

Quantifying co-evolution of socio-economic activities with geo-historical data

J. Raimbault^{1,2,3,4,*}

*juste.raimbault@ign.fr

¹LASTIG, Univ Gustave Eiffel, IGN-ENSG

²CASA, UCL

³UPS CNRS 3611 ISC-PIF

⁴UMR CNRS 8504 Géographie-cités

3e journée du séminaire SoDUCo-BnF

23/05/2023

Urban systems and geo-historical data

- Contemporary intra-urban dynamics are better and better characterised through the emergence of urban data and urban analytics [Kandt and Batty, 2021]; more difficult with past dynamics.
- Interdisciplinary approaches to the modeling of settlement systems transitions: qualitative or very sparse data, stylised models (Transmondyn project) [Sanders, 2018]
- Stylised models for systems of cities on long time scales [Pumain and Reuillon, 2017]
- Difficulty to build geo-historical data: geocoding [Cura et al., 2018], vectorisation [El Gouj et al., 2022]

→ Multi-dimensionality of urban systems is one aspect of their complexity, strongly present in the co-evolution of economic activities locations.

→ Understanding past processes better inform urban theories and models for future sustainable planning.

Research objective of this contribution (partly WP3):

Use geo-historical data to quantify the co-evolution of economic activities in Paris during the 19th century; methodological aspects on the issues linked to the exploitation of such data.

LISTE GÉNÉRALE

AADRESSES DE PARIS,

ET DES PRINCIPAUX ÉTABLISSEMENTS DE CETTE CAPITALE.

Abadie, architecte, Marais-la-Tripolie, 80.
Abadie (P.), passementier, Bouché, 6 (L).
Abadie (P.), peintre, Faub. -St-Martin, 56.
Abadie, tailleur, Montmartre, 132.
Abadie, tailleur, Basse-Erfance, 28.
Abascourt (Vie d'), C. de p. air, présid. à la cour des comptes, Anas, 3 bis.
Abascourt (Vie) & c. messager d'Etat, Corneille, 5.
Abatour: Grosveaux, — Montmartre, — Miroulet, — Montmartre, — Villouf.
Abault, charpentier, Corbeaux, 15.
Abazac et Cie, commission, Fêtes-Ecuries, 24.
Abbadie (H.), pharmacien, Ste-Apolline, 33 35.
Abbat, tailleur, St-Honoré, 262.
Abbaucucci & deparé, Commanche, 41.
Abbaye-au-Bois (communauté de l'), église sacrale de St-Thomas-d'Aquin, Sevres, 16.
Abbaye (l'), pension militaire, pl. Ste-Marguerite-St-Germain.
Abhey (John), fact. d'orgues, Faub.-Poissonnière, 40.
Abiel, vicare général honoraire, St-Louis-en-l'Isle, 22.
Abille, proprié., Basse-du-Rempart, 36.
Abiel, coutelier, Paradis-Poissonnière, 51.
Abiel, cuisinier, Coligny, 19.
Abiel, tailleur, Notre-Dame-de-Lorette, 25.
Abiel-Laroché, papet. fine, dentier, peintures, tableaux, Honoree, 5.
Abiel de Puget & (de l'Institut), peintre d'hist., Allouy, 18.

Accart, libraire, Casette, 22.
Accardi et Gallipio, pharmacien, Paix, 19.
Accouplements (cable et usines d'), Bourla, 3.
Accrois alain, cuisinier, en quinz., Charlot, 41.
Achard, ciseleur, Marais, 62.
Achard, glorieux de papier, St-Sauveur, 30.
Achard, hôtel du Duc de Clarence, Grenelle-St-Germain, 26.
Achard (Ch.), lapidaire, Palais-Royal, galerie Montpensier, 23, et rue Montpensier, 18.
Ac. ar. (L.P.), jouiller, Montmartre, 11.
Achard, meubles, Bourbon-Villeneuve, 57.
Achard, meubles, Ste-Apolline, 72.
Achard, fab. de parapluies, écoles de la Trinité, rue de la Harterie, 40.
Achard (Mme), fab. de poupées, St-Martin, 317.
Achard, avocat à la cour royale, Ferns, 5.
Achari et Cie, épuration de litrerie, Beaupaire, 13 34.
Achard, lapidaire, Pastarelle, 24.
Achilles Guillaume & c. caissier de la compagnie du chemin de fer de St-Etienne à Lyon, Lille, 165.
Aché, coutelier, Erivras, 3.
Ackermann, sellier, Faub. -St-Denis, 53.
Acklin, herbieriste, Orfèvre-St-Marcet, 29.
Acloque (B.), avocat, Conde, 10.
Acoulon slat, cordier et march. de chaux, Ferrussere, 27.
Acquary Kervera, ancien notaire, boul. Poissonnière, 14.
Acres (Broune des), Bae, 30 bis.

Adam (H.), peintre, Matignon, 3.
Adam, peint. vitr., St-Germain-des-Prés, 1.
Adam, plâtrier et maçon, Descartes, 24.
Adam (H. E.), prop., Niveles-Petit-Ch., 6.
Adam, cuisinier, cours des Augustins, 55.
Adam, sous-chef à l'émigré, Grac-Chenet, 9.
Adam, tabac, Noyers, 19.
Adam, tourneur sur métaux, Henry, 3.
Adam, vins, Prouvaires, 22.
Adam et Lespaut, layettes, Quincampoix, 64 35.
Adam-Zeller, serrur. en voit., Cadet, 30.
Adami, peintre-vitrerie, Faub. -Saint-Denis, 165 bis.
Addé, jardinier-écuriste, pl. de la Madeleine, 6.
Addé, libraire, boulevard Poissonnière, 17.
Addé-Margas, mod., Faub.-Poissonnière, 4.
Addé, prof. au collège Henri IV, Copéau, 34.
Adelener (R. F.), prop., Bretagne, 6.
Adelès jeune, maçon-plâtrier, Jour, 40.
Adelès, prop., Vaugoussier, 4.
Adelès, cuisinier, St-Martin, 145.
Adelmann, gardien des collections à l'École des Mines, Enfer, 24.
Adelès & c. modiste, Four-St-Germain, 47.
Adelwaerd (baron G. d'), secrétaire à la légation de Suède, Anjou-St-Honoré, 55.
Adeli (Mme), lingerie, St-Martin, 179.
Adéan de la Roserie, Dargère, 2.
Adet de Roseville, médecin, Paradis-Poissonnière, 14.

Several commercial economic activities repertoires, archived and digitalised: cf previous seminars.

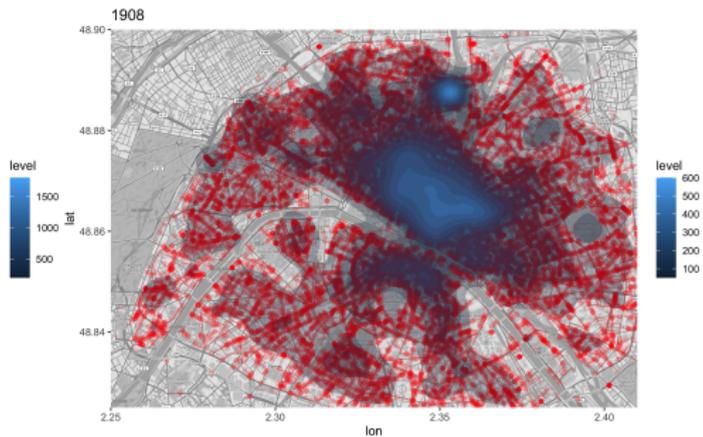
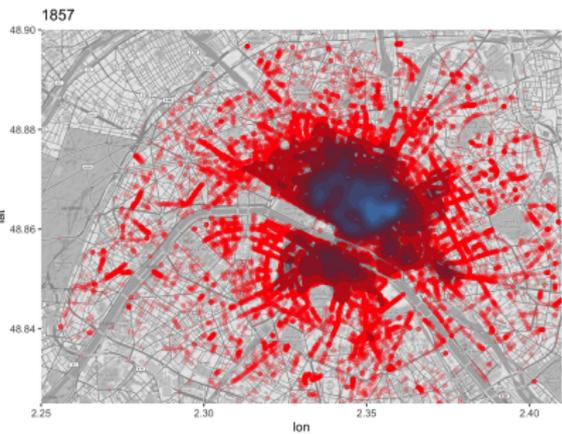
Processing by other WPs of the SoDUCo project:

- Document segmentation, OCR
- Named Entity Recognition to extract names, addresses, activities
- Historical geocoding

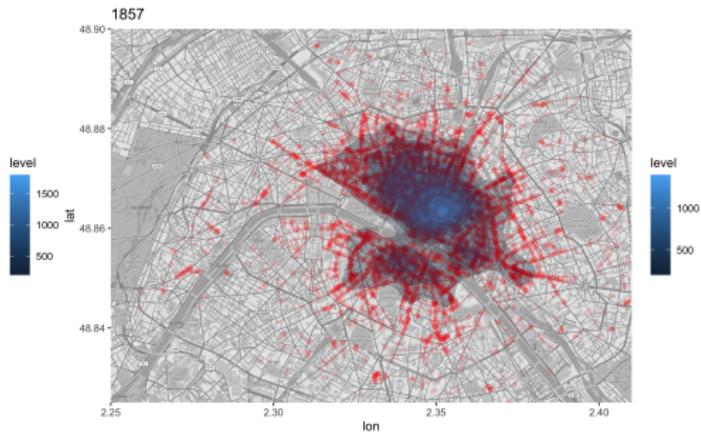
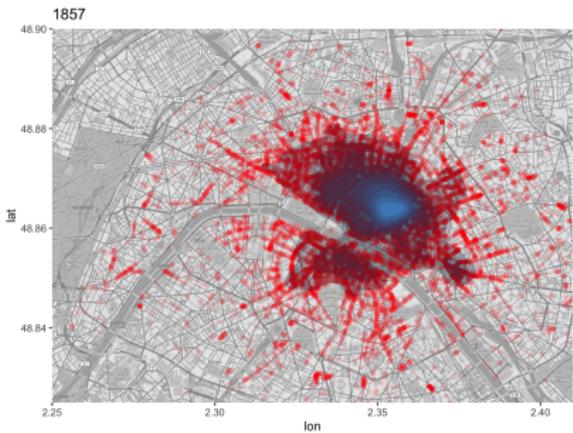
→ Work on *Didot-Bottin*, covering most of 19th century (to avoid multi-source bias for now)

- Data covering 1857-1908: 4,218,048 entries, 80.32% with coordinates and a defined activity.
- Natural Language Processing: stop-words removal and stemming to descriptions of activities.
- Stems with more than 100 occurrences (996) coded for broad activities (food, craftsmanship, art and literature, health, law and governance, service, teaching)
- 1,990,222 entries with coordinates and classified activities

Location of activities



Location of activities



Left: craftsmanship; Right: food.

Defining co-evolution

Objects: Cities and territories (*Evolutionary Urban Theory* [Pumain, 2018]) co-evolving with transport networks (*Territorial Theory of Networks* [Dupuy, 1987])

Processes:

A multi-level definition of co-evolution:

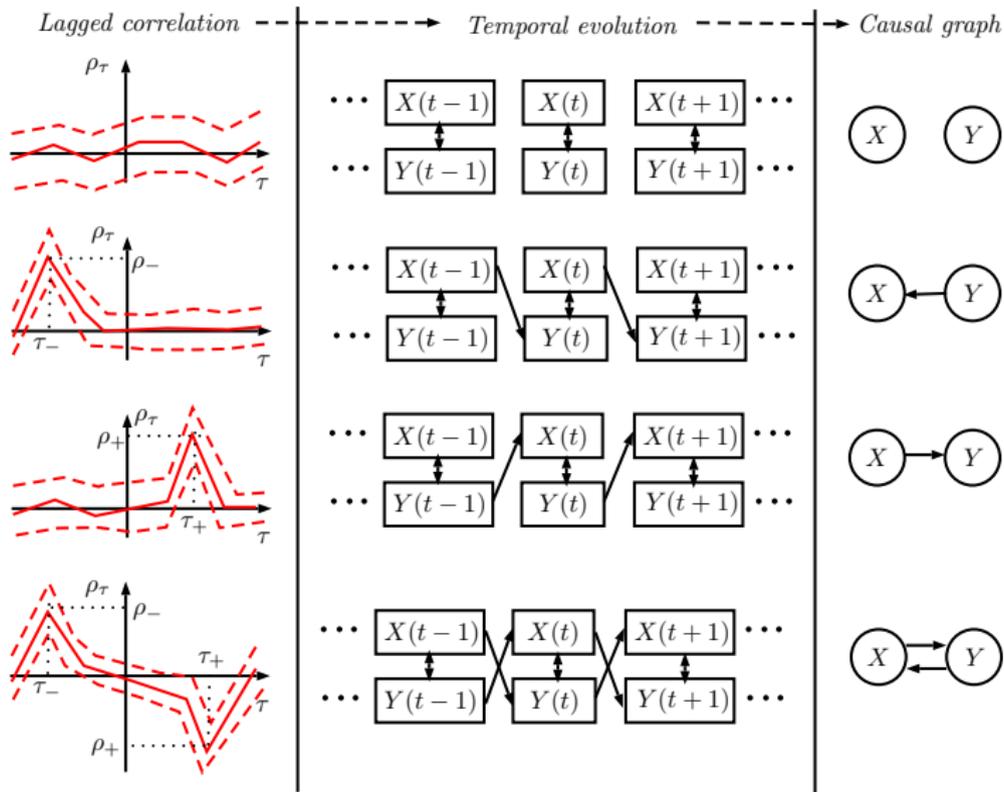
- 1 agents level
- 2 agent populations level (niches)
- 3 global system level

Corresponding approaches:

- 1 Empirical approach (microscopic level)
- 2 Morphogenesis approach (niche level)
- 3 Evolutionary theory approach (global level)

Raimbault, J. (2019). Modeling interactions between transportation networks and territories: a co-evolution approach. arXiv preprint arXiv:1902.04802.

Method to characterise co-evolution



Application to this dataset

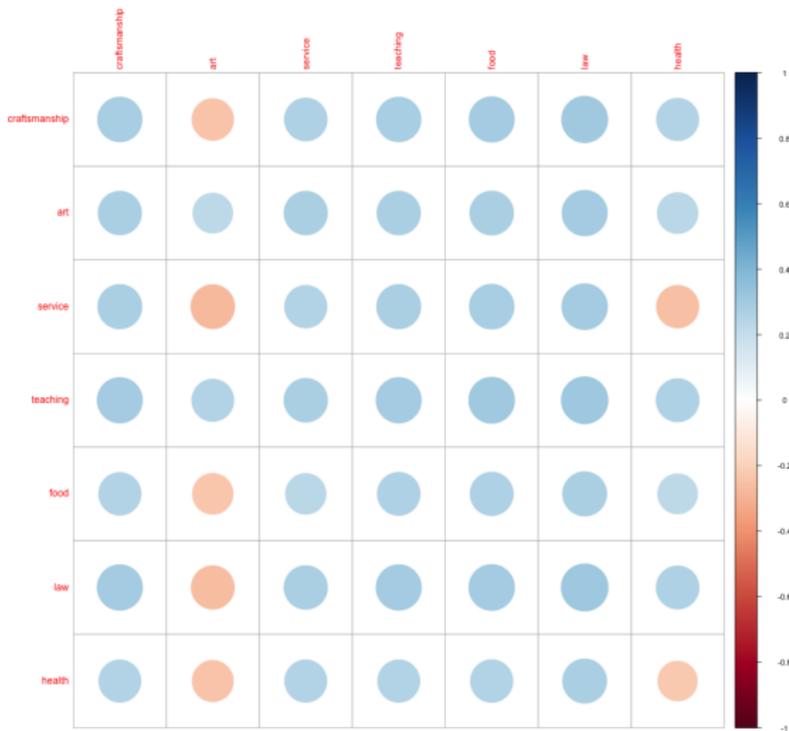
→ Activity counts $N_{a,r}$ within raster cells: 10x10 grid to split the covered area into zones.

→ Variation of activity counts in time $\Delta N_{a,r}(t) = N_{a,r}(t + \Delta t) - N_{a,r}(t)$

→ Lagged correlations in time between activities

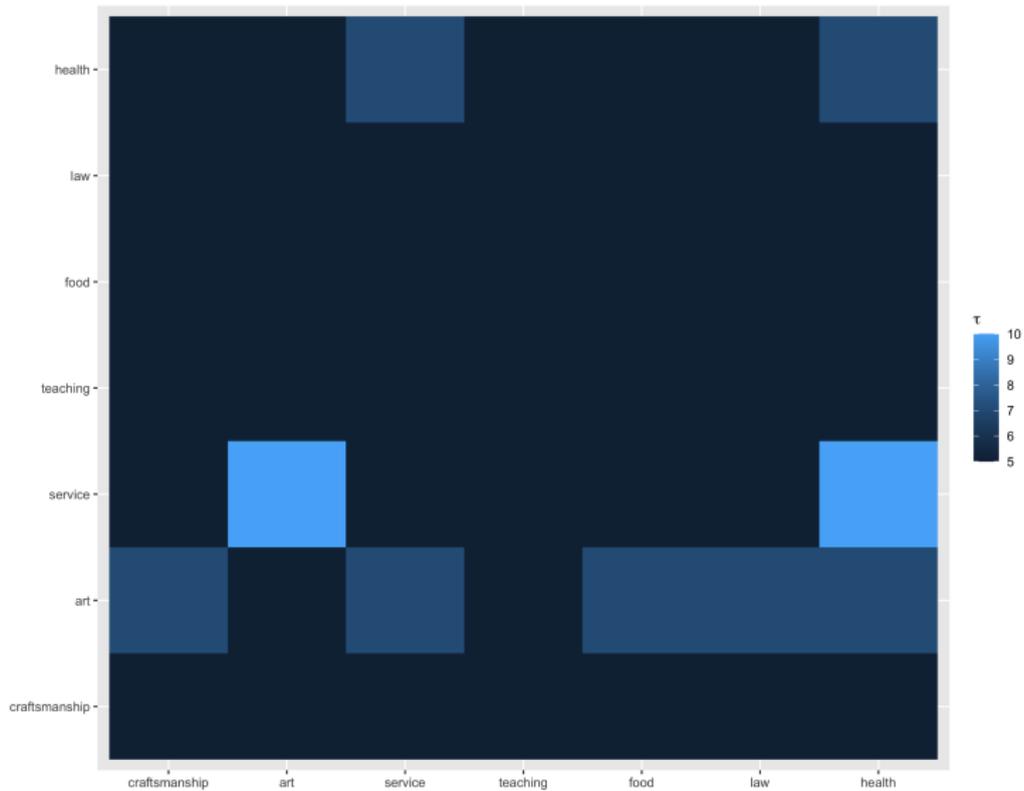
$$\rho_{a_1, a_2}(\tau) = \rho [\Delta N_{a_1, r}(t), \Delta N_{a_2, r}(t - \tau)]$$

Results: lagged correlations



Optimal lagged correlations between variations of activity counts

Results



Corresponding delays

- Micro insights into historical intra-urban economic processes.
- Existence of a co-evolution between some activities (circular causality in location dynamics).
- In discussion with historians in the project: capture qualitative knowledge (e.g. “*fabrique urbaine*”)?

Current and future work:

- Sensitivity analysis to classification, meta-parameters; null model with random activities.
- Endogenous spatial neighbourhoods to estimate correlations, using a GWR-like approach [Brunsdon et al., 1998]; temporal moving-window.
- Benchmark of methods to measure co-evolution (instrumental variables, causal machine learning, transfer entropy).

- Geo-historical data is new data; quantification of past intra-urban processes; many consistence and processing issues.
- Opening for interdisciplinary discussions and collaborations: actual new knowledge and its validation depends on disciplines.

Models and results open at

<https://github.com/JusteRaimbault/HistoricalData>

References I

-  Brunsdon, C., Fotheringham, S., and Charlton, M. (1998). Geographically weighted regression. *Journal of the Royal Statistical Society: Series D (The Statistician)*, 47(3):431–443.
-  Cura, R., Dumenieu, B., Abadie, N., Costes, B., Perret, J., and Gribaudi, M. (2018). Historical collaborative geocoding. *ISPRS International Journal of Geo-Information*, 7(7):262.
-  Dupuy, G. (1987). Vers une théorie territoriale des réseaux: une application au transport urbain. In *Annales de géographie*, pages 658–679. JSTOR.
-  El Gouj, H., Rincón-Acosta, C., and Lagesse, C. (2022). Urban morphogenesis analysis based on geohistorical road data. *Applied Network Science*, 7(1):1–26.



Kandt, J. and Batty, M. (2021).

Smart cities, big data and urban policy: Towards urban analytics for the long run.

Cities, 109:102992.



Pumain, D. (2018).

An evolutionary theory of urban systems.

In *International and transnational perspectives on urban systems*, pages 3–18. Springer.



Pumain, D. and Reuillon, R. (2017).

Urban dynamics and simulation models.

Springer.



Raimbault, J. (2017).

Identification de causalités dans des données spatio-temporelles.

In *Spatial Analysis and GEOmatics 2017*.



Raimbault, J. (2019).

Modeling interactions between transportation networks and territories: a co-evolution approach.

arXiv preprint arXiv:1902.04802.



Sanders, L. (2018).

Peupler la terre: De la préhistoire à l'ère des métropoles.

Presses universitaires François-Rabelais.