}$



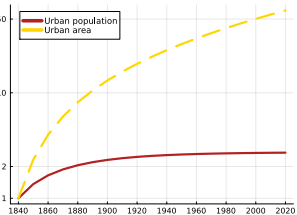
(a) Rural Labor Share.



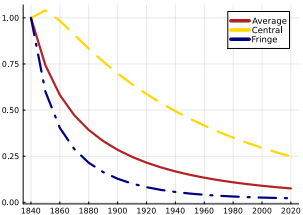
(b) Spending Shares.



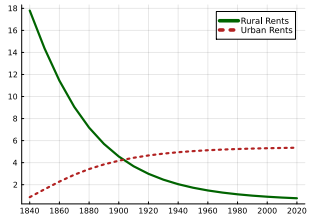
(c) Relative price p.



(d) Area and Population.



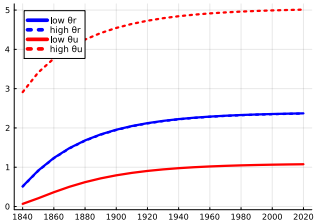
(e) Average Urban Densities.



(f) Average land rents.

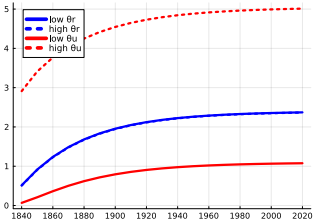
Artificial Model. $K = 4$: Identifying Cross sectional differences via $\left\{\theta^k_{s,t}\right\}$

Artificial Model. $K = 4$: Identifying Cross sectional differences via $\left\{\theta_{s,t}^k\right\}$

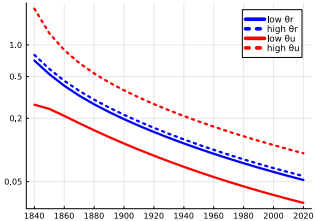


(a) Urban population.

Artificial Model. $K = 4$: Identifying Cross sectional differences via $\left\{\theta^k_{s,t}\right\}$

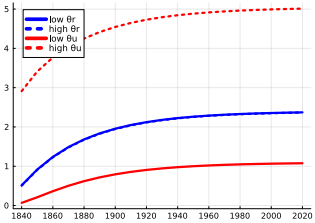


(a) Urban population.

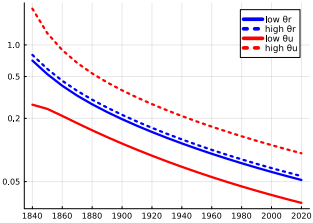


(b) Average urban Densities.

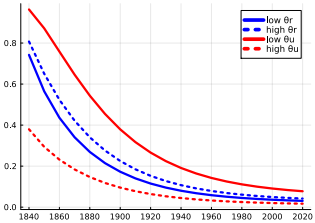
Artificial Model. $K = 4$: Identifying Cross sectional differences via $\left\{\theta^k_{s,t}\right\}$



(a) Urban population.

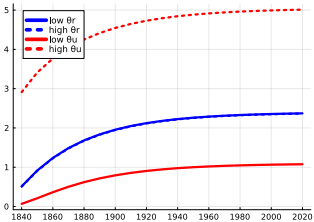


(b) Average urban Densities.

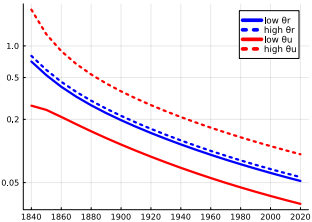


(c) Rural employment share.

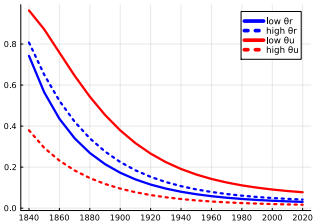
Artificial Model. $K = 4$: Identifying Cross sectional differences via $\left\{\theta^k_{s,t}\right\}$



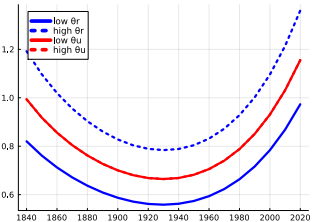
(a) Urban population.



(b) Average urban Densities.

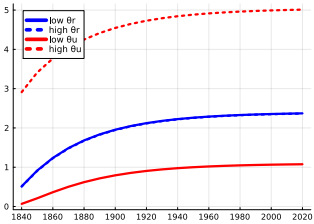


(c) Rural employment share.

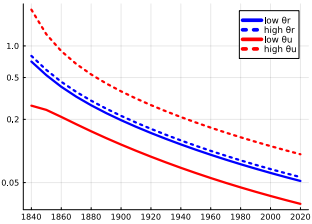


(d) Rural Land Rents.

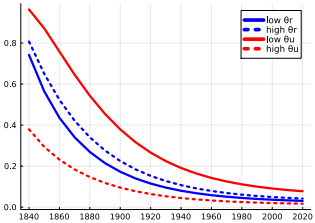
Artificial Model. $K = 4$: Identifying Cross sectional differences via $\left\{\theta^k_{s,t}\right\}$



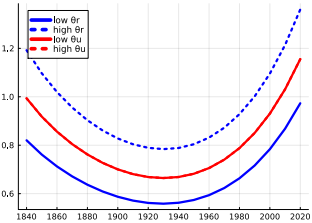
(a) Urban population.



(b) Average urban Densities.



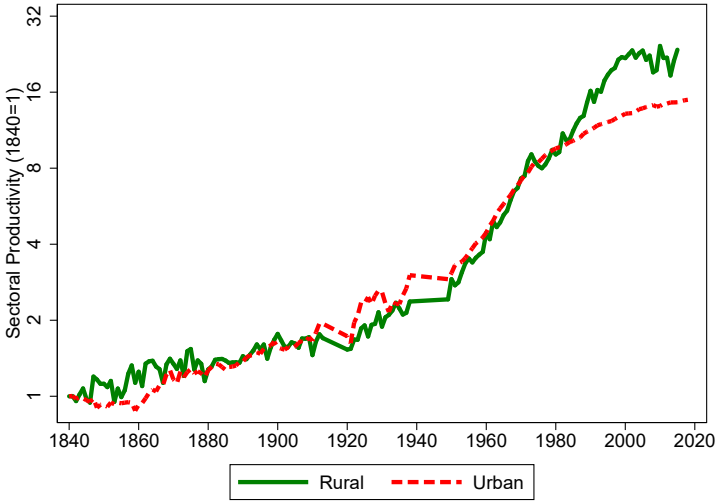
(c) Rural employment share.



(d) Rural Land Rents.

Local vs Global Shocks!

(Aggregate) Productivities Estimated From Data



- $\theta_{s,k,t} = \theta_{s,t} \cdot \theta^k_{s,t}$
- Aggregate Processes: $\theta_{s,t}$
- Regional shifters: $\theta^k_{s,t}$

Estimation and Identification

We target the following moments:

Aggregate:

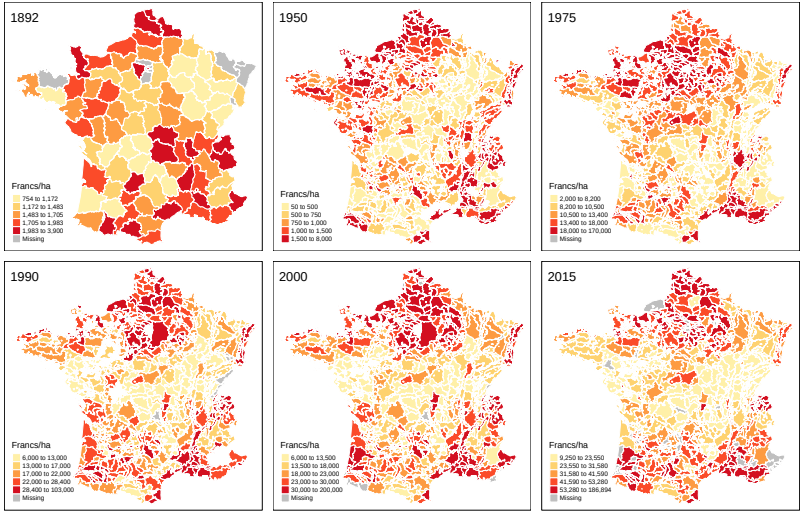
- L_{rt}/L_t: *Aggregate* employment share in each period.
- *Average* City is 18% of rural area in 2015.
- *Aggregate* spending share on housing 1900 and 2010.

Regional:

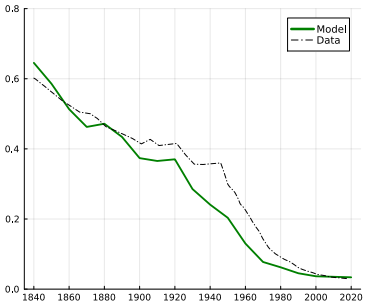
- L_{ukt}/L_{u1t}: Urban pop in city k rel. to city 1 (Paris) $\Rightarrow \{\theta^k_{u,t}\}$
- ρ_{kt}/ρ_{1t}: Farmland value outside city k rel. to city 1. $\Rightarrow \{\theta^k_{r,t}\}$

Internal city structure, density fall, commuting speed, house price: not targeted!

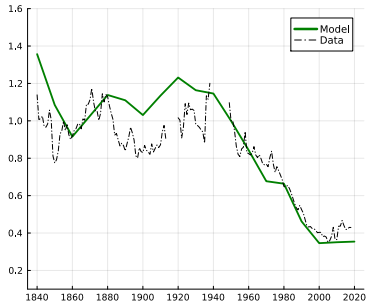
Novel Data on Land Values!



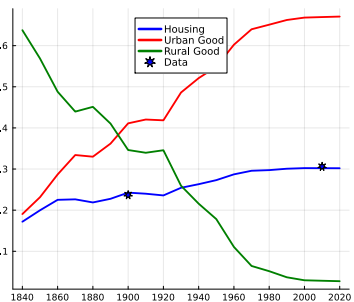
Aggregate Results: Structural Change



(a) Rural employment share.



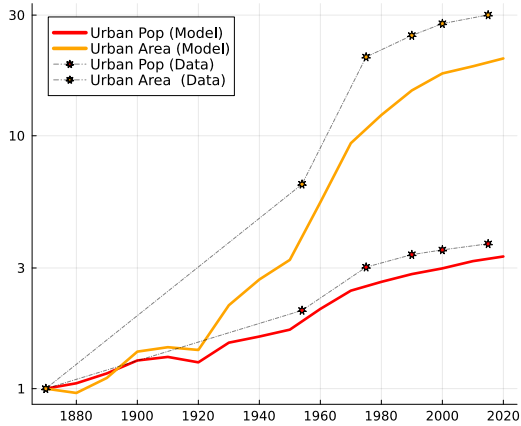
(b) Relative price of rural good.



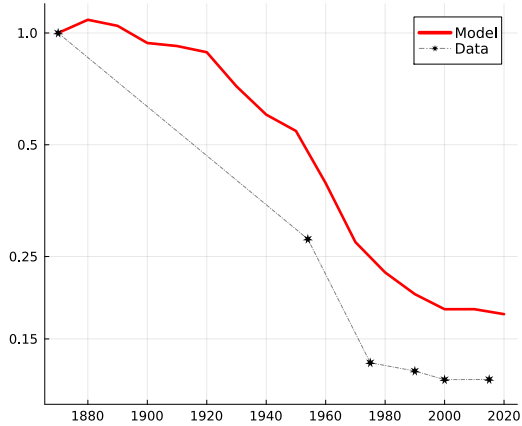
(c) Spending shares.

Figure: Structural change aggregated over K cities.

Aggregate Results: Urban Expansion



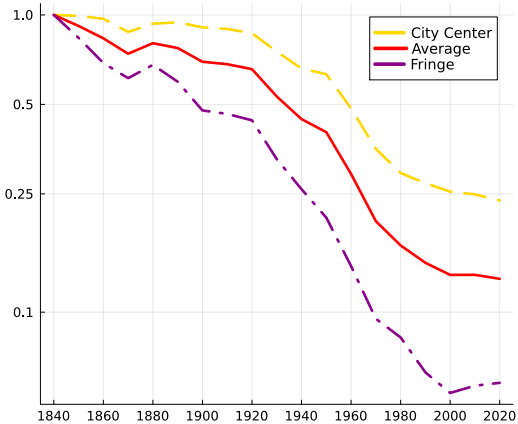
(a) Urban Area and Population (1870=1)



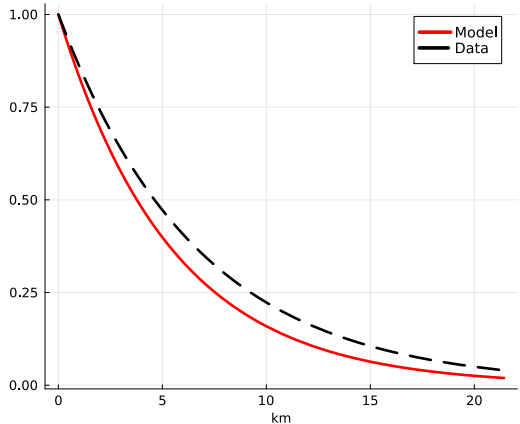
(b) Average urban density (1870=1)

Figure: Urban expansion aggregated over K cities.

Aggregate Results: Urban Structure



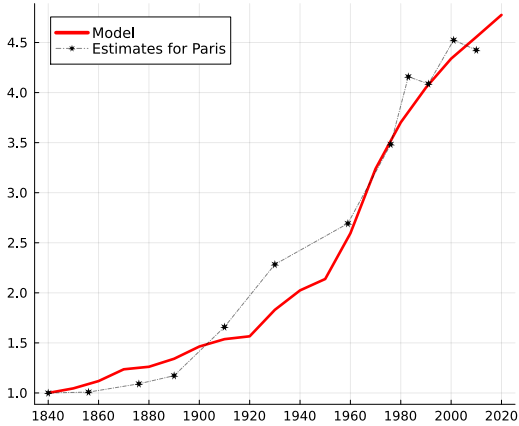
(a) Urban density (1840=1).



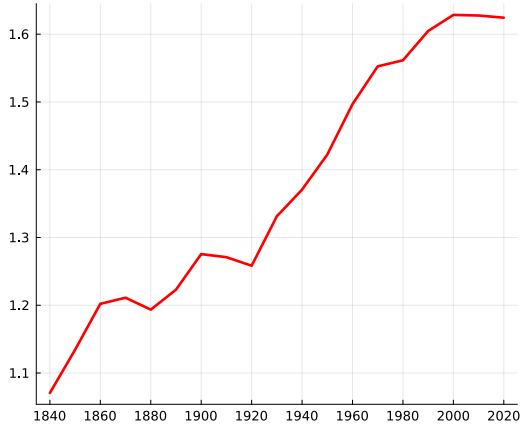
(b) Density gradient (2020).

Figure: Density across space.

Aggregate Results: Commuting Speed and APG



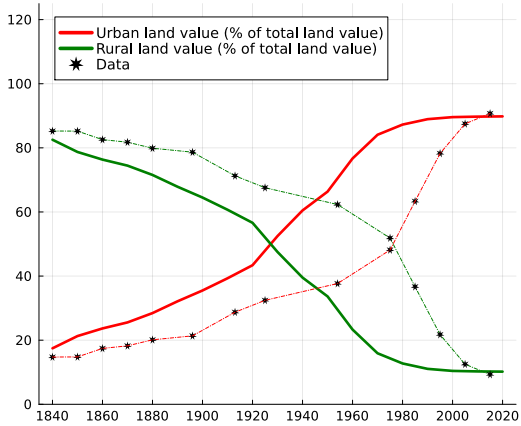
(a) Average urban commuting speed (1840=1).



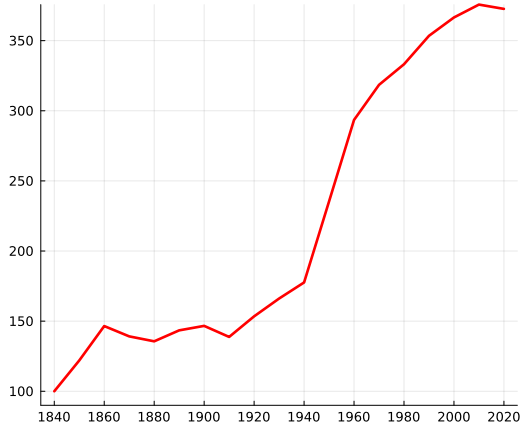
(b) Agricultural productivity gap.

Figure: Commuting speed and the 'agricultural productivity gap'

Aggregate Results: Wealth Distribution and House Price



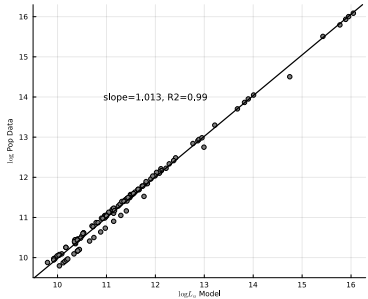
(a) Urban versus rural land wealth.



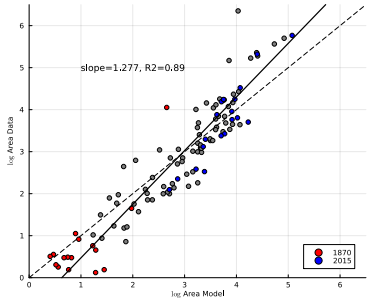
(b) Real Housing Price Index (1840=100).

Figure: Land values and housing price

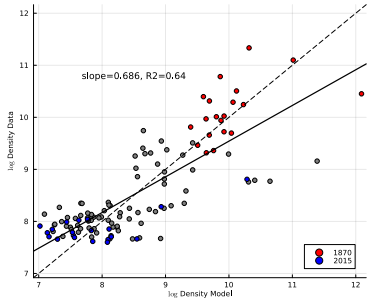
Regional Results: Outcomes Across Regions



(a) Urban Population.



(b) Urban Area.



(c) Urban Density.

Figure: Regional Urban Moments

Regional Results: Urban Density and Land Values

	log Urban Density		
	Model	Data (OLS)	Data (IV)
$\log \overline{\rho}_{r,k,t}$	0.371***	0.126***	0.346***
	(0.018)	(0.026)	(0.098)
Controls	$\log w_{u,k,t}$	$\log w_{u,k,t}$	$\log w_{u,k,t}$
Num.Obs.	80	766	314
R2	0.994	0.253	0.272
FE: year	X	X	X

Table: Urban density and rural land values in model and data.

Sensitivity Analysis

Counterfactuals enlightening the mechanisms

- The role of rural productivity growth. ▸ lower rural growth
- The role of faster commuting modes. ▸ $\xi_w = 1$
- The elasticity of substitution between land and labor in the rural sector. (Section B.3.1. in Appendix B)
- Constant housing elasticity $\epsilon = 3$. ((Section B.3.2. in Appendix B))

Extensions

1. Agglomeration. (Section B.3.3. in Appendix B)
2. Relaxing Monocentricity. (Section B.3.4. in Appendix B)

Conclusion

We introduced a spatial general equilibrium model of land use to explain

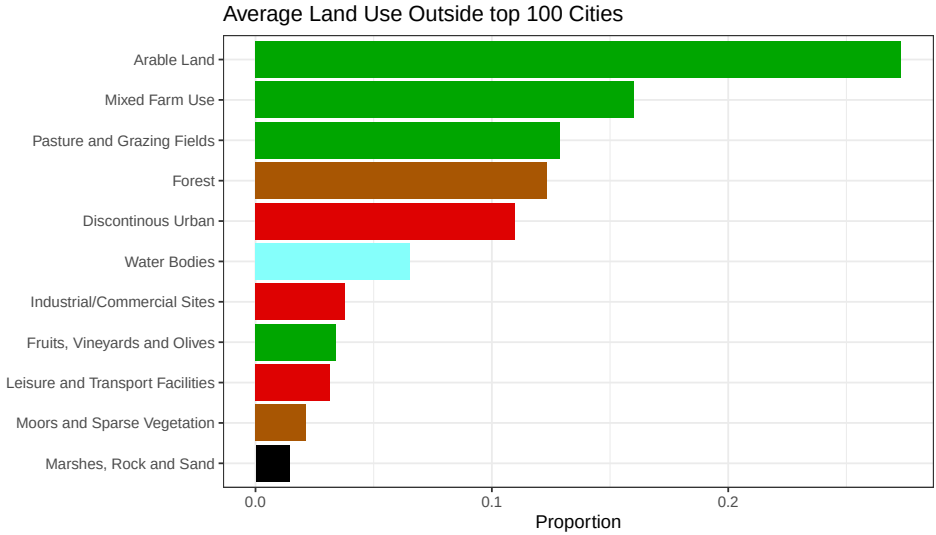
1. Evolution of sectoral allocation across space.
2. Evolution of Urban Density.
3. Evolution of the land value distribution.

We found:

- Rural Productivity growth is crucial to understand urban expansion.
- Quantitatively, both rural and urban productivity growth as well as falling commuting costs are needed to explain data.

THANK YOU!

Land Use *Outside* Top 100 French Cities Today



▸ Paris

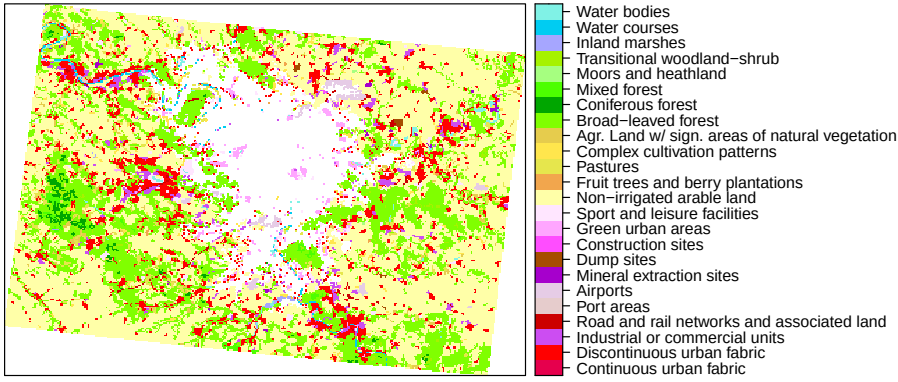
▸ Lyon

▸ Marseille

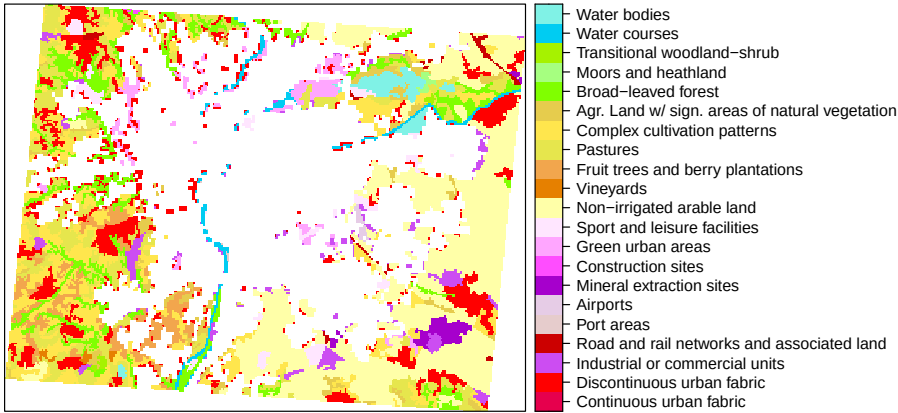
▸ Bordeaux

▸ back

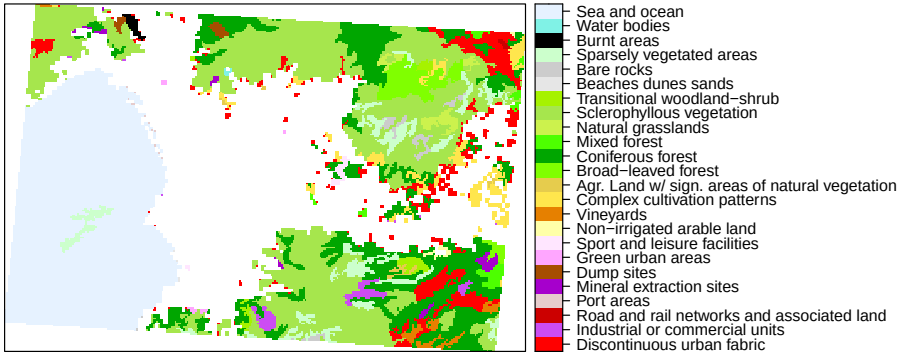
Land Use outside Paris 2020



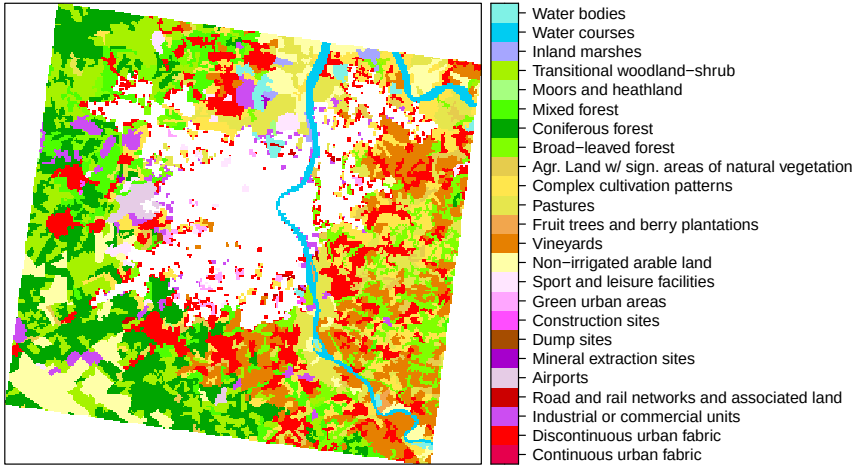
Land Use outside Lyon 2020



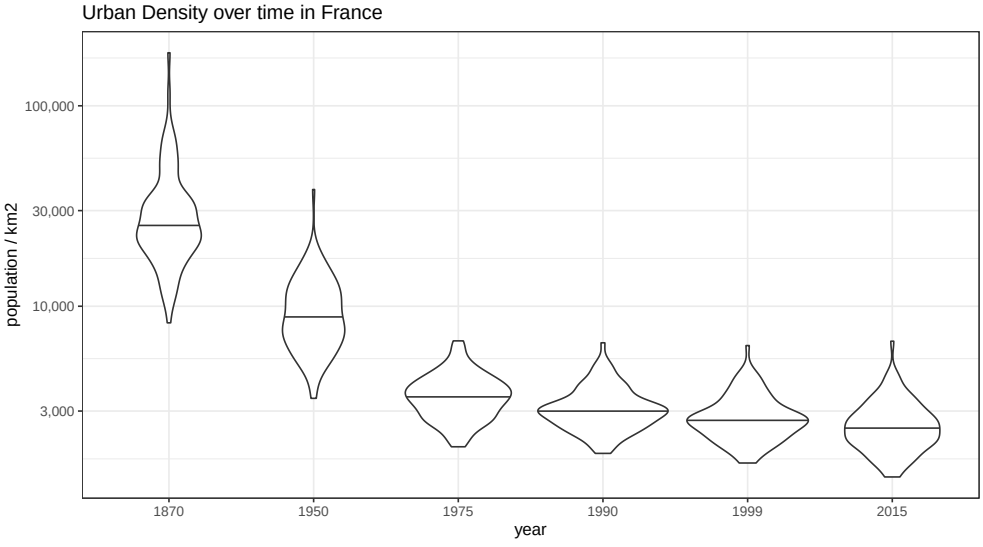
Land Use outside Marseille 2020



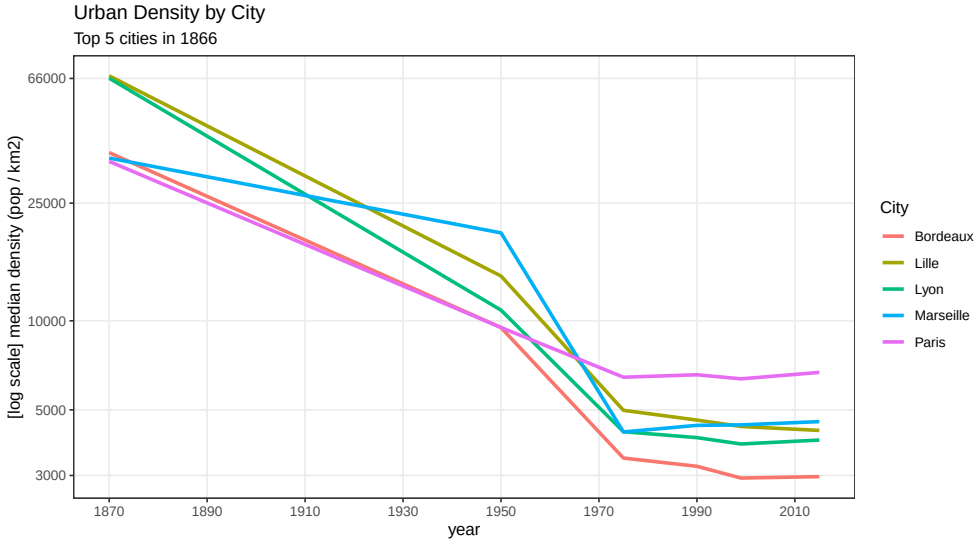
Land Use outside Bordeaux 2020



The historical fall in urban density

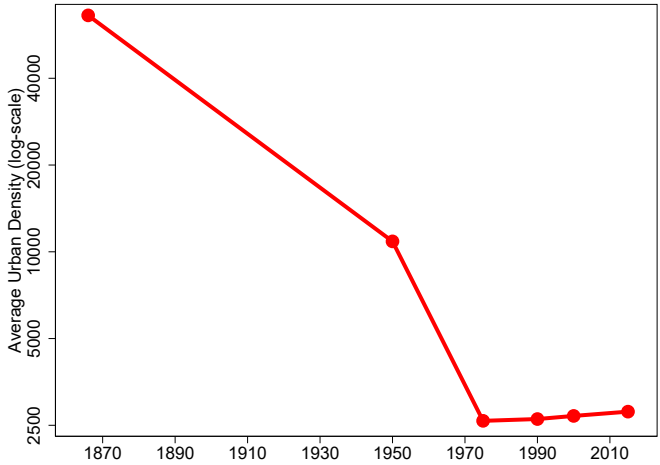


The historical fall in urban density



The historical fall in urban density

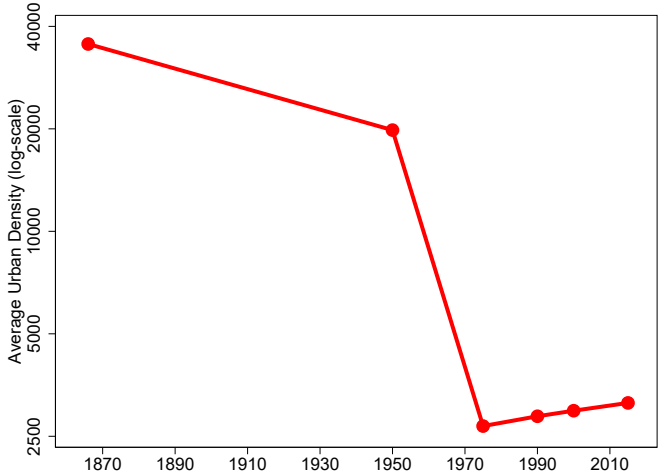
Lyon



back

The historical fall in urban density

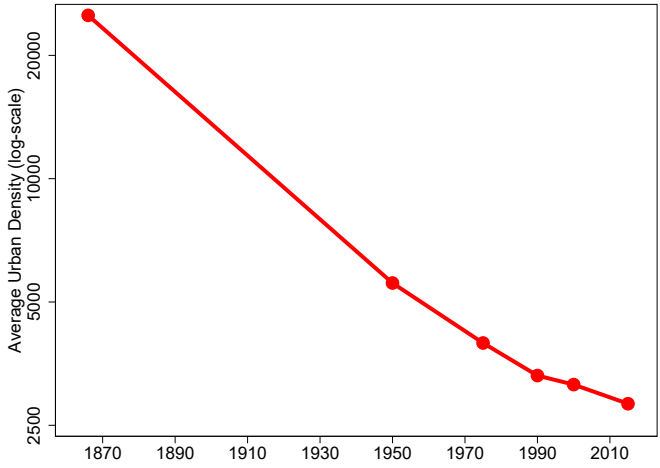
Marseille



back

The historical fall in urban density

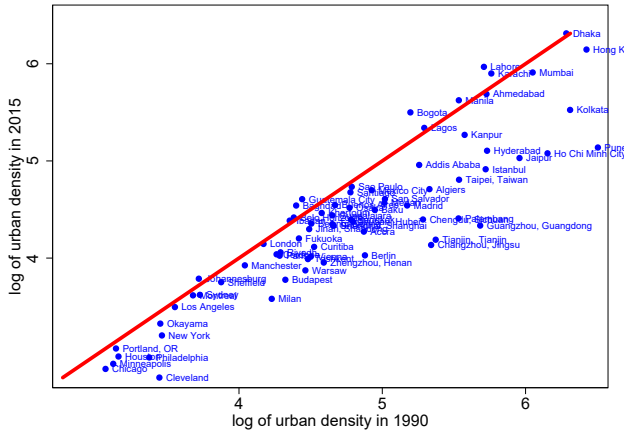
Reims



back

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).

back

Housing Market Equilibrium

Land developers

- Housing supply provided by land developers.
- Use more or less intensively the land for residential purposes.
- Technology

  In each location, developers supply housing space $H(\ell)$ per unit of land with a convex cost,

  $$\frac{H(\ell)^{1+1/\epsilon}}{1+1/\epsilon},$$

  in units of the numeraire.

  $\epsilon =$ cost parameter, possibly dependent on the location.

Housing Market Equilibrium

Housing supply

- Profits per unit of land at ℓ,

$$\pi(\ell) = q(\ell)H(\ell) - \frac{H(\ell)^{1+1/\epsilon_\ell}}{1+1/\epsilon_\ell} - \rho(\ell),$$

  $\rho(\ell)$ the price of a unit of **land** in ℓ.

- Housing supply from profit maximization,

$$H(\ell) = q(\ell)^{\epsilon_\ell},$$

  with housing supply elasticity $\epsilon_\ell \geq 0$, $\partial\epsilon_\ell/\partial\ell \geq 0$.
  see Baum-Snow and Huan (2019).

Housing Market Equilibrium: Supply

Land Prices and Land Use

- Profit maximization and free entry of developers pins down land prices in ℓ,

$$\rho(\ell) = \frac{q(\ell)^{1+\epsilon_\ell}}{1+\epsilon_\ell},$$

- Land use with the highest rental value (Rivalry)
- Indifference conditions across uses at the fringe,

$$\rho_r = \frac{(q_r)^{1+\epsilon_r}}{1+\epsilon_r} = (1-\alpha)p\theta_r \left(\frac{L_r}{S_r}\right)^{\alpha}.$$

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GHSL Measurement - Reims

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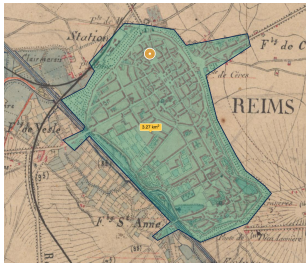
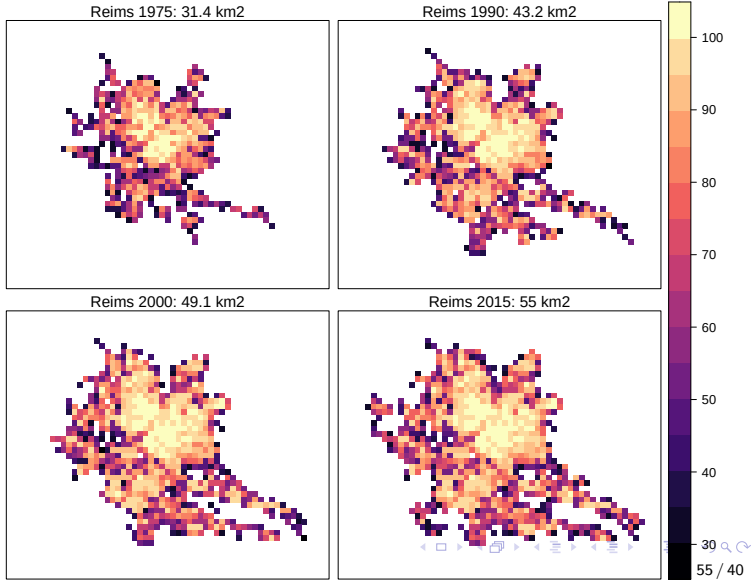
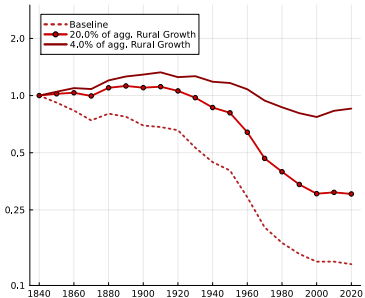


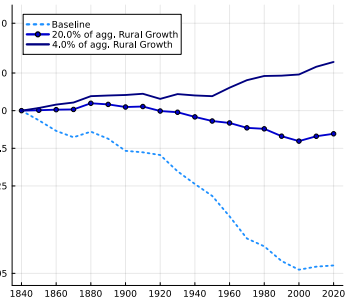


Sensitivity Analysis

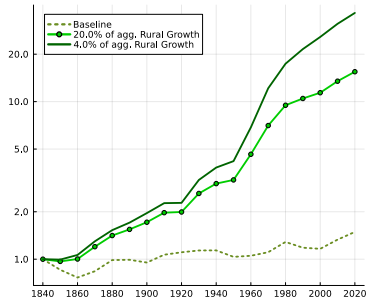
The role of rural productivity growth



(a) Average density (1840=1).



(b) Density at the fringe (1840=1).



(c) Rental price of farmland.

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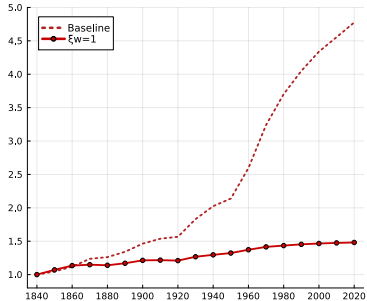
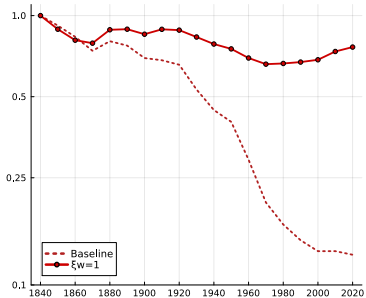
Sensitivity Analysis

The role of increasing commuting speed

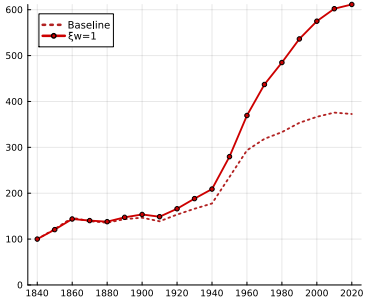
$$\tau(\ell) = a \cdot w_u^{\xi_w} \cdot \ell^{\xi_\ell}$$



(a) Commuting speed (1840=1).



(b) Average density (1840=1).



(c) House Price Index (1840=1).

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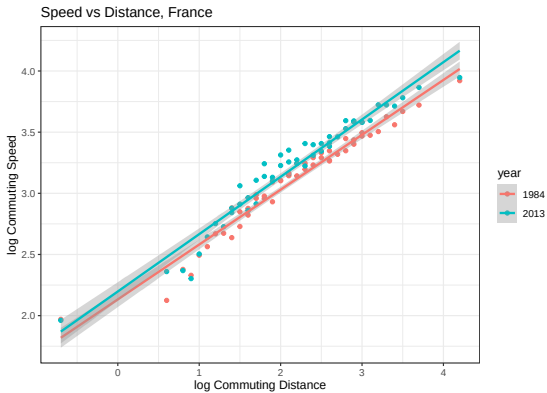
Calibration of τ

- Micro foundation yields:

$$\tau(\ell) = a \cdot w_u^{\xi_w} \cdot \ell^{\xi_\ell}$$

- The elasticites of commuting speed m with respect to income and speed are defined and measured in individual commuting data as:

  1. Income: $1 - \xi_w$. Given distance, increase in speed over increase in income (across years (see plot).
  2. Distance: $1 - \xi_\ell$. Given income, elasticity of speed to distance (in a given year - see table III in appendix).



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