Structural Change, Land Use and Urban Expansion

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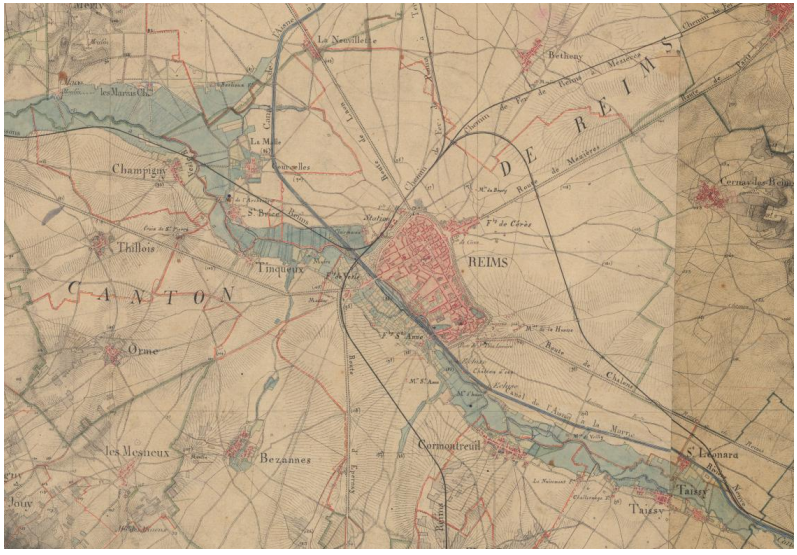
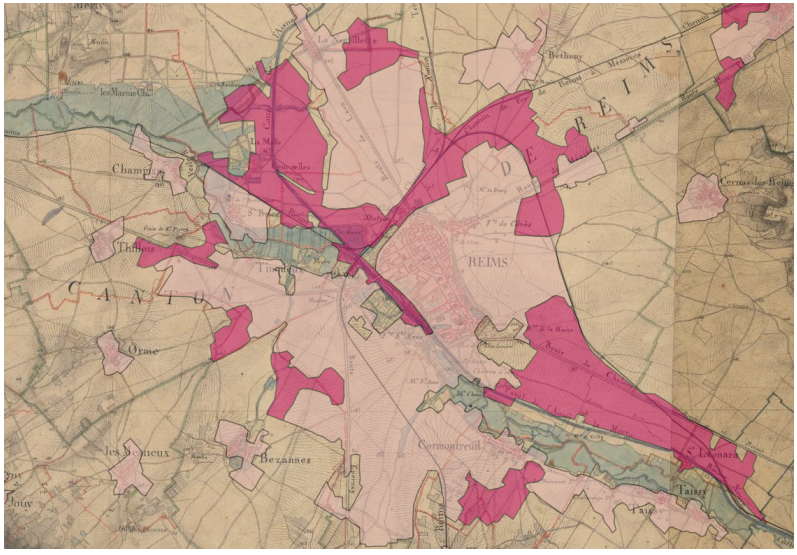
https://floswald.github.io/publication/landuse/

Sailing The Macro 2023 ⛵

Motivation: Reims in 1866

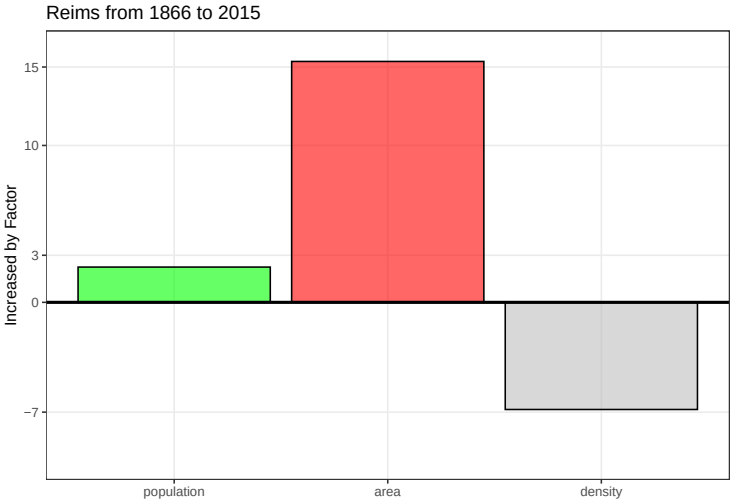


Motivation: Reims in 1866 vs IGN *Buildings* in 2017



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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   - Food subsistence constraint 🍗 is binding initially. High land values. No income left for bigger houses. (No need to commute to large suburban houses.)
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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

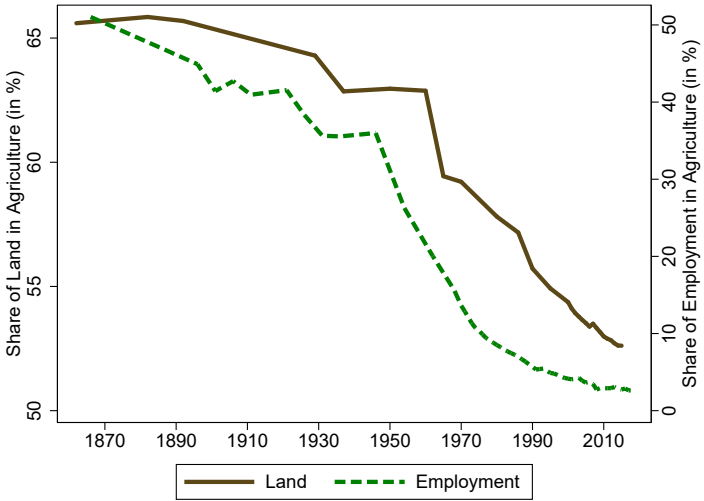
- Survey: Herrendorf, Rogerson and Valentinyi (2014). Theory: Kongsamut et al. (2001), Gollin et al. (2002), Boppart (2014), Acemoglu and Guerrieri (2008), Ngai and Pissarides (2007)... Structural change and urbanization. Lewis (1954), Michaels et al. (2012). Eckert and Peters (2018).
- Agricultural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

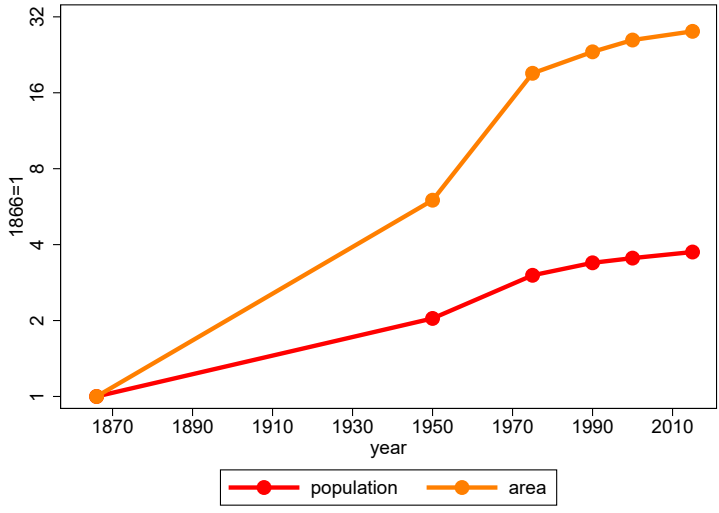


Sources:

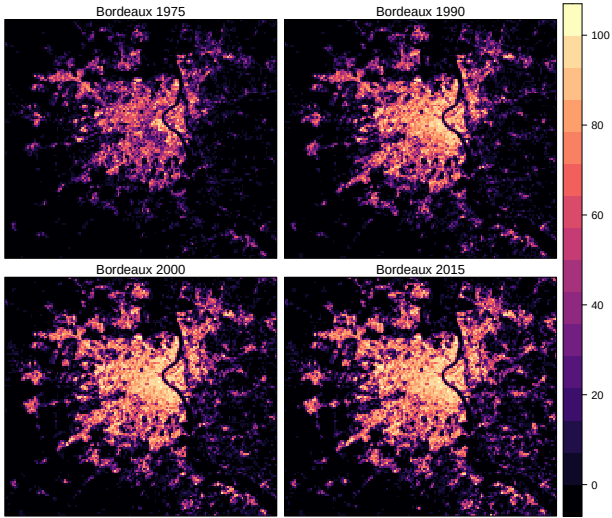
1. Toutain (1993)
2. Recensement Agricole (Ministry of Agriculture)
3. INSEE
4. Villa (1996)

Urban Expansion

Top 100 Cities in France

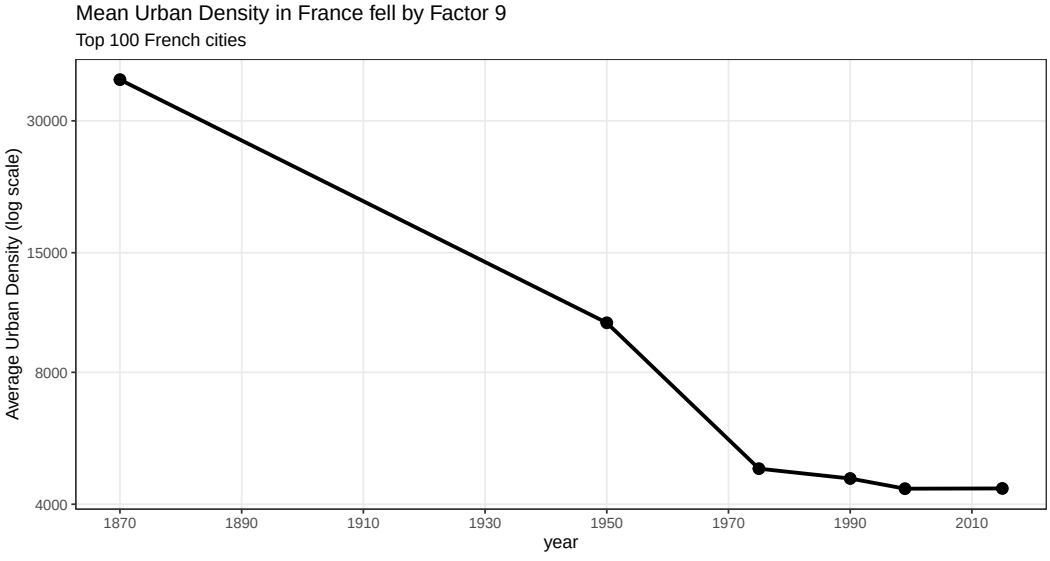


City Area and Population Measurement



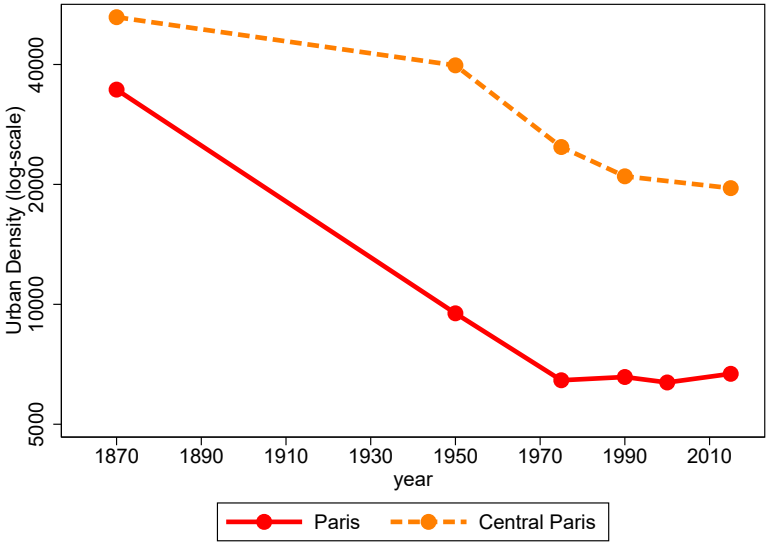
- 1866: Manual + Census
- 1950: Manual + Census
- 1975, 1990, 2000, 2015: GHSL
- ▸ More details please!

The Historical Fall in Urban Density



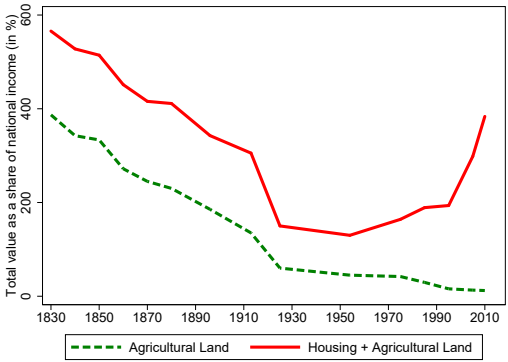
mean weighted by population in 1975

The Historical Fall in Urban Density: Within Paris

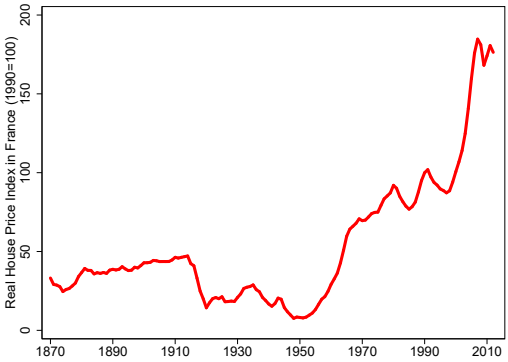


Distribution
Top 5
World

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



(a) Picketty and Zucman (2014)



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

Model

A general equilibrium model of land use

Set-up

- Three sectors and goods: rural (r), urban (u) and housing (h).
  - Different intensity in the use of land as input
  - Rival Land Use: Agriculture *or* Housing
  - Fixed Supply of Land
- 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 and Rural goods Production

- For the urban good, only labor for simplicity,

$$Y_u = \theta_u L_u.$$

- For the rural good,

$$Y_r = \theta_r \left(L_r^{\alpha} \cdot S_r^{1-\alpha} \right).$$

- 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 of one unit of housing in location ℓ.
$\mathbf{r}$ rental income 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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3. Residence at any $\ell \in [0, 1]$

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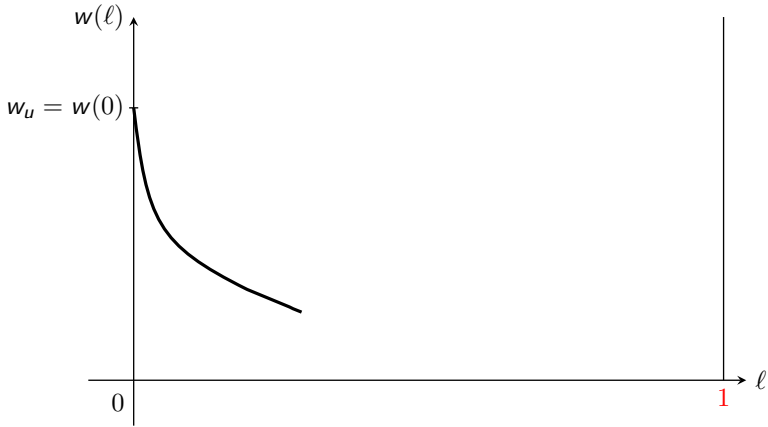

1. Space $\ell \in [0, 1]$
2. Urban production at $\ell = 0$
3. Residence at any $\ell \in [0, 1]$
4. $\tau(\ell)$: commuting cost from ℓ
5. $w_u - \tau(\ell)$ urban wage

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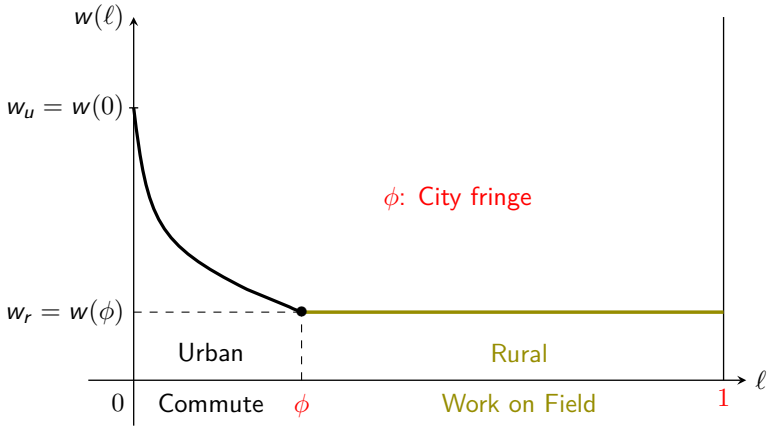

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4. $\tau(\ell)$: commuting cost from ℓ
5. $w_u - \tau(\ell)$ urban wage
6. ϕ denotes urban fringe.

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:

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

- Land Market Clearing.
- Labour Market Clearing.
- Land Rents consistently defined.

Summary of Main Mechanisms

Transitory Dynamics with Rising Productivity and Falling Commuting Costs

- **Old Times:** 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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- **Recent Times:** Reallocation of factors/land use slows down. Cities expand less and land prices increase more with rising productivity. Land particularly scarse in some locations.

Results

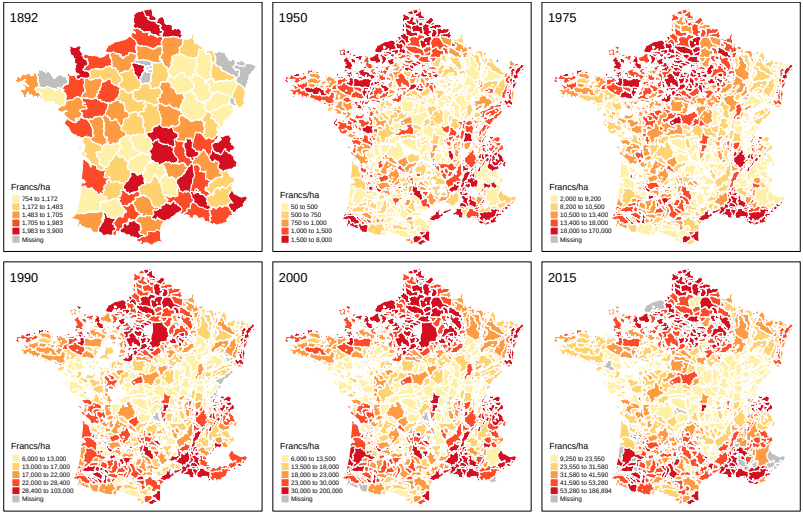
Numerical Model: K Cities

- To leverage cross-sectional data, we extend the model to K regions with one city each.
- Each region/city has a different (exogenous) path of productivies in each sector s, i.e.

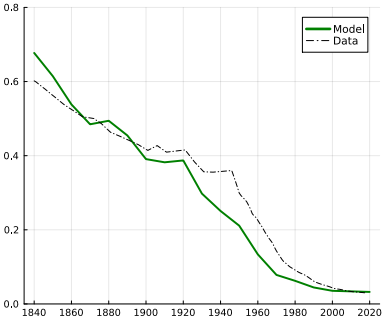
$$\theta_{s,k,t} = \theta_{s,t} \cdot \theta^k_{s,t}$$

  where $\theta^k_{s,t} = 1$ collapses to the one-city model presented above.
- We impose that the aggregation reconstructs the *average* French city.
- Fit Population distribution and land value distributions across regions.

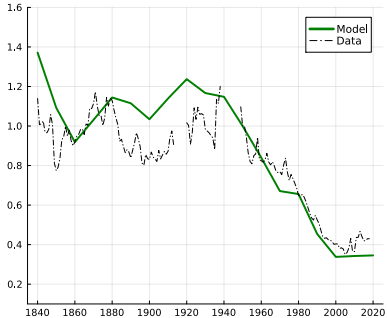
Novel Data on Land Values!



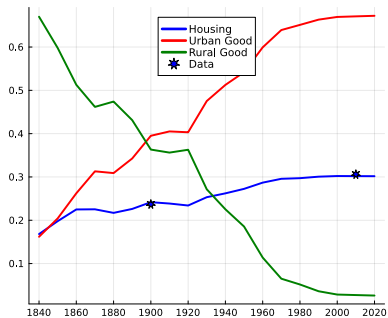
Aggregate Results: Structural Change



(a) Rural employment share.



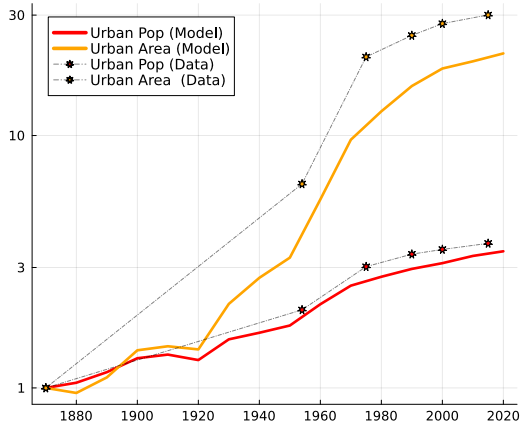
(b) Relative price of rural good.



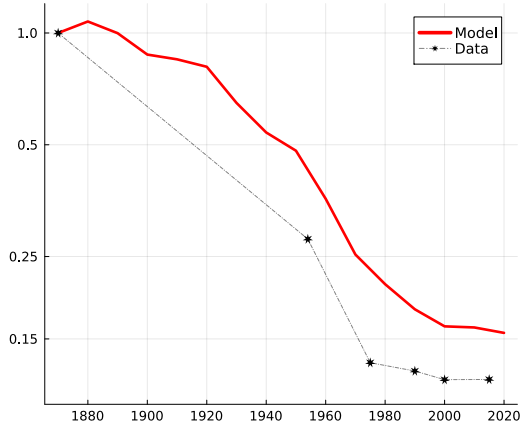
(c) Spending shares.

Figure: Structural change aggregated over K cities.

Aggregate Results: Urban Expansion



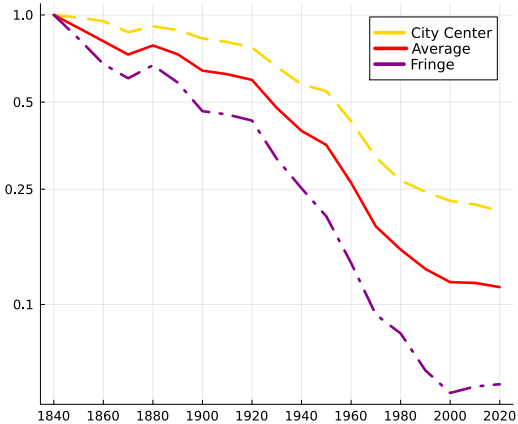
(a) Urban Area and Population (1870=1)



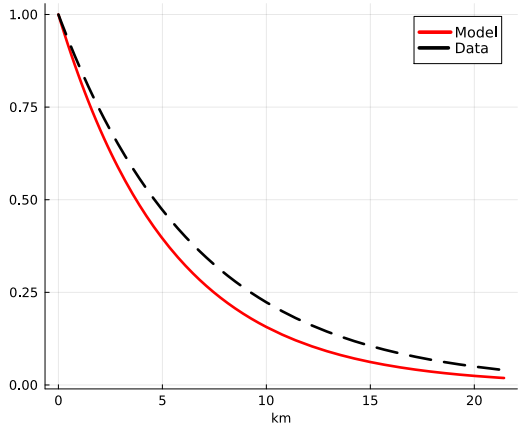
(b) Average urban density (1870=1)

Figure: Urban expansion aggregated over K cities.

Aggregate Results: Urban Structure



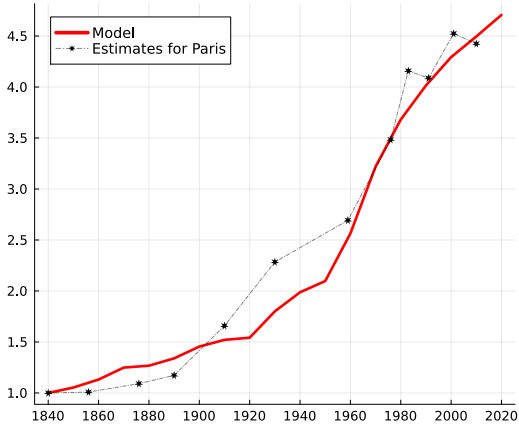
(a) Urban density (1840=1).



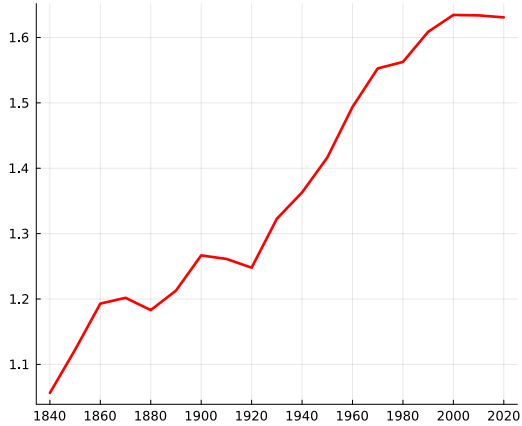
(b) Density gradient (2020).

Figure: Density across space.

Aggregate Results: Commuting Speed and APG



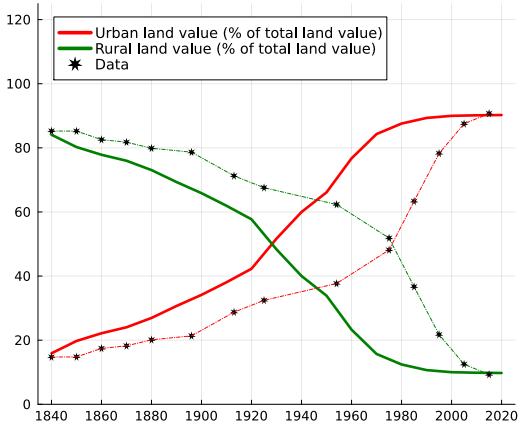
(a) Average urban commuting speed (1840=1).



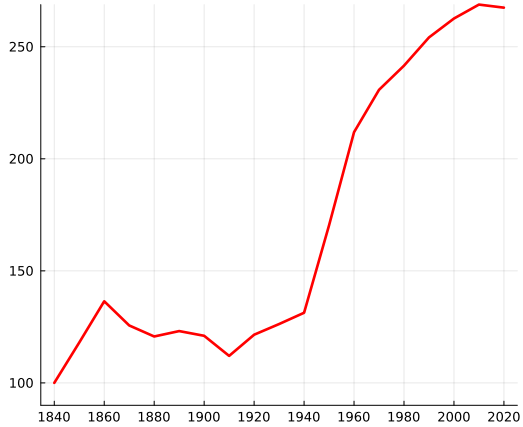
(b) Agricultural productivity gap.

Figure: Commuting speed and the 'agricultural productivity gap'

Aggregate Results: Wealth Distribution and House Price



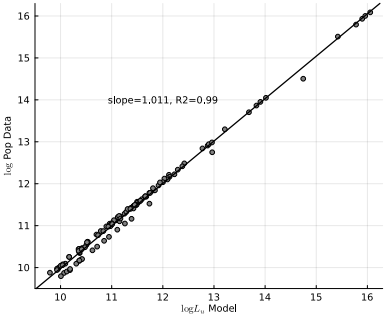
(a) Urban versus rural land wealth.



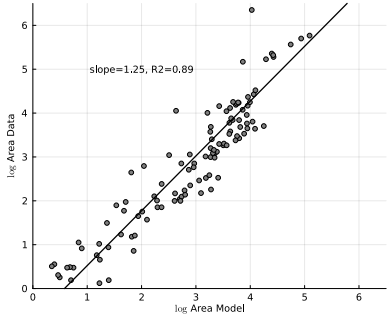
(b) Real Housing Price Index (1840=100).

Figure: Land values and housing price

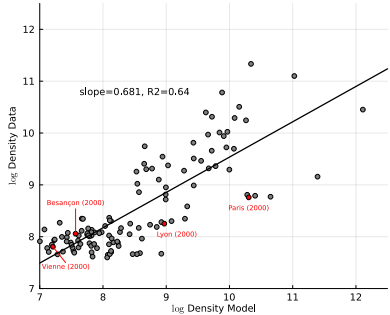
Regional Results



(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)
$\log \overline{\rho}_{r,k,t}$	0.370***	0.126***	0.346***
	(0.020)	(0.026)	(0.084)
Num.Obs.	80	766	314
R2	0.994	0.253	0.336
Controls	$w_{u,k,t}$	$w_{u,k,t}$	$w_{u,k,t}$
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. (in paper)
- Constant housing elasticity $\epsilon = 3$. (in paper)

Extensions

1. Agglomeration. (in paper)
2. Relaxing Monocentricity. (in paper)

Conclusion

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

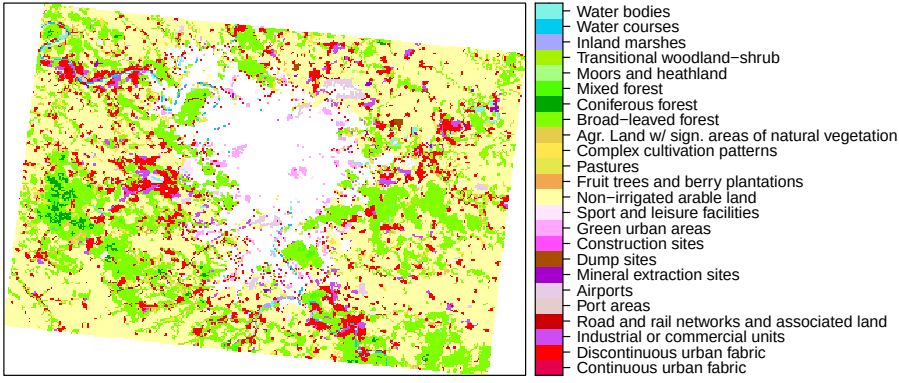
1. Evolution of sectoral allocation across space.
2. Evolution of Urban Density.
3. Evolution of the land value distribution.

We found:

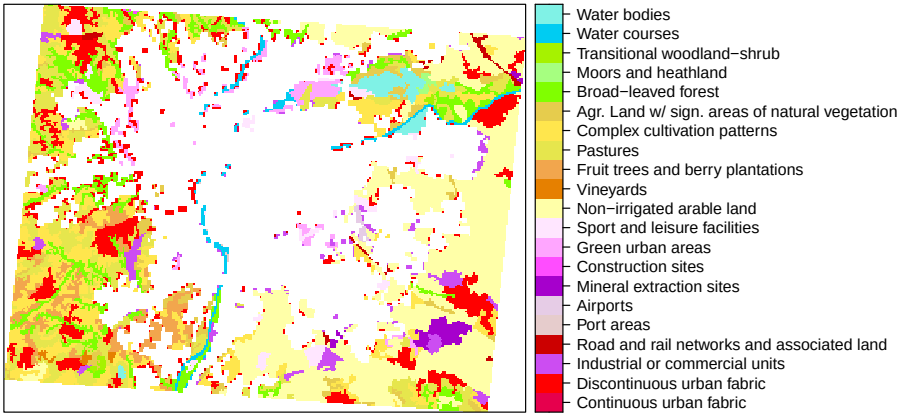
- Rural Productivity growth is crucial to understand urban expansion.
- Quantitatively, both rural and urban productivity growth as well as falling commuting costs are needed to explain data.

THANK YOU!

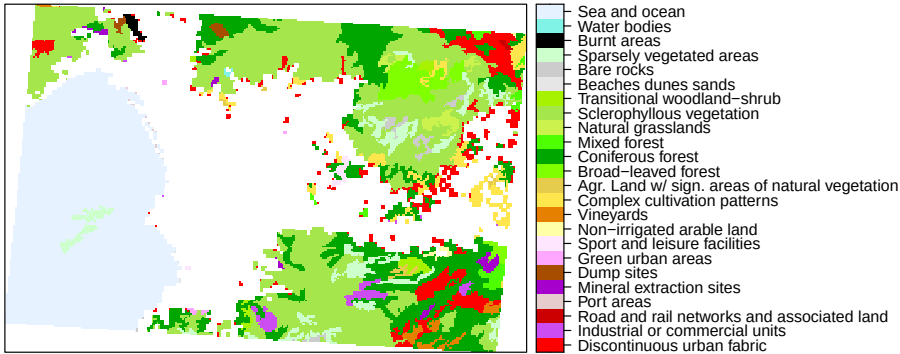
Land Use outside Paris 2020



Land Use outside Lyon 2020



Land Use outside Marseille 2020



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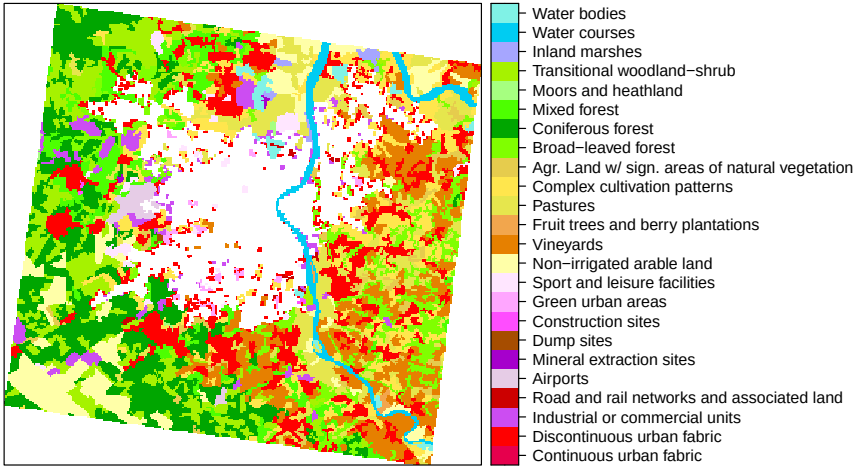
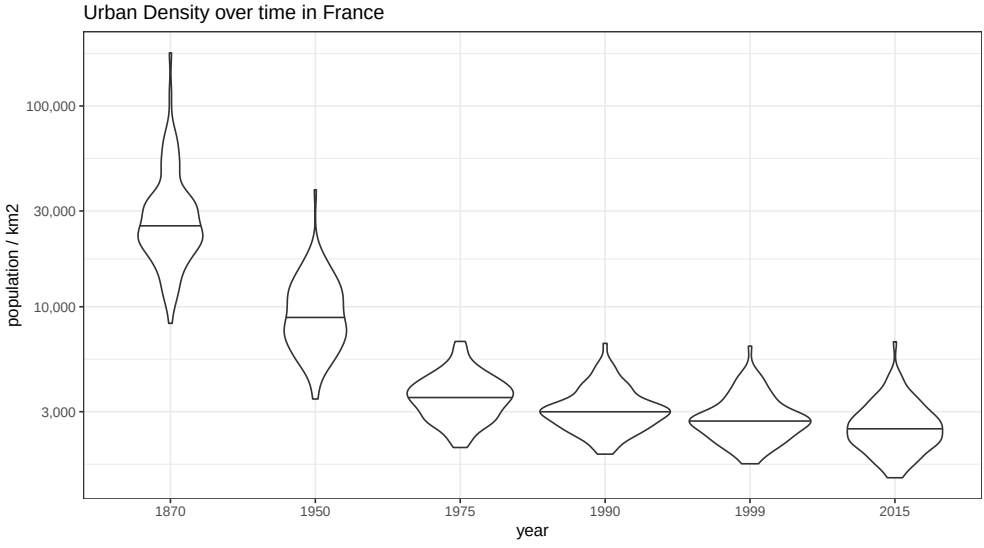
Land Use outside Bordeaux 2020



The historical fall in urban density



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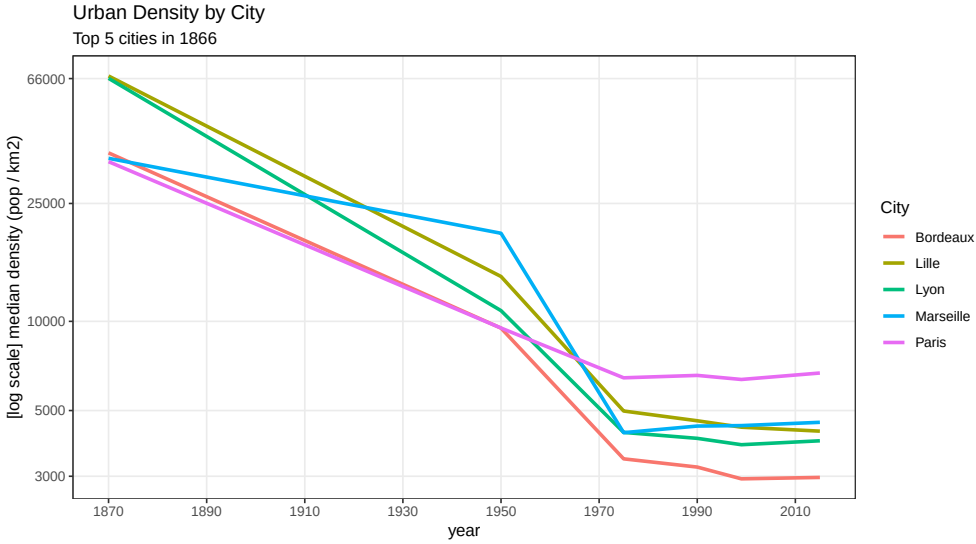
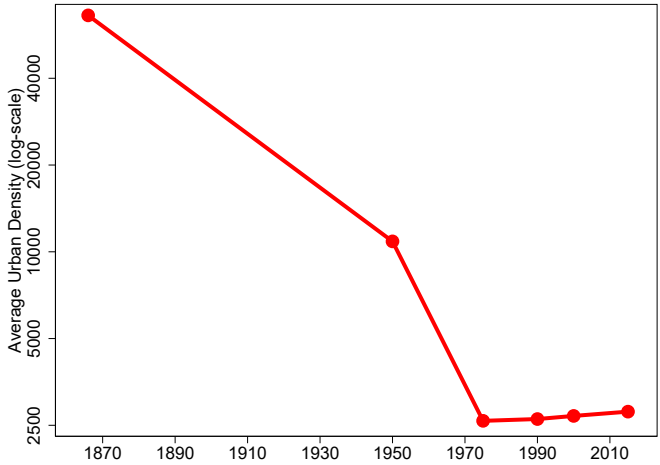


The historical fall in urban density

Lyon



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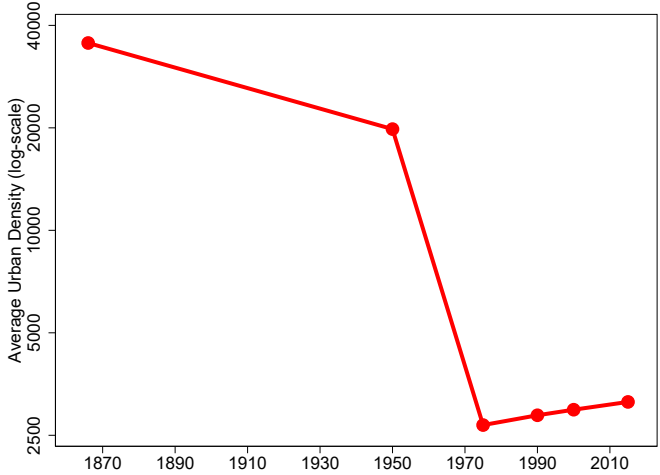
The historical fall in urban density

Marseille



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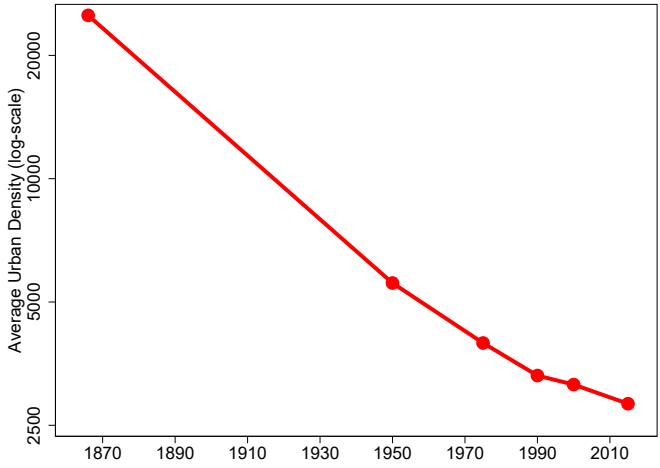
The historical fall in urban density

Reims



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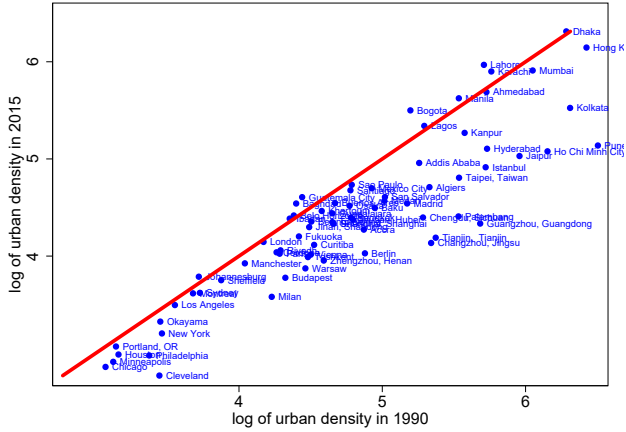
The fall in urban density across the globe, 1990-2015

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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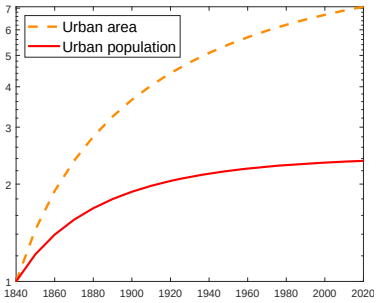
Numerical Illustrations

Rural Productivity Growth Only



(a) City Size

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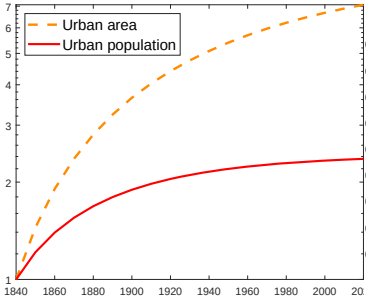
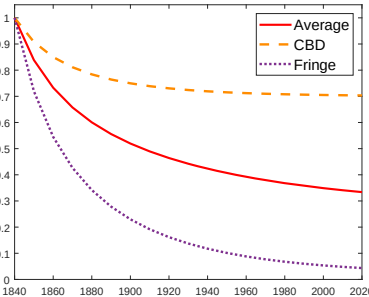
Numerical Illustrations

Rural Productivity Growth Only



(a) City Size



(b) Urban Densities

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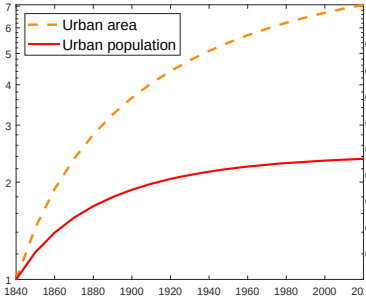
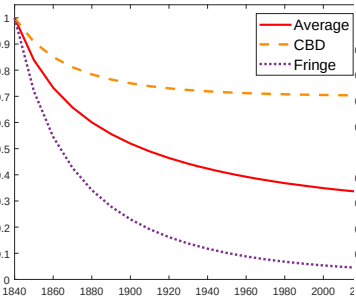
Numerical Illustrations

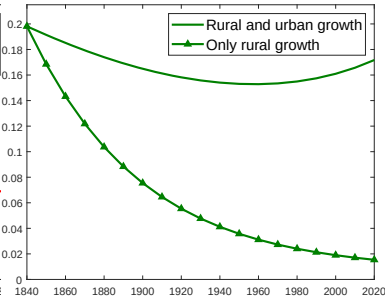
Rural Productivity Growth Only



(a) City Size



(b) Urban Densities



(c) Farmland Price

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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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Agricultural Productivity Gap

- Gollin et al (2013) show that sizeable productivity gap between agricultural and other sectors: Value added is higher in non-agricultural sectors, particularly in developing countries.
- Proposed mechanisms in literature: migration costs, selection of migrants.
- Here spatial frictions together with ℓ-specific housing:

$$w(\phi) = w_u - \tau(\phi) = w_r$$

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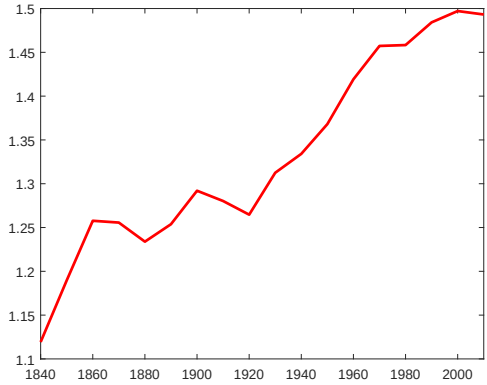

Figure: Agricultural Productivity Gap

GHSL Measurement - Reims

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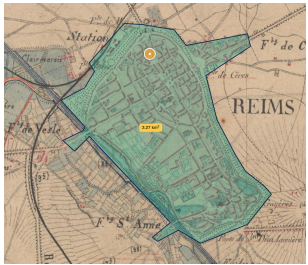
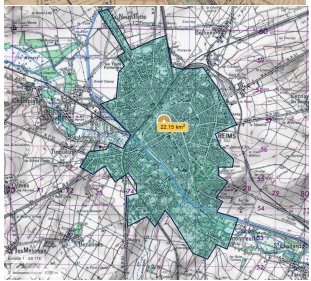
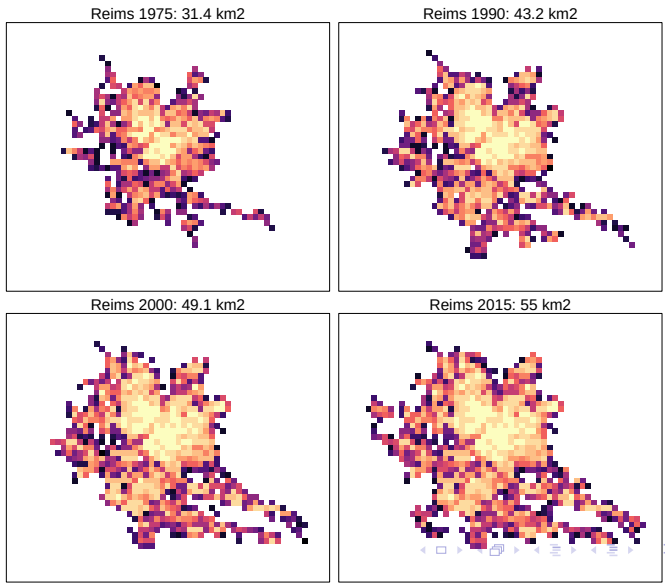
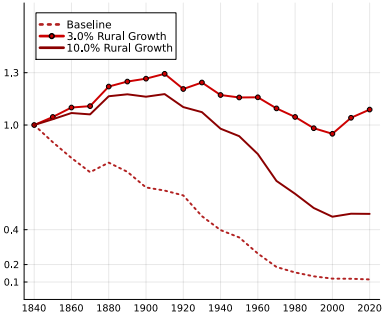




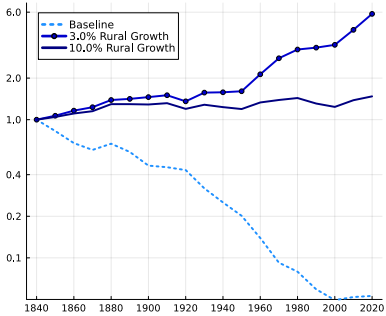


Sensitivity Analysis

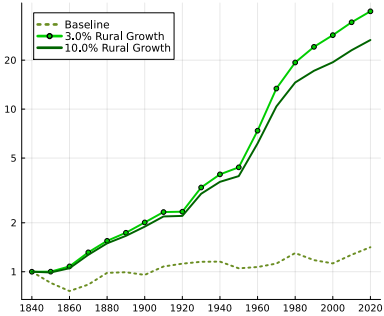
The role of rural productivity growth



(a) Average urban density (1840=1).



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



(c) Rental price of farmland.

Figure: Sensitivity to rural productivity growth.

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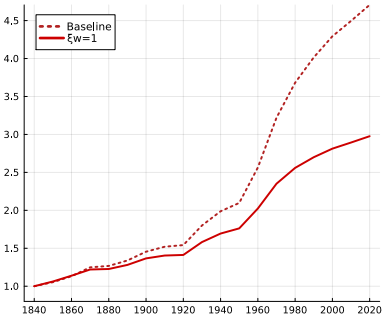
Sensitivity Analysis

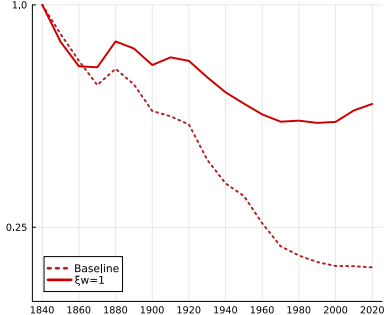
The role of increasing commuting speed

Commuting costs: $\xi_w = 1$

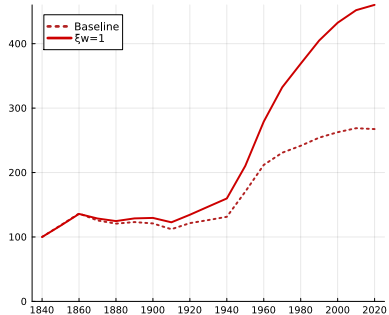
$$\tau(\ell) = a \cdot w_u^{\xi_w} \cdot \ell^{\xi_\ell}$$



(a) Average commuting speed.



(b) Average urban density.



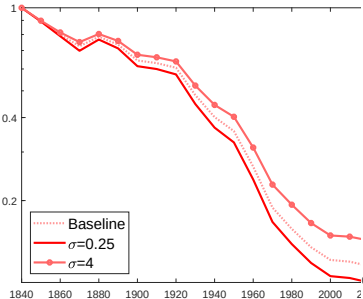
(c) Real Housing Price Index.

Sensitivity Analysis

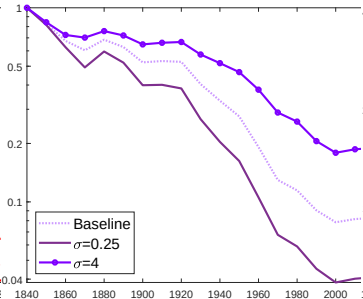
The elasticity of substitution between land and labor in the rural sector

Rural good production function:

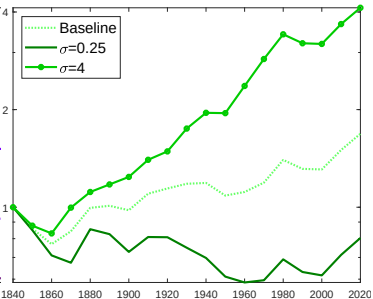
$$Y_r = \theta_r \left(\alpha (L_r)^{\frac{\sigma-1}{\sigma}} + (1-\alpha)(S_r)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$$



(a) Urban Density



(b) Fringe Density



(c) Farmland rental price

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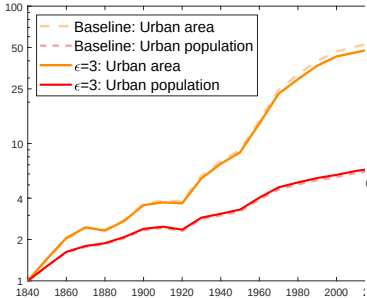
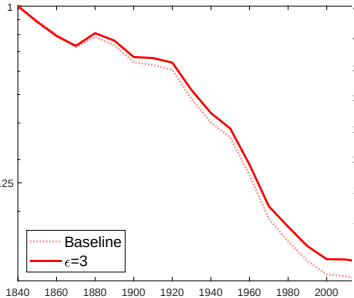
Sensitivity Analysis

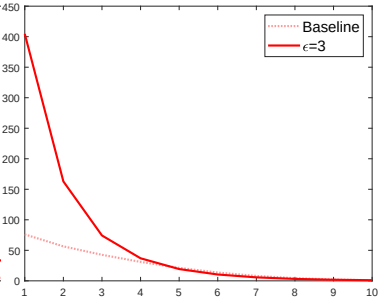
Constant housing elasticity $\epsilon = 3$



(a) City Size



(b) Urban Density



(c) Density by decile (2010)

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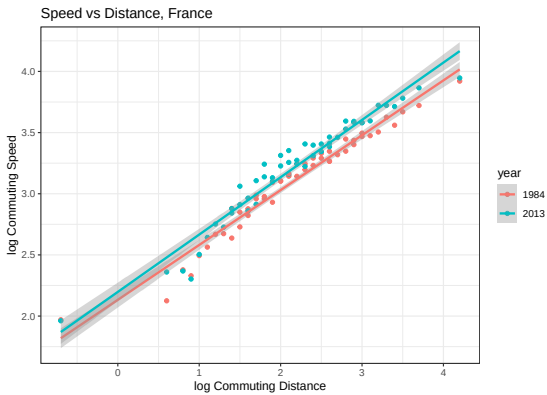
Calibration of τ

- 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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