Agglomeration Economies, Transport Accessibility and Productivity: Evidence from Toulouse Metropolitan Area

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Séminaire Evaluation des Politiques Publiques (EPOP)
25 Novembre 2022

Definitions

- **Transport Accessibility**: Accessibility to transport infrastructure and accessibility by the transport network .
  1. Local supply of transport infrastructure.
  2. Local average commuting time by different means of transport.
- **Agglomeration Economies**: Positive externalities on productivity coming from the interaction between economic agents:
  1. Denser input–output linkages.
  2. Better matching of employees' skills with firms' needs.
  3. Technological externalities.
  4. Learning share.
- **Productivity**: Measured by local wages.

Motivation and Main Research Question

- **Objective**: disentangle between the role of agglomeration externalities and urban transport accessibility levels on the internal productivity structure of a metropolitan area.

Why local transport accessibility has an effect on local productivity?

- Indirect and a direct mechanisms.
  1. The indirect mechanism acts through the boost in agglomeration externalities.
  2. The direct mechanism acts through the increment in local amenities, attracting better economic agents.

Literature Review

Agglomeration Economies

Long list of papers evaluating agglomeration externalities using **across cities variation.**

- Ciccone and Hall (1996), Rosenthal and Strange (2008), Ciccone (2002), Ciccone and Hall (1996), Glaeser and Maŕe (2001), Combes et al. (2008a), Combes et al. (2010), De La Roca and Puga (2012), Mion and Naticchioni (2009), D'Costa and Overman (2014), Groot et al. (2014)...
  - Estimates around 0.01 and 0.037.

Agglomeration literature exploiting within city variation is very scarce.

- Arzaghi and Henderson (2008).

Few studies used transport-based accessibility to employment measures

- Graham (2007), Holl (2012), Gibbons *at al.* (2019)

Contribution: introduce transport exposure measures into the agglomeration discussion, and include public-transport-based accessibility to employment

Literature Review

Evaluation of Transport Investment Infrastructure

- Long list of papers analyzing the relationship between roads or public transport and several city variables: population, employment growth, intercity trade, driving habits, land prices...
- Gibbons at al. (2019): impact of new road infrastructure on labour productivity.
- Main challenge: Infrastructure placement not random.
  - Historical plans (Baum-Snow (2007, 2010), Michaels (2008), Duranton and Turner (2011, 2012), Mayer and Trevien (2017).
  - Physical geography (Banerjee et al. (2012), Faber (2014), Jedwab and Moradi (2016).
  - Incidental benefficiaries of links (Chandra and Thompson (2000), Holl (2004a), Melo et al. (2010).

Contributions:

- Introduce different local accessibility measures by different transport networks (public transport, roads), taking also into account agglomeration measures.
- Estimate the aggregate impact of transport exposure measures.
  1. Transport exposure not considered as a treatment: continuous variable causally affecting spatial productivity divergence.
  2. Account for the positive or negative effects on non-directly treated areas.

Literature Review

Indirect Effect of Transport on Productivity

Only two papers: Chatman and Nolan (2014) and Melo and Graham (2018)

- Data aggregated to the U.S. metropolitan level.

Contributions:

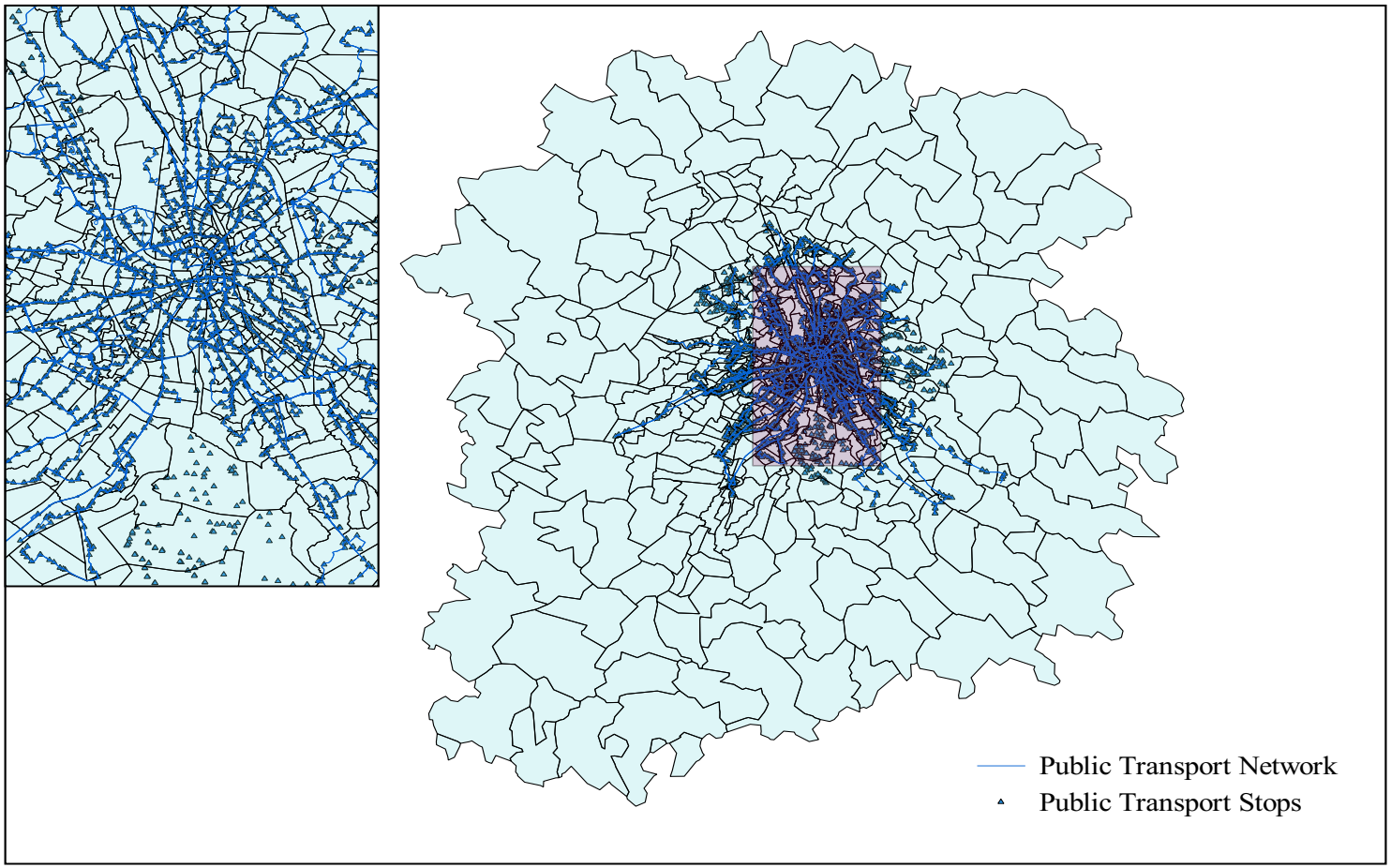
- Results more informative to an urban planner who wants to maximize wealth by shaping the transport network within a city.

Data

1. Agency of Urbanism and Planning of Toulouse (Agence d'Urbanisme et d'Aménagement de Toulouse, **AUAT**).
   - Geographical decomposition of Toulouse metropolitan area in 862 zones.
   - Exact location of establishments in 2013 and 2015.
   - 862x862 matrix of commuting times by private vehicle, public transport and bike, for 2013 and 2015.
2. TISSEO:
   - Public transport network from 2004 to 2015.
3. Institut National de la Statistique et des Études Économiques (**INSEE**): Annual Social Data Declarations (Déclaration annuelle des données sociales, **DADS**).
   - Establishments and Employees files for the period 2004-2015.

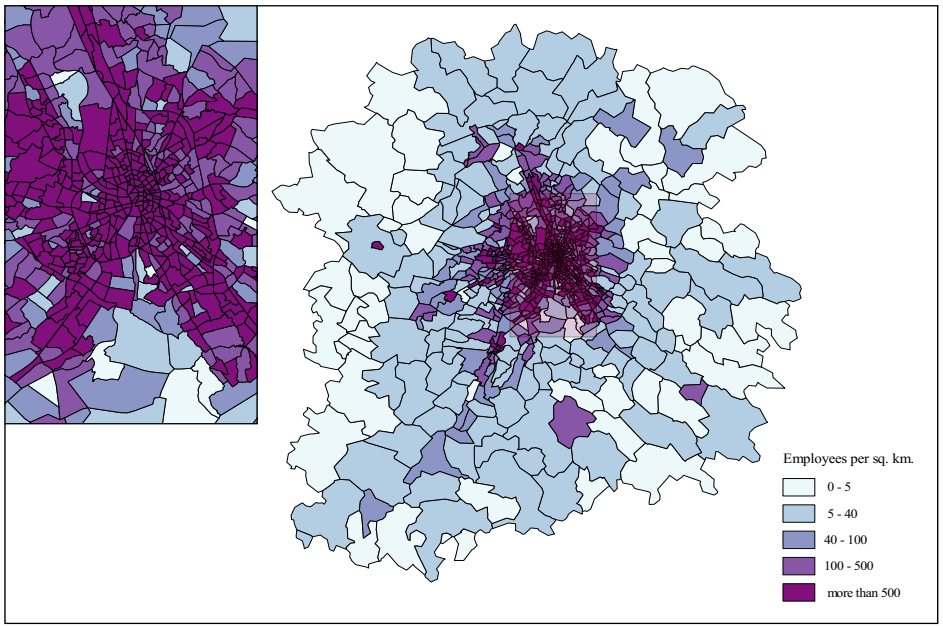
Geographical merge by SIRET: dissagregated and georeferenced data on 1,066,719 employees.

Metropolitan Area of Toulouse and Public Transport Network

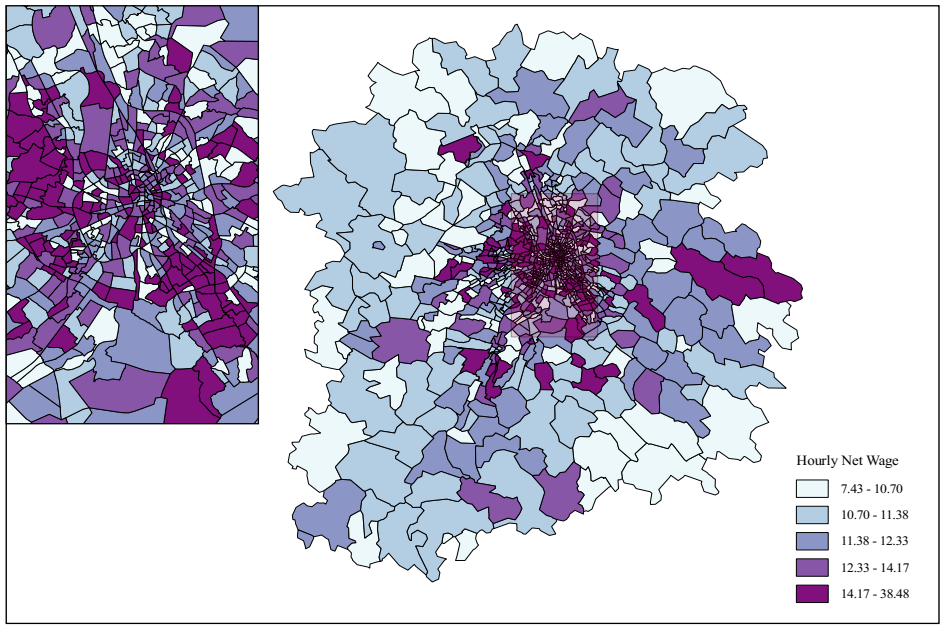


Density and Productivity Distributions in 2013

▸ Distributions in 2015



Employees per squared kilometer



Average Hourly Net Wage

- Density of employment higher along the public transport network.
- The highest values of density and productivity are concentrated in the center.
- The distributions have similar geographic structures.

Transport Accessibility Measures

Origin-Destination Commuting Times

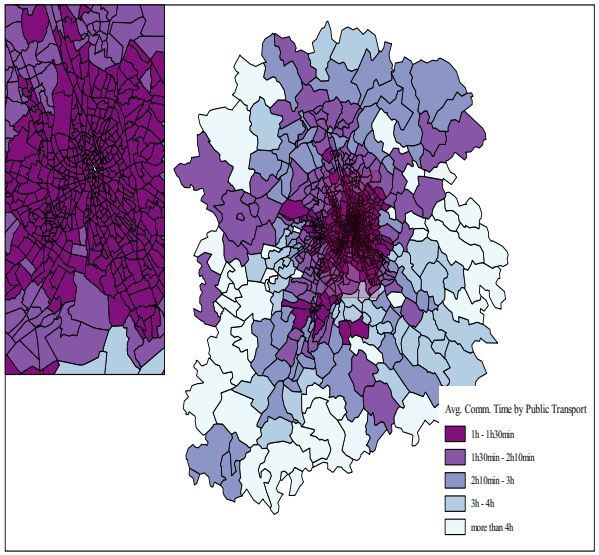
1. **Public Transport** ⇨ access time to the public transport network + in-vehicle time of the optimal path for the most favorable combination of public transport services + egress time from the public transport network. Daily average.
2. **Private Vehicle** ⇨ daily average time of the optimal path by car.
3. **Bike** ⇨ daily average time of the optimal path by car.

Transport Accessibility Measures: local average commuting time to a zone, from all the others, by:

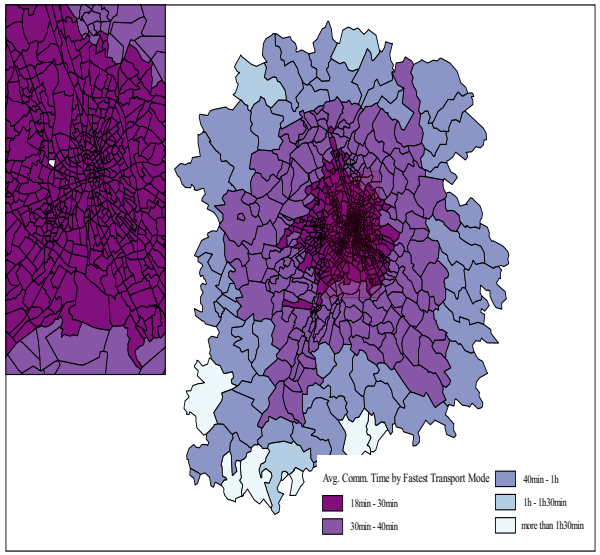
1. public transport,
2. the fastest mode per pair of zones and,
3. the average of the three modes.

Commuting Times Distribution for 2013

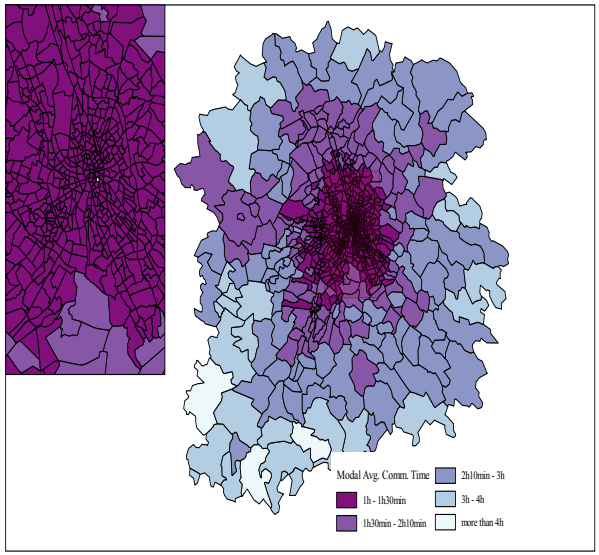
- Distributions in 2015



Public Transport



Fastest Transport Mode



Modal Average

Individual Wage Determination Model

Maximization problem of a competitive firm: Equilibrium wage

Asuming a Cobb-Douglas production function, employee i working in zone z and industry k in year t receives a wage equal to her marginal product:

$$w_{i,t} = b(1-b)^{\frac{(1-b)}{b}} \times \left(p_{z,k,t} \frac{A_{z,k,t}}{\left(r_{z,k,t}\right)^{1-b}} \right)^{\frac{1}{b}} s_{i,t}$$

$$= s_{i,t} B_{z,k,t}$$

where

- b is the exponent of labor in the Cobb-Douglas production function,
- $p_{z,k,t}$ is the firm's output price,
- $A_{z,k,t}$ is the total factor productivity,
- $r_{z,k,t}$ is the price of the non-labor inputs and,
- $s_{i,t}$ represents individual skills.

Micro-Econometric Specification of the Wage Equation

We take the wage equation into the data:

$$w_{i,t} = s_{i,t} B_{z,k,t} \implies log\left(w_{i,t}\right) = log\left(s_{i,t}\right) + log\left(B_{z,k,t}\right)$$

Specification for the log of the skills

$$log\left(s_{i,t}\right) = X_{i,t}\alpha + \gamma_i + \varepsilon_{i,t}$$

Specification for the log of local productivity differences

$$log\left(B_{z,k,t}\right) = \delta_{z,t} + \theta_{k,t} + X_{z,k,t}\beta_k$$

Individual log wage specification:

$$log\left(w_{i,t}\right) = log\left(s_{i,t}\right) + log\left(B_{z,k,t}\right) = \gamma_i + X_{i,t}\alpha + \delta_{z,t} + \theta_{k,t} + X_{z,k,t}\beta_k + \varepsilon_{i,t}$$

Aggregation by Industry and Zone

Aggregation: As employees are not followed over time, I aggregate their log wages by zone and industry.

Aggregating the log wages by zone and industry:

$$w_{z,k,t} = \frac{1}{N_{z,k,t}} \sum_{i \epsilon (z,k,t)} log\left(w_{i,t}\right)$$
$$= \delta_{z,t} + \theta_{k,t} + X_{z,k,t}\beta_k + \alpha \frac{1}{N_{z,k,t}} \sum_{i \epsilon (z,k,t)} X_{i,t} + \varsigma_{z,k,t}$$

where $\varsigma_{z,k,t} = \frac{1}{N_{z,k,t}} \sum_{i \epsilon (z,k,t)} \varepsilon_{i,t}$

First and Second Stage Specification

First Stage Specification:

$$w_{z,k,t} = \delta_{z,t} + \theta_{k,t} + X_{z,k,t}\beta_k + \alpha \frac{1}{N_{z,k,t}} \sum_{i \epsilon (z,k,t)} X_{i,t} + \varsigma_{z,k,t}$$

Second Stage Specification:

$$\hat{\delta}_{z,t} = \nu_0 + \kappa_t + \eta_c + Agg_{z,t}\psi + TE_{z,t}\pi + X_{z,t}\theta + \upsilon_{z,t}$$

First Stage Specification

First Stage Specification:

$$w_{z,k,t} = \delta_{z,t} + \theta_{k,t} + X_{z,k,t}\beta_k + \alpha \frac{1}{N_{z,k,t}} \sum_{i \epsilon (z,k,t)} X_{i,t} + \varsigma_{z,k,t}$$

Issue:

- The quality of the workforce in an area is likely to be endogenous $\rightarrow$ inclusion of transport accessibility measures.

Estimation Issues

- Endogeneity of agglomeration and transport exposure measures.
  - **Omitted variable bias**: any correlation between local characteristics and the average skills of the local workforce, included in the error term, may lead to biased estimates (*sorting*).
  - **Reverse causality bias** between agglomeration and transport exposure measures and productivity.
  - The allocation of transport infrastructure is **not random**.

Second Stage Specification

Second Stage Specification:

$$\hat{\delta}_{z,t} = \nu_0 + \kappa_t + C_{z,t}\psi + U_{z,t}\pi + \upsilon_{z,t}$$

- Heteroskedasticity $\rightarrow$ observations in the first stage weighted by root square of the number of employees.
- Local characteristics are likely to be endogenous to local wages $\rightarrow$ Instrumental variables approach.
  1. Lagged levels of employment densities,
  2. the local proportion of unbuildable land,
  3. employment accessibility levels of neighboring zones,
  4. transport accessibility rates in neighboring zones
  5. the lagged presence of physical infrastructure.

Stage I: Local industrial wage average.

- The estimated coefficients for the first stage of the estimation have the expected sign and are consistent with previous literature.

Summary of the coefficients

- The log **industry** specialization measure has a positive and significant effect for all industries, **0.187.**
- The log **number of establishments** has a negative average effect on local industrial productivity**,** -**0.03.**
- The log of the **proportion of professionals** in the industry is very positive and significant for all industries, with an average effect of **0.7671.**
- The coefficients for the **mean age** and the **mean of the squared ages** in the industry are **0.039** and -**0.0004,** respectively.
- The coefficients for the **porportion of woman** in the industry, and the **proportion of full-timers** are -**0.077** and **0.163**, respectively.

Stage II: Fastest Transport Mode Accessibility Measures.

▸ First Stage FM

Stage II Results. Fastest Transport Mode Accessibility Measures

	Dependent Variable: First Stage Zone-Year Effects							
	OLS	OLS	OLS	OLS	OLS	IV	First Diff.	First Diff. IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log(density)	0.014***	0.021***	0.014***	0.019***	0.015***	0.008***	0.018***	0.142
	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.003)	(0.006)	(0.105)
log(diversity)		-0.010*	-0.009*	-0.012**	-0.010*	-0.009	0.012	0.048
		(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.014)	(0.034)
log(area)		0.013***	0.024***	0.022***	0.026***	0.028***		
		(0.002)	(0.003)	(0.003)	(0.003)	(0.003)		
log(acc. to employment)			0.014***		0.010***	0.018***	0.103***	0.084
			(0.003)		(0.003)	(0.005)	(0.037)	(0.092)
log(avg. comm. time)				-0.079***	-0.044**	-0.096***	-0.499***	0.410***
				(0.018)	(0.021)	(0.034)	(0.021)	(0.064)
log(number of lines)				0.008**	0.005	-0.025***	-0.002	0.174
				(0.004)	(0.004)	(0.007)	(0.018)	(0.270)
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,723	1,723	1,723	1,723	1,723	1,677	861	838
R^2	0.253	0.272	0.285	0.283	0.287	0.247	0.008	0.010
Adjusted R^2	0.253	0.270	0.283	0.280	0.284	0.244	0.003	0.005
Residual Std. Error	0.089	0.088	0.087	0.087	0.087	0.088		
F Statistic	292.025***	160.296***	136.678***	112.628***	98.681***		-1.943	-63.771
Note:	Significance levels are defined by * if p-value < 0.1; ** if p-value < 0.05, and, *** if p-value < 0.01							

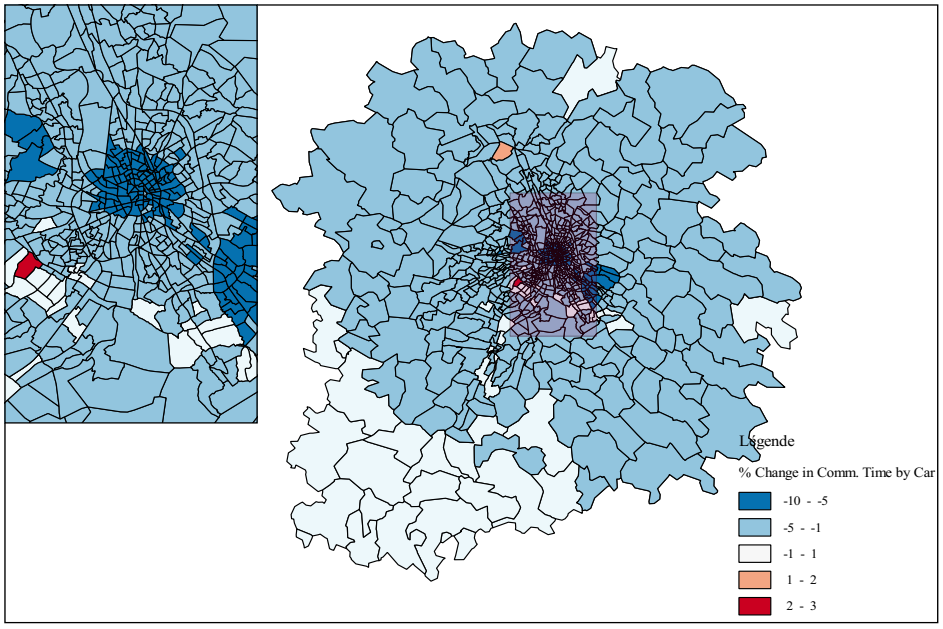
Evaluation of Toulouse Third Metro Line

- Simulation of commuting time matrix after the construction of the metro line.
- Elasticity of transport accessibility on productivity: computed from the model.

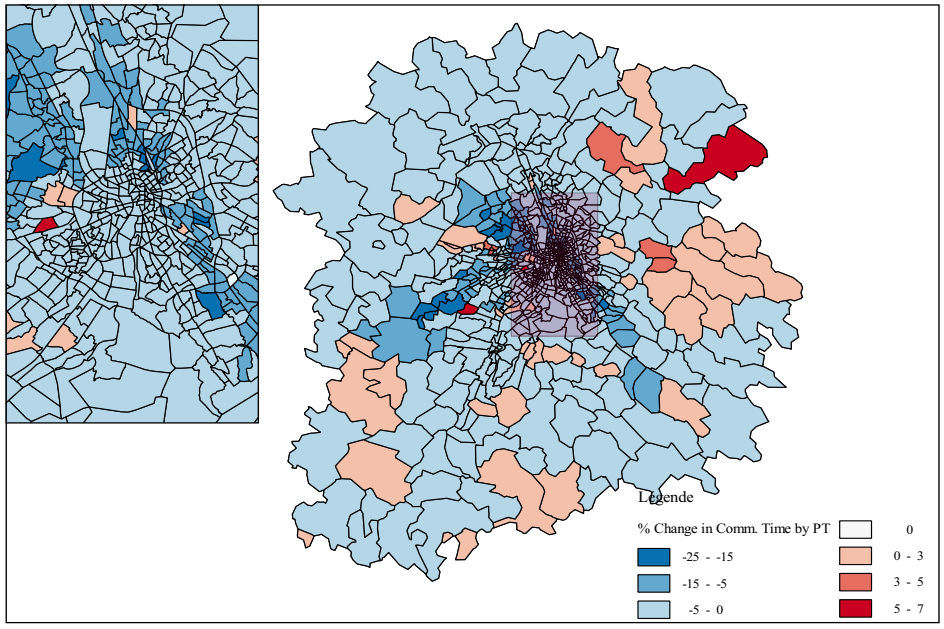
Computation

$$\%\Delta Productivity_{z,t} = \%\Delta TransportAccessibility_{z,t} * Elasticity$$

% Change in Transport Accessibility

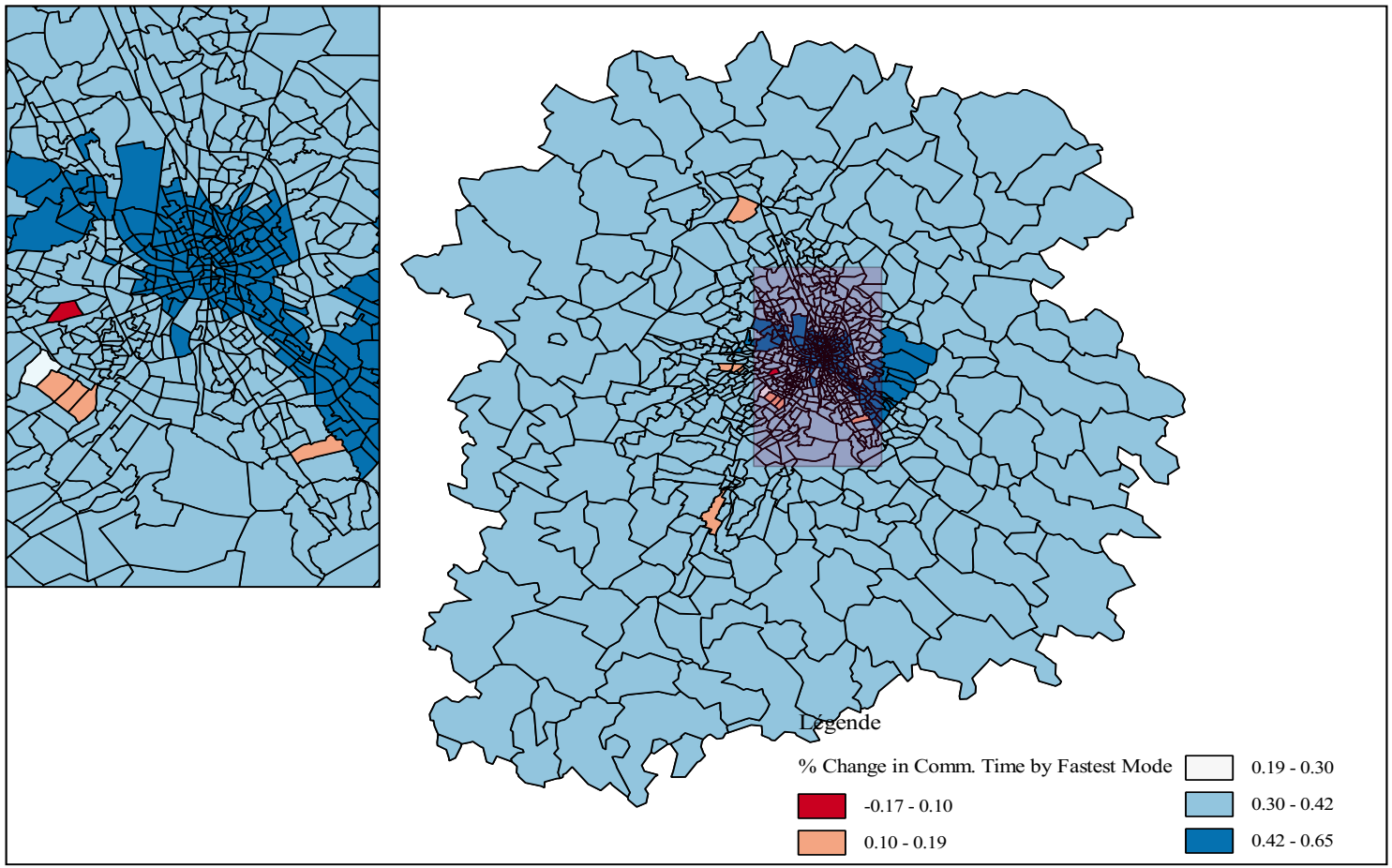


% Change in Transport Accessibility by Car



% Change in Transport Accessibility by Public Transport

% Change in Productivity



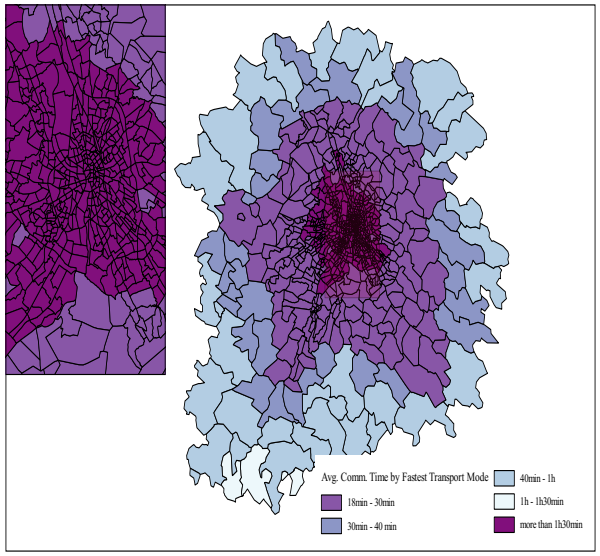
Conclusion

- This paper develops a framework to investigate the sources of wage disparities across local labor markets within a metropolitan area.
- We show that the introduction of transport accessibility measures is indeed important.
  - On average, the effect of doubling the local average commuting time, decreases local productivity by 10%.
  - The effect of agglomeration measures decreases quantitatively and qualitatively.
- Overall effect of third metro line in Toulouse metropolitan area: 0.36%.

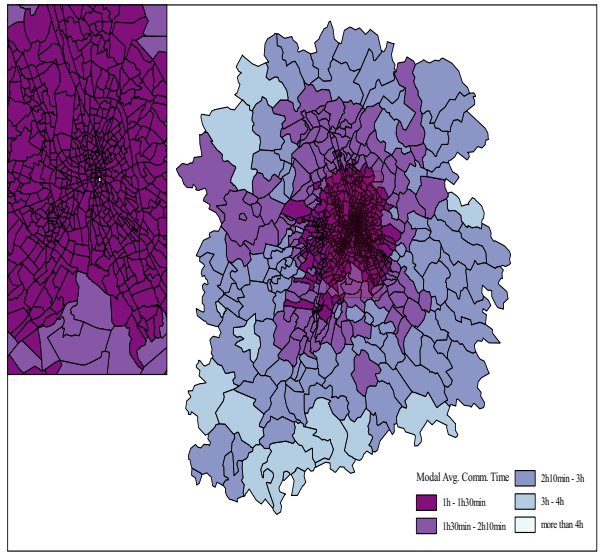
Average Commuting Times Distributions in 2015

◂ Distributions 2013

Public Transport



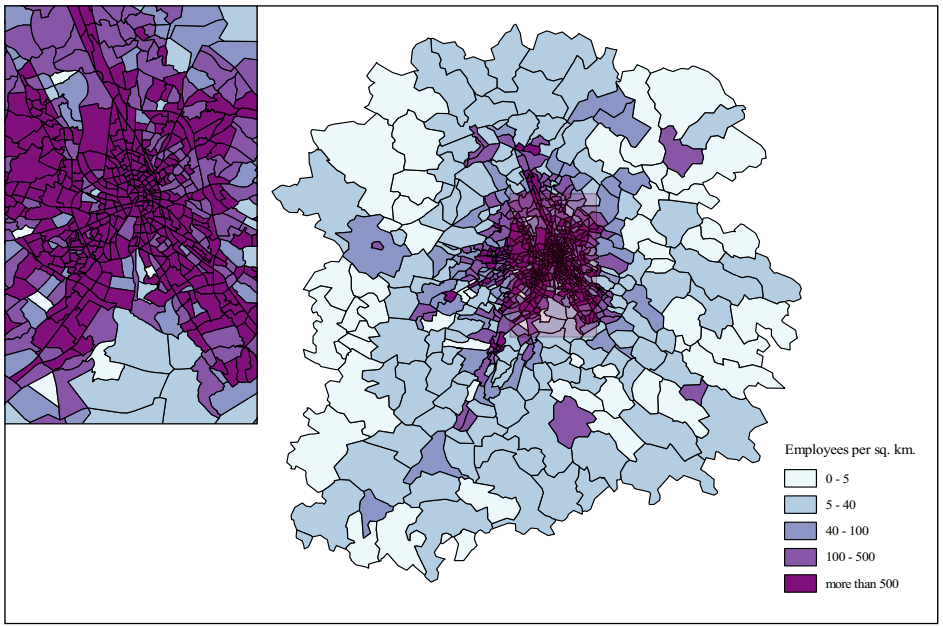
Fastest Transport Mode



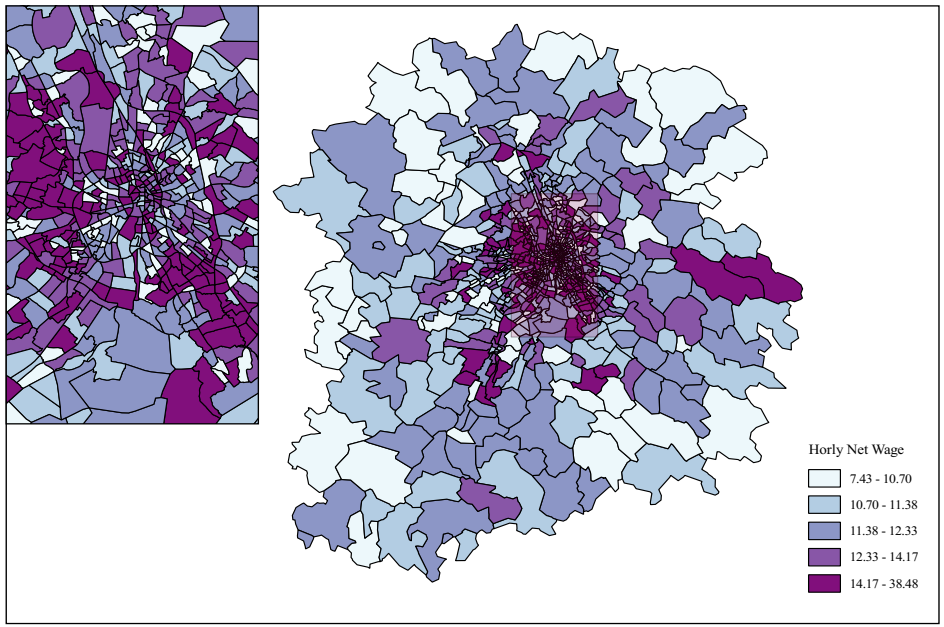
Modal Average

Density and Productivity Distributions in 2015

Distributions 2013



Employees per squared kilometer



Average Hourly Net Wage

First Stage Results for Fastest Transport Mode Specification

◂ Stage II FM

First Stage Regressions for Endogenous Variables

	Dependent Variable:			
	log(density)	log(acc. employment)	log(avg.comm. time)	log(n. lines)
	(1)	(2)	(3)	(4)
log(diversity)	-0.293***	-0.260***	-0.008*	-0.039
	(0.062)	(0.041)	(0.004)	(0.031)
log(area)	-0.124***	-0.124***	0.004*	-0.055***
	(0.033)	(0.021)	(0.002)	(0.016)
log(density in 2004)	0.125***	0.079***	-0.001	0.019
	(0.026)	(0.017)	(0.002)	(0.013)
log(density in 2006)	0.626***	0.261***	-0.005**	0.031**
	(0.028)	(0.019)	(0.002)	(0.014)
log(stations in 2004)	-0.017	-0.104	0.005	0.094*
	(0.099)	(0.065)	(0.007)	(0.049)
log(stations in 2006)	-0.013	0.139**	0.008	0.277***
	(0.097)	(0.064)	(0.007)	(0.048)
log(prop. of water)	-0.031	0.256	-0.015	-0.460*
	(0.503)	(0.332)	(0.035)	(0.247)
log(neighbors acc. to employment)	-0.0004	0.394***	0.018***	0.009
	(0.042)	(0.028)	(0.003)	(0.021)
log(neighbors avg. comm. time)	-1.532***	-3.022***	1.229***	-0.287
	(0.464)	(0.306)	(0.032)	(0.228)
Time Effects	Yes	Yes	Yes	Yes
Observations	1,678	1,678	1,678	1,678
R^2	0.860	0.941	0.934	0.577
Adjusted R^2	0.859	0.941	0.933	0.575
Residual Std. Error	0.910	0.601	0.063	0.447