

Quantifying the co-evolution of economic activities locations with geo-historical data: Paris, 19th century

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Session 8: New data, new methods, new fields (2)
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Social Dynamics in Urban Context

Open tools, models and data - Paris and its suburbs, 1789-1950

Welcome to the SODUCO project

SODUCO is a 4 years pluridisciplinary project funded by the French National Research Agency, it has started in march 2019 and will end in 2023. SODUCO brings together people from the geographical sciences, from urban history, specialists of network morphogenesis and computer scientists to study the evolution of Paris over time, both in terms of its morphological transformations and its social evolutions.

Project partner institutions

L'ÉCOLE
DES HAUTES
ÉTUDES EN
SCIENCES
SOCIALES

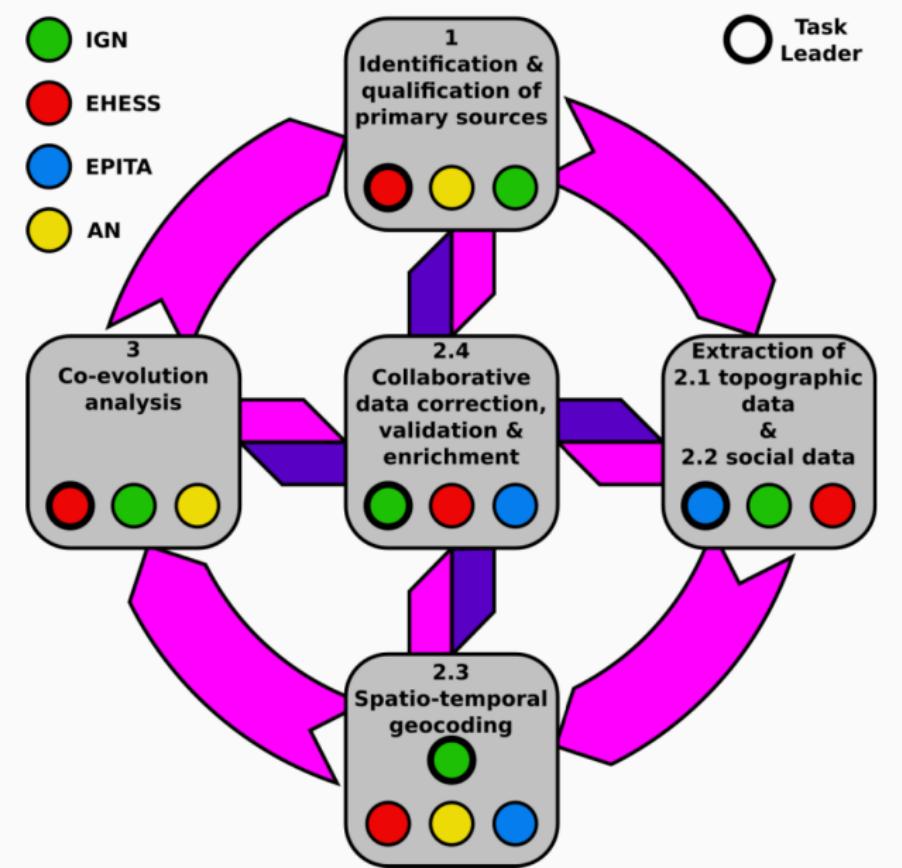
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INSTITUT NATIONAL
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ET FORESTIÈRE

EPITA
ÉCOLE PRIVEE D'INFORMATIQUE

**ARCHIVES
NATIONALES**

<https://soduco.github.io/>

Structure of the SODUCO project



WP 1: Identification and qualification of relevant sources

→ Catalog of primary sources; qualification of sources and metadata construction; online publication as Linked Open Data; modeling of uncertainties.

WP 2: Digitalisation of sources

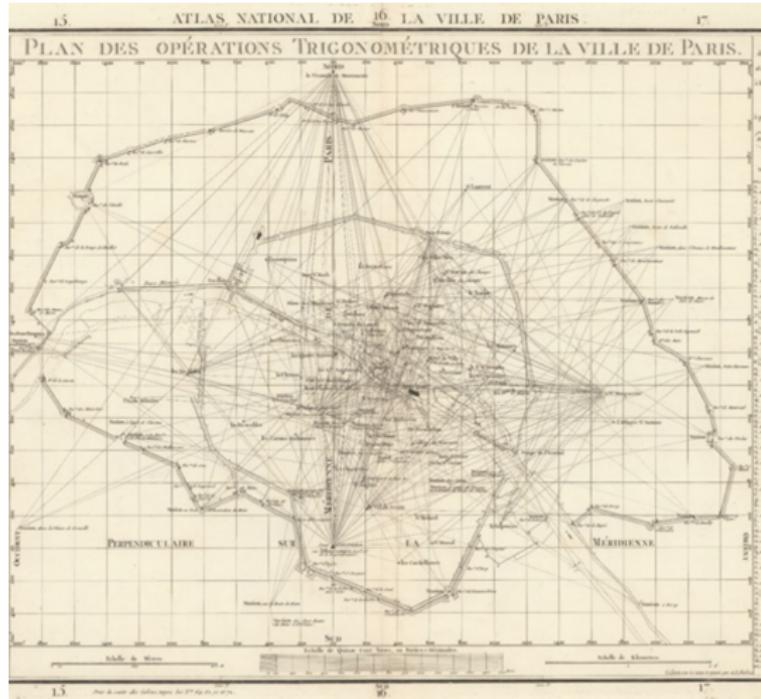
→ Extraction of topographic data (2.1); extraction of socio-economic data (2.2); spatio-temporal geocoding (2.3); collaborative data correction, validation and enrichment (2.4).

WP 3: Co-evolution analysis

→ geovisualisation of data and associated dynamics.

Tools: collaborative open platform to ensure reproducibility and traceability of data and processes.

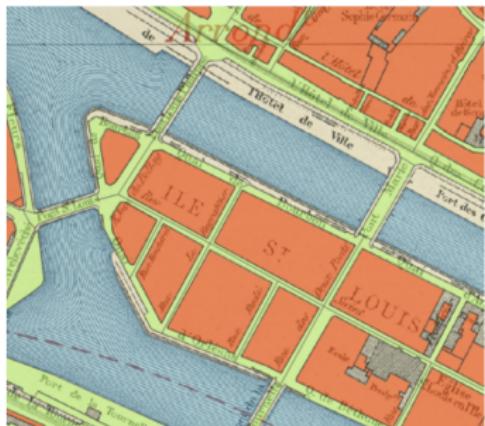
Verniquet atlas accuracy



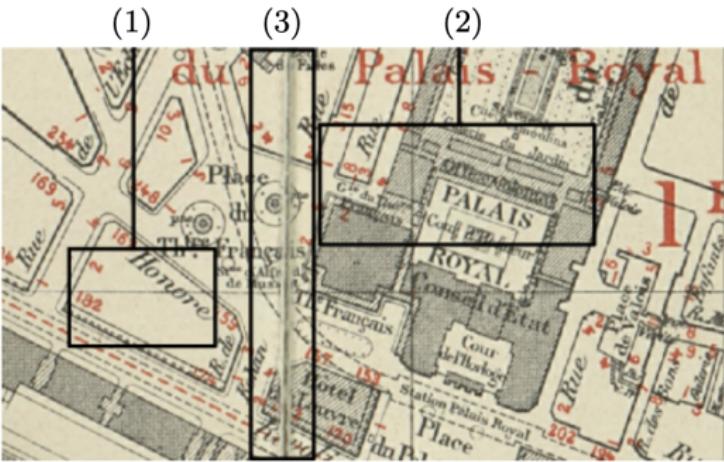
Fieldwork survey with modern instruments to verify the planimetric accuracy of Verniquet atlas (claimed at 1/10 of a toise $\simeq 19\text{cm}$)

- Claimed uncertainties were correct
- CRS parameters for the historical coordinate system (reused as reference in many historical plans)

Vectorisation of historical maps



Historical Map



Edge Probability Map



Deep Contour Detection



Filtering & Watershed



Closed Shapes

PhD thesis by Yizi Chen soon finished: vectorisation combining deep learning and mathematical morphology [Chen et al., 2021b] [Chen et al., 2021a]

- 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.

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]

Data extraction

Several commercial economic activities repertoires, archived and digitalised.

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

Abladie, architecte, Maréchal-Temple, 69.
Abladie fils, passementier, Bouillon, 6 [E].
Abladie (P. J.), peintre, Faub. -St-Martin, 56.
Abladie, tabac, Monceau-plant, 122.
Abladie, tailleur, Bon-Enfants, 36.
Abancourt (Vie de), C. Q., prieur, présid. à la
cour des comptes, Assas, 3 bis.
Abancourt (Vie de), messager d'Etat, Cor-
sica, 10.
Abat-voix, Grenelle, — Ménimontant, — Mirro-
nail, — Montmartre, — Villemouf.
Abat-voix, chanteur, Corbeil, 1.
Abazar et Cie, cosmétis, Petits-Ecuries, 24.
Abbadie (H.), pharmacie, Ste-Apolline, 33 [E].
Abbat, tailleur, St-Honoré, 369.
Abbaucourt (F.), décret, Camaret, 41.
Abbaucourt (G.), comte de l'ordre ?, église au-
tours de St-Thomas-d'Aquin, Sevres, 16.
Abbége (I.), prison militaire, pl. Ste-Marguerite-Saint-Germain.
Abbaye (John), fact. d'orgues, Faub.-Puissam-
our, 48.
Abel, ouvrier général hasseurier, St-Louis-en-
l'Île, 22.
Abelle, peintre, Bassens-du-Rempart, 36.
Abel, peintre, boulevard du Temple, 51.
Abel, tapissier, Galysse, 19.
Abel, tailleur, Notre-Dame-de-Lorette, 25.
Abel-Laroche, papet, fine, dessins, peintures,
tableaux, Hurepoix, 5.
Abel du Pojet (de l'Institut), peintre d'hist.,
Albert, 18.

Abenet, libraire, Cassette, 24.
Accordé et Gallipot, pâtissier-sucréier. Faub. 19.
Acquaviva (card. et marquis d'), Bourg, 3.
Acquerello alfi, cestier, en quinca., Chabot, 41.
Acharde, ébéniste, Moreau, 62.
Acharde, gâteau de papier, St-Sauveur, 30.
Acharde, fab. du pain Dus de Charente, Grenelle-
Ste-Germain, 50.
Acharde (Ch.), lapidaire, Palais-Royal, galerie
Montpensier, 23, et rue Montpensier, 18.
Ac and (J.-F.), joailler, Marais, 11.
Academie des Beaux-Arts, Ville-Évrard, 97.
Acharde, menuisier, Ste-Apolline, 22.
Acharde, fab. de parapluies, enclos de la Tri-
nité, rue de la Larterie, 40.
Acharde (Emile), fab. de peignes, St-Martin, 217.
Achart, marchand de la viande royale, Fermo, 5.
Achart et Cie, épicerie de Etarie, Bousre-
paires, 13 [E].
Acheniv, lapidaire, Pastorelle, 24.
Achille (Guillaume), p., caissier de la compa-
gnie du chemin de fer de St-Étienne à Lyon,
Lille, 105.
Aciér, coûteleur, Ecrivains, 3.
Achenmann, vellier, Faub.-St-Denis, 53.
Achenmann, vellier, Faub.-Marcel, 28.
Aclercs fils, avocat, Cendre, 19.
Acolon alad, cordier et march. de chasse,
Fermeuse, 27.
Acquery Kervra, ancien notaire, boul. Pois-
sonnière, 14.
Actes (Baronne des), Bac, 36 bis.

Adem (H.), peintre, Matignon, 3.
Adam, peintre vitr., St-Germain-des-Prés, 3.
Adam, pâtissier et maçon, Descartes, 24.
Adam (H. E.), peintre, Nve-des-Petits-Ch., 6.
Adam, salicier, quai des Augustins, 55.
Adam, soucier à l'engrenage, Gros-Chêne, 9.
Adam, tourneur, Neuilly, 10.
Adam, tourneur tenu, Henry, 2.
Adam, vins, Prusse, 22.
Adam et Lepetit, layettes, Quincampoix,
64 [E].
Adam Zellera, serrur. en voit., Cadet, 29.
Adamini, peintre-ritzier, Faub. -Saint-Denis, 105 bis.
Addet, jardinier-deuriste, pl. de la Madeleine,
rue de la Larterie, 40.
Addet, libraire, boul. Poissonnière, 17.
Addle-Margras, nôd., Faub.-Poissonnière, 4.
Addé, prof. au collège Henri IV, Copœu, 34.
Addeler (R. E.), prop., Bretagne, 6.
Addet Jean, maçon-pâtissier, Four, 4.
Addelin, prop., Viette, 4.
Addelin, rouennier, St-Martin, 145.
Addemann, gardien des collections à l'Ecole
des Beaux-Arts, 30.
Addicks (G. medecin, Faub.-St-Germain, 47.
Addewaerd (baron G. d'), secrétaire à la légation
de Suède, Anjou-St-Honoré, 58.
Addet (Mme), imprimeur St-Martin, 179.
Addet (Musé), librairie, Bourse, 2.
Addet de Rosière, médicin, Paradis-Poit.,

→ Work on *Didot-Bottin*,
covering most of 19th
century

→ Document segmentation,
OCR

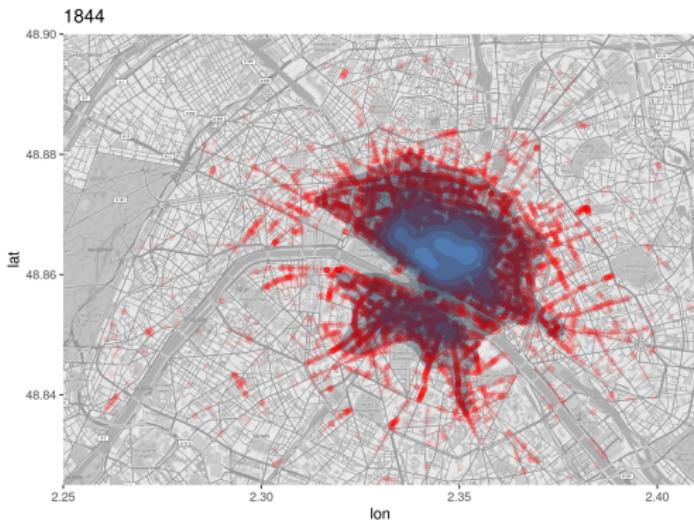
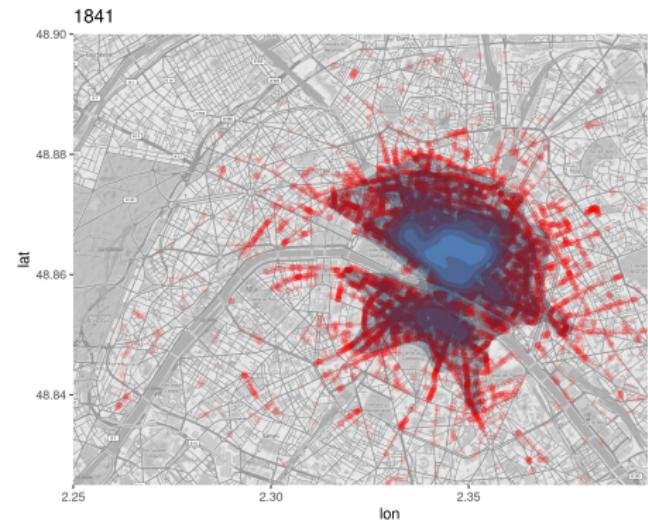
→ Named Entity Recognition
to extract names, addresses,
professions

→ Historical geocoding

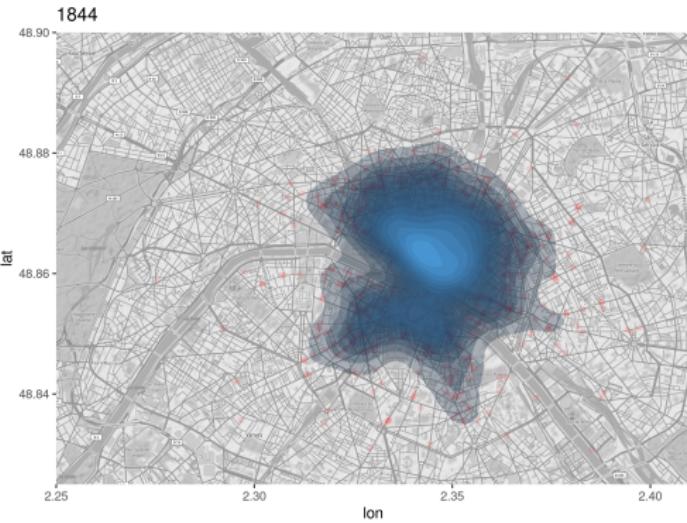
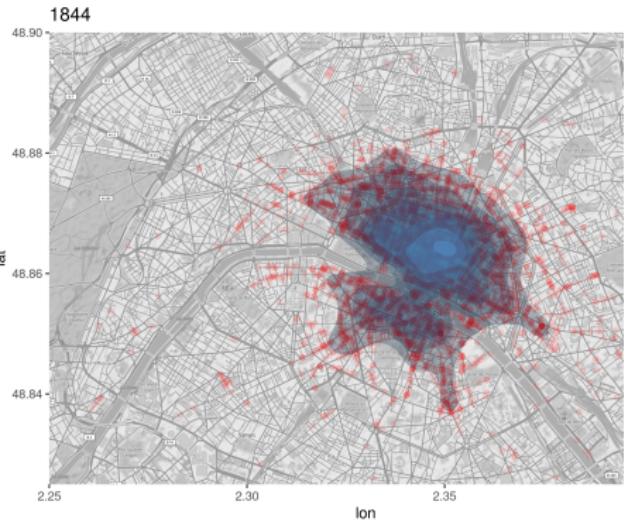
Data pre-processing

- Data sample covering 1841-1844: 415,976 entries, 33% with coordinates.
- Natural Language Processing: stop-words removal and stemming to descriptions of activities.
- Stems with more than 100 occurrences (578) coded for broad activities (food, craftsmanship, art and literature, health, law and governance, service, teaching)
- 36,072 entries with coordinates and activities

Location of activities



Location of activities



Left: craftsmanship; Right: law.

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:

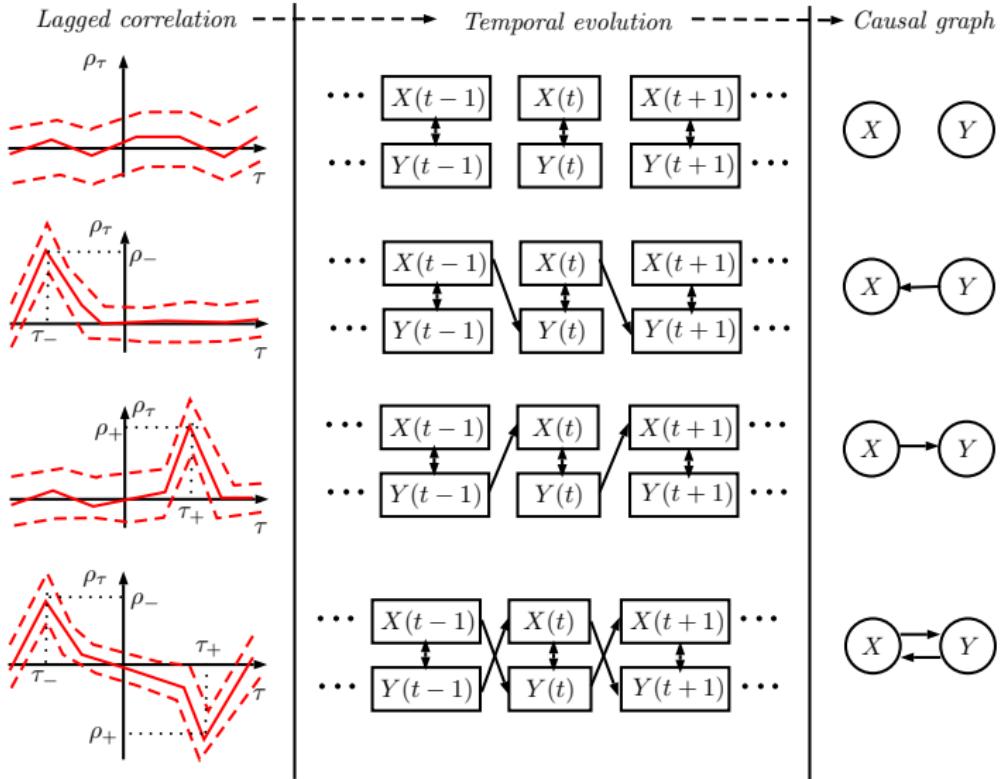
- ① agents level
- ② agent populations level (niches)
- ③ global system level

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



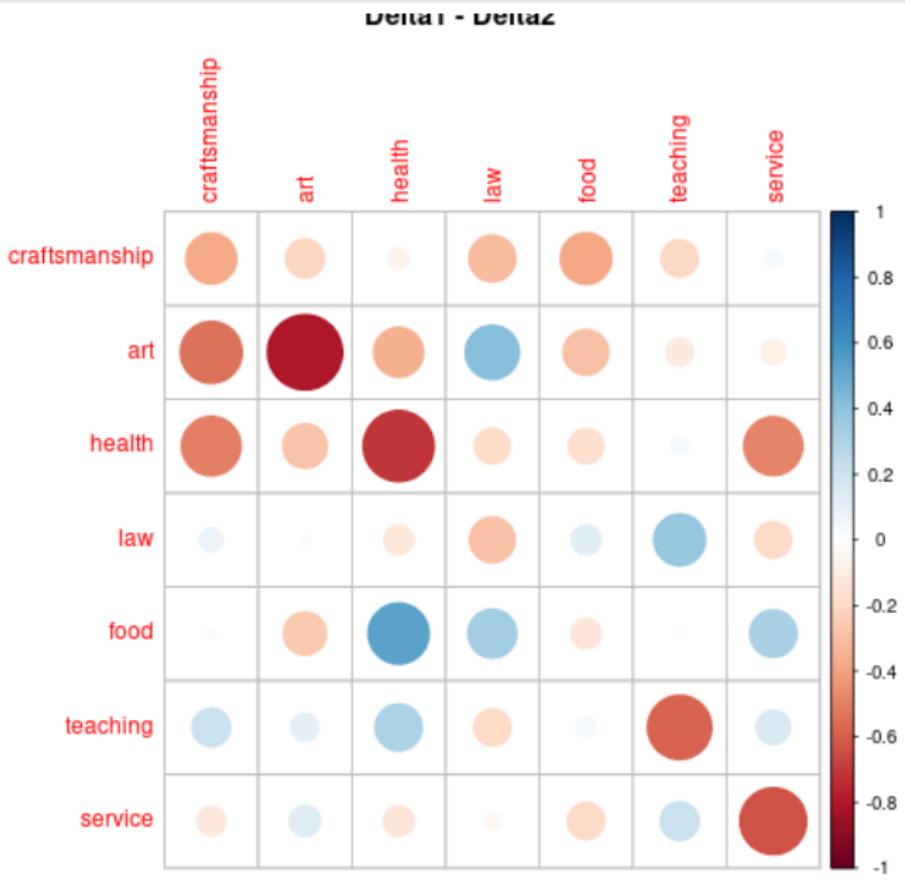
Application to this dataset

- 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

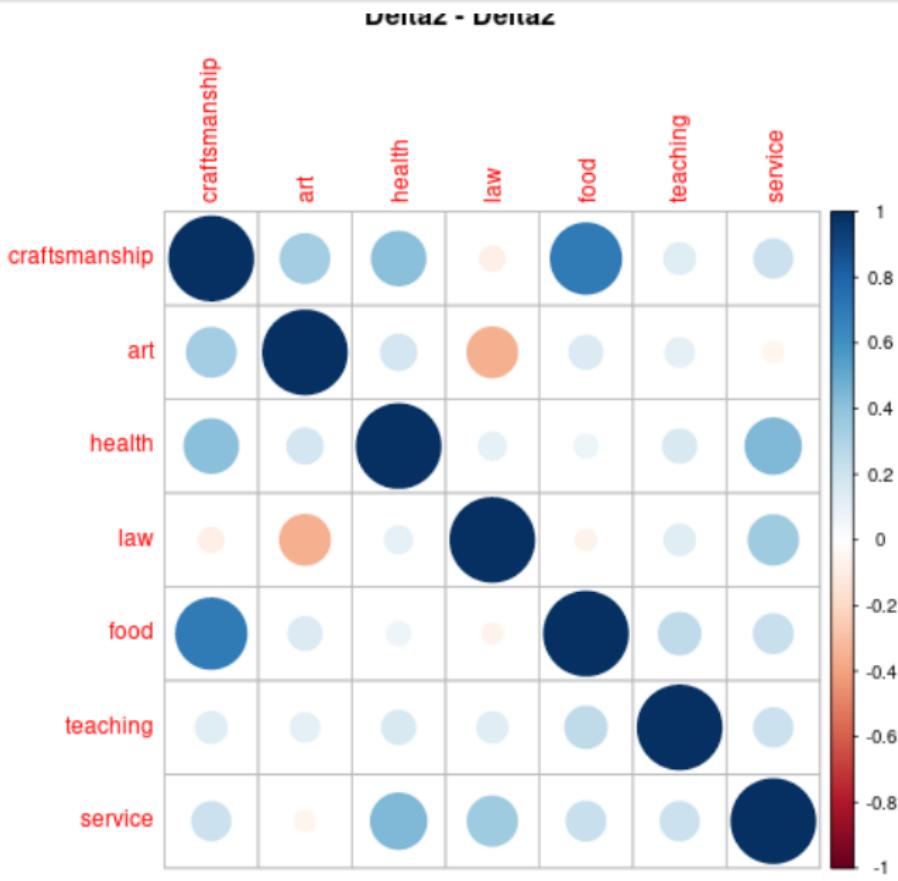
$$\rho_{r,s}(\tau) = \rho [\Delta N_{a,r}(t), \Delta N_{a,s}(t - \tau)]$$

- On the sample dataset, $\tau = 1$ (3 exploitable dates)

Results: co-evolution



Simultaneous correlations



Discussion

- 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:

- Extension to a longer time span (all repertoires soon processed for OCR).
- 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].
- Benchmark of methods to measure co-evolution (instrumental variables, causal machine learning).

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.

Soduco website and repository:

<https://soduco.github.io/>

<https://github.com/soduco>

Models and results open at

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

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