

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

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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.

Data extraction

LISTE GÉNÉRALE ADRESSES DE PARIS, ET DES PRINCIPAUX ÉTABLISSEMENTS DE CETTE CAPITALE.

Ablard, architecte, Marais-du-Temple, 69.
Ablard fils, passementier, Boucher, 6 (E).
Ablard (P.), peintre, Faub. -St-Martin, 56.
Ablard, tabac, Monceau-plant, 132.
Abadie, tailleur, Marais, 26.
Abadie (Vito d.), C. @ 26*, présent à la cour des comptes, Anax, 2 bis.
Abancourt (Vte), @, messager d'Etat, Cer-
cise le, 5.
Abascal : Grenoble, — Monceau-plant, — Min-
eral, — Montmartre, — Villeguif.
Abault, charpentier, Corbeau, 57.
Abazet et Cie commis, Petits-Ecuries, 24.
Abbadie (H.), pharmacies, Ste-Apolline, 33 (E).
Abbadie (J.-B.), pharmacien, Marais, 10.
Abbaucci @, député, Casseris, 41.
Abdeugne-dos (commandant de l'), église sur-
crois de St-Thomas-d'Aquin, Sevres, 16.
Abdeugne (F.), prison militaire, pl. St-Marc-
seigneur, 10.
Abney (John), fact. d'orgues, Faub.-Puissant-
nière, 40.
Abel, vêture général huissiere, St-Louis-en-
l'Ile, 22.
Abel à sa propriété, Bourg-du-Rempart, 26.
Abel, coiffeur, Paradis-Poissomière, 51.
Abel, tapissier, Colysee, 10.
Abel, tailleur, Notre-Dame-de-Lorette, 25.
Abel-Gardon, papier fine, dessins, peintures,
tableaux, Hébert, 5.
Abel de l'Urg @ (de l'institut), peintre d'hist.,
Albey, 18.

Acast, libraire, Caenette, 23.
Accord et Gallopin, pharmaciens. Fair, 19.
Acouplements ('école et maison d'), Bourre, 3.
Acotte aliné, commis, en quinc., Charlot, 41.
Achard, ébéniste, Moreau, 62.
Achard, ébéniste, Moreau-Sauvage, 20.
Achard, libell du Due de Clermont, Grenelle-
St-Germain, 25.
Achard (Ch.), lapidaire, Palais-Royal, galerie
Mazarin, 10. Achard et Moreau, Marais, 18.
Ae arid (J.-P.), peintre, Montmartre, 11.
Achard, meubles, Bourbon-Villemeure, 57.
Achard, meubles, Sté-Apolline, 22.
Achard, fab. de parapluies, enclos de la Tri-
partite, 10. Achard (Mme), fab. de perruques, St-Martin, 217.
Achard, avocat à la cour royale, Forno, 5.
Achard et Ge., épuration de stérile, Bourre-
pare, 13 (E). Achard, ébéniste, Marais, 10.
Achard, ébéniste, Pastorelle, 94.
Achard Guillaume @, caissier de la compa-
gnie du chemin de fer de St-Etienne à Lyon,
Lille, 105.
Acer, coiffeur, Ecrivains, 3.
Acker, tailleur Faub. -St-Denis, 53.
Acklin, herboriste, Orleans-St-Marcel, 28.
Aclique fils, avocat, Coudé, 10.
Aclique sind, cordier et march. de chausse,
Fermeuse, 27.
Aclique, huissier, ancien notaire, boul. Pois-
sonnière, 14.
Acre (Baronne des), Bas, 36 bis.

Adams (H.), peintre, Matignon, 3.
Adans, peint, vitr. St-Germain-des-Prés, 3.
Adam, plâtrier et mason, Descartes, 24.
Adam (H. E.), prop., Nve-des-Petits-Ch., 6.
Adam, vendeur de papier, Augustin, 55.
Adam sous-déf à l'enseigne, Gras-Chenet, 9.
Adam, tabac, Noyers, 10.
Adam, tourneur sur métal, Henry, 2.
Adam, vins Prouvaires, 22.
Adam et Lepaut, bayeries, Quincampoix,
64, 35.
Adam-Zeller, serrur, en voit., Cadet, 20.
Adamini, peintre-vitrer, Faub. -Saint-Denis, 105 bis.
Adèle, jardinier-deuriste, pl. de la Madeleine,
6.
Adèle, libraire-boul. Poissonnière, 17.
Adèle-Margras, mid., Faub.-Poissonnière, 4.
Adèle, prof. au collège Henri IV, Copœu, 34.
Adelmer (R. E.), prop., Bretagne, 6.
Adèles jeans, mason-plâtrier, Jour, 4.
Adeline, prop., Victoire, 4.
Adeline, rouennaise, St-Martin, 145.
Adeline, vendeuse de collections à l'Ecole
des Mines, Enfer, 34.
Adelox @, médecin, Faub.-St-Germain, 47.
Adelaïward (Emile G. d.), secrétaire à la légis-
lation, 10. Adelaïward (G. d.), avocat, 28.
Adet (Mme), imprimerie, St-Martin, 179.
Adets de la Roserie, Bergère, 2.
Adets de Roserville, médecin, Paradis-Poiss.,

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

Processing by other WPs of the
SoDUCo project:

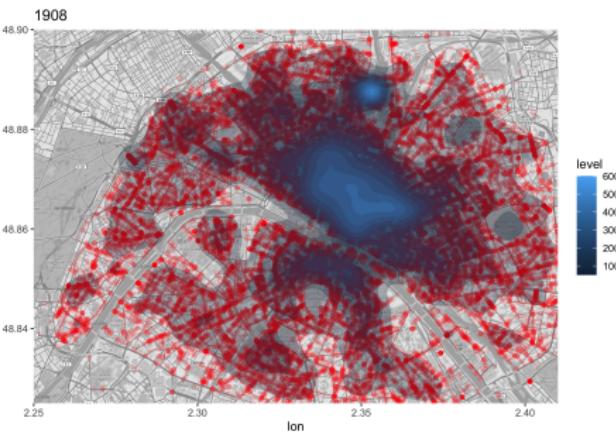
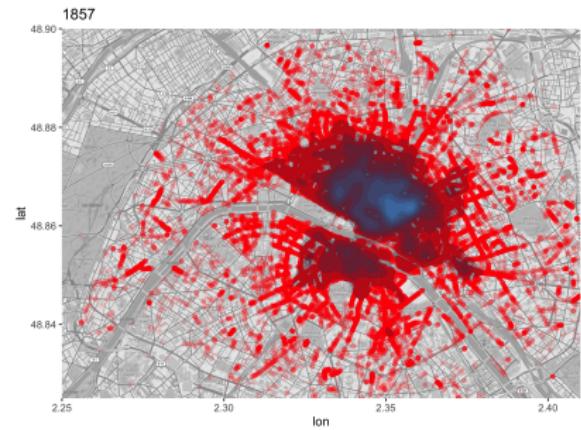
- Document segmentation, OCR
- Named Entity Recognition to extract names, addresses, activities
- Historical geocoding

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

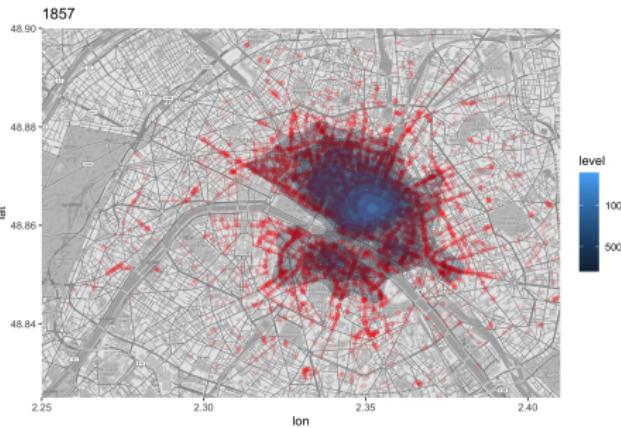
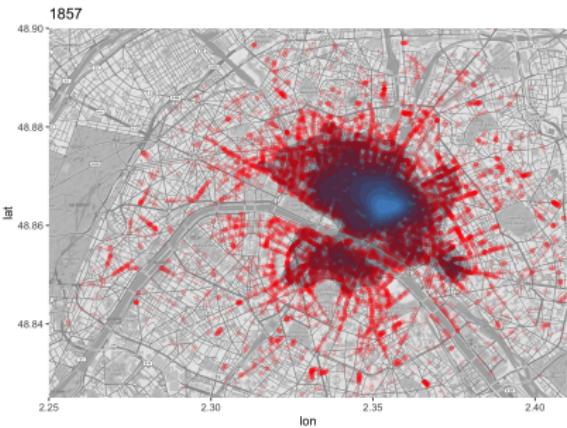
Data pre-processing

- 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:

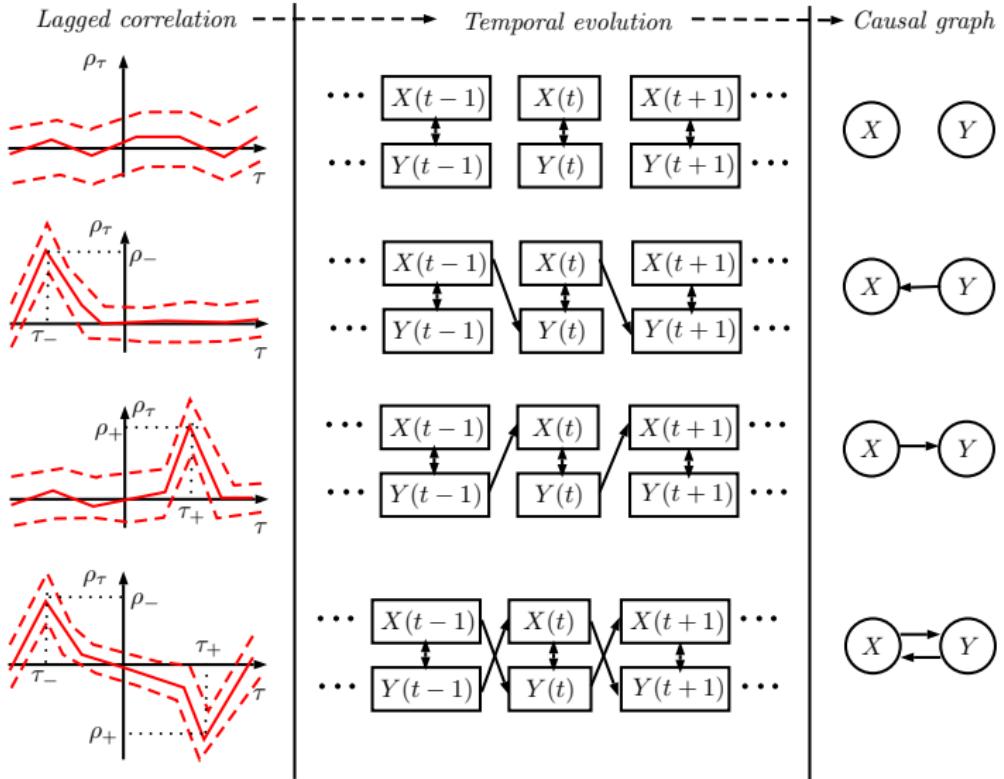
- ① agents level
- ② agent populations level (niches)
- ③ global system level

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

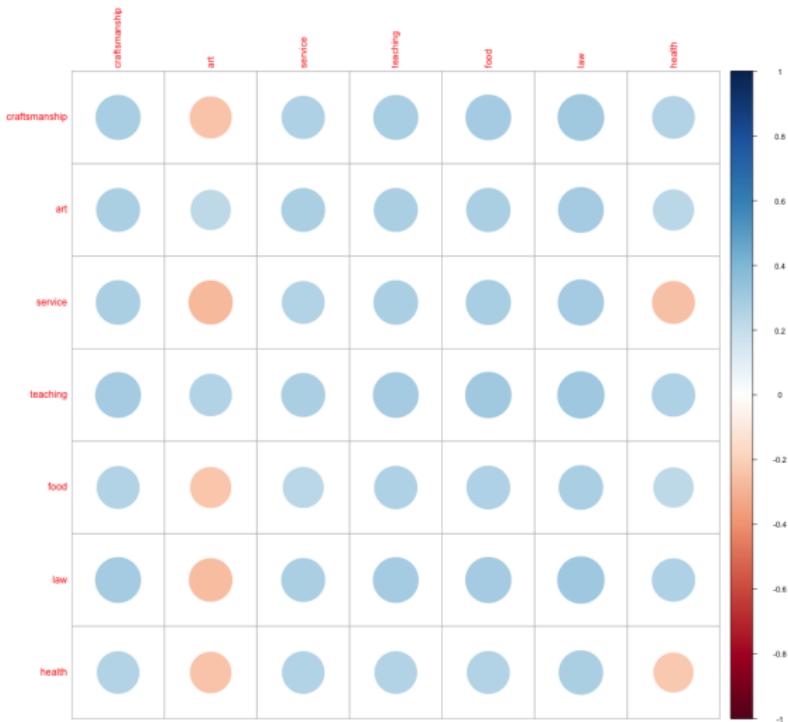


Application to this dataset

- 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

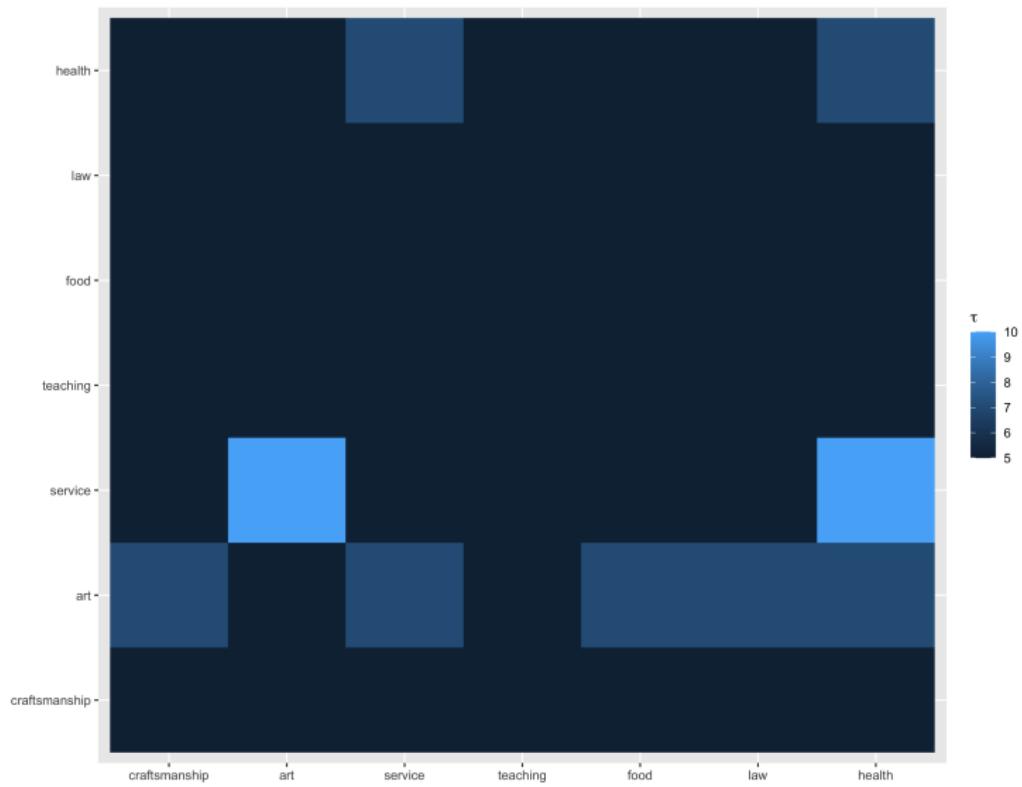
$$\rho_{a_1,a_2}(\tau) = \rho [\Delta N_{a_1,r}(t), \Delta N_{a_2,r}(t - \tau)]$$

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).

Conclusion

- Geo-historical data is new data; quantification of past intra-urban processes; many consistency 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>

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