Evaluating sustainable transportation offers through housing price: a comparative analysis of Nantes urban and periurban/rural areas (France)

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Third International Workshop: The Energy Transition in Land Transportation: 9 November 2017

Why this study ?

The relationship between house prices and transport infrastructure is a popular research topic (Europe, America and China)

ORIGINALITY:

- Alternative to solo cars use considered as “less polluting” and “sustainable solutions”
- 2 areas : urban and periurban/rural

2 areas

● **Urban area** (where sustainable solutions are well known : bike-sharing, tramway etc.)

● **Perirurban/rural areas** (where sustainable solutions are less studied as carpool areas, rural line of bus)

Aims

- The main aim was **to assess the impact** of a **sustainable transportation infrastructure** on the **property sale price**
- to **help policy-makers reduce solo car use in different territories**.

How ?

- The **hedonic price method** and the **techniques of spatial econometrics and local analyses**.

Content

I-Econometrical model-some words

Method : Hedonic price model

- The objective : is to **reveal the implicit prices** of the different attributes of a heterogeneous good on the basis of its overall price (Lancaster, 1966, Rosen 1974)

- The most common problems are:
  - the failure to take into account the expectations of **future levels of amenities** (Freeman, 1979).
  - the **endogeneity** of certain explanatory variables
  - **spatial heterogeneity** and **spatial dependence**

…Spatial models

- The geolocalized data : **postal addresses of the transactions (in our study)**, require special treatment (Le Gallo and Thomas, 2015).
- Spatial observations are frequently interdependent:
  - « What happens in a particular location depends on what happens in other locations » : **Spatial dependence** (Anselin, 2001)

- Spatial econometric methods use an instrument to represent these spatial interactions : the weight matrix (W)

Spatial econometric models used

Spatial AutoRegressive Model (SAR) (Le Gallo, 2002; Lesage and Pace, 2009):

$$Y = \rho WY + X\beta + \varepsilon \quad (1)$$

where : Y is the variable explained,
X is the matrix of the exogenous variables,
ε is an error term,
and β is the vector of regression coefficients.

The price of the house sold (Y) depends on the prices of neighboring houses, ρ being the spatial parameter to be estimated.

Spatial Error Model (SEM) (Le Gallo, 2002; Lesage and Pace, 2009):

$$Y = X\beta + \varepsilon \qquad with\ \varepsilon = \lambda W\varepsilon + \mu \qquad (2)$$

where Y is the variable explained,
X is the matrix of the exogenous variables,
ε is an error term,
β and is the vector of regression coefficients.

The SEM model is specified with an autoregressive structure of the error term, where λ is the spatial parameter to be estimated.

Spatial Durbin Model (SDM) (Le Gallo, 2002; Lesage and Pace, 2009):

$$Y = \rho WY + X\beta + \gamma WX + \varepsilon \quad (3)$$

Where Y is the variable explained,
X is the matrix of the exogenous variables,
ε is an error term,
and β is the vector of regression coefficients.

The spatial autoregressive process is applied to both the explained and explanatory variables.

Local regression models

Geographically Weighted Regression (GWR) (Brunsdon et al., 1996):

$$y_i = \beta_0(u_i, v_i) + \sum_k \beta_k (u_i, v_i) X_{ik} + \varepsilon_i \quad (4)$$

where (u_i, v_i) represents the geographical coordinates of location and $\beta_k(u_i, v_i)$ is a realization of the continuous function $\beta_k(u, v)$ at point *i*.

The GWR model aims to detect the spatial heterogeneity by exhibiting spatial patterning of **local regression coefficients**.

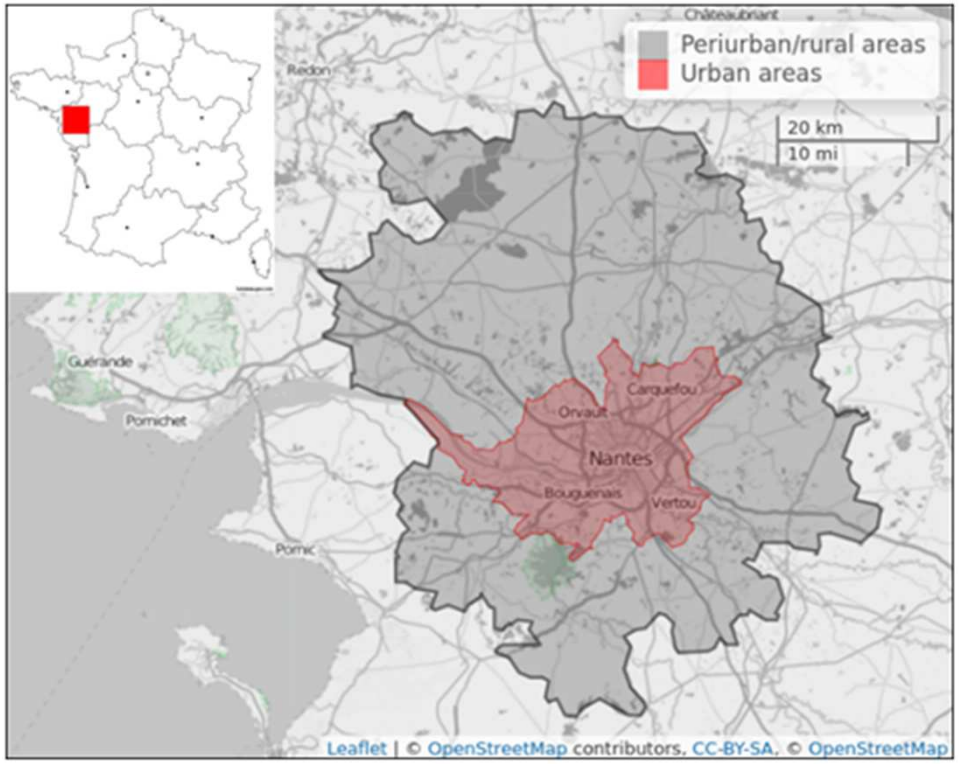
One weighted regression is performed per data point, according to a spatial weighting scheme giving more importance to nearer neighbors than farther ones.

II-Study area and database

In order to distinguish spatial contexts, the study area was divided into two samples:

(i) the urban area (Nantes Métropole: including 619,000 inhabitants in 2014)

(ii) the periurban and rural areas (321,000 inhabitants without Nantes Métropole)



2,262 house transactions including:

- **1,353 in the urban area**
- **909 in the periurban and rural areas (for 2012)**

House related variables

- The sale prices and intrinsic variables of the houses came from the **PERVAL notarial database**.

- The variable explained is the 2012 sale price in €.

- The intrinsic variables used in the study are the followings:

  -**Living surface area (m²)**

  -Land surface area (m²)

  -Construction period : When the house was built, with 7 different classes: **A: <1913**; B: 1914-1947; **C: 1948-1969**; D: 1970-1980; **E: 1981-1991**; F: 1992-2000; **G: 2001-2012: the reference variable**

Two contextual variables

- Two contextual variables were added to the models:
  - population density (hab./km²)
  - unemployment rate (%).

- These variables were assessed at the IRIS Census unit scale.

Mobility offers in the Nantes urban area-variables

3 mobility offers are of interest.

- **1- Railway stations** : **11 railway stations** that were in service in 2012
  + 5 railway stations in the northern part of the urban area (the “tram-train” line from Nantes to Châteaubriant, was opened in 2014).

Railway station variable : **Distance to the nearest railway station**

- **2-Tramway and Busway** : 3 lines of tramways were implemented and the fourth one the “busway”, a Bus Rapid Transit or BRT line.

Tram or busway station variable: Distance to the nearest tram or busway station

- 3- **The “Bicloo” bike-sharing offer:** was provided in the central districts of the Nantes urban area in 2008. The station network was gradually extended over a wider territory and **included 103 stations in 2012.**

Bike-sharing station variable: Distance to the nearest bike-sharing station

Mobility offers in the periurban and rural area- variables

- **1-Railway stations** : the railway stations along the five train lines leaving Nantes outwards.

Railway station variable:
Distance to the nearest railway station

●**2-“Lila” bus stations** were implemented in the whole *département* and within the periurban and rural area (n=435).

Lila” bus station variable :
At least one “Lila” bus station in a buffer of 500 m radius near the house. It is a dummy variable, 1 if <500

- **3-carpool stations** have been either implemented or authorized since 2009

Carpool area variable:
At least one carpool area in a buffer of 1500 m radius near the house.
It is a dummy variable, 1 if <1500 m

- Once the database was built, **multicollinearity between regressors** was checked through **the variance inflation factor (VIF).**

- No values higher than 5 were present so all the variables were kept.

III-Model calibration

- The price of the house : the dependent variable (in a logarithmic form).
- Independent variables included house intrinsic characteristics, socio-economic variables and sustainable transport attributes.

- First, the spatial dependence of the linear model (OLS) residuals was tested through the global Moran test.
- Moran's I exhibited a significant p-value (<0.001), **indicating a strong spatial autocorrelation.**

- In order to overcome this, the following spatial models were used:
  - Spatial AutoRegressive Model (SAR),
  - Spatial Error Model (SEM) and
  - Spatial Durbin Model (SDM).

Spatial weight matrix (W)
=
exponential function

- The optimal number nearest neighbors (minimizing the AIC of the models) **20 nearest** neighbors were selected in the **urban area** and **8** in the **periurban and rural areas.**

- In addition, a Geographically Weighted Regression (GWR) model was run.

An adaptive kernel bandwidth was chosen.
The optimal number of neighbors (AIC minimization procedure):
64 for the **urban area** and **74** for the periurban and rural areas

IV-Results and discussion

Urban area

	OLS	SAR	SEM	SDM	GWR
AICc	453.838	425.333	422.012	427.645	395.851
Nagelkerke R^2	-	0.606	0.607	0.616	-
Adjusted R^2	0.587	-	-	-	0.632
Moran's I	0.001	0.092	0.589	0.52	0.147

Results urban area: n=1353

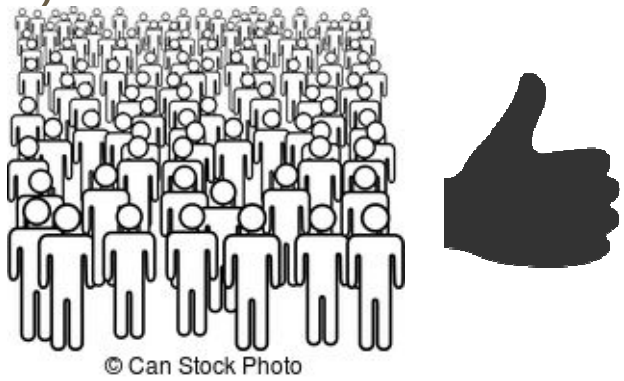
- In each model (OLS, SAR, SEM and SDM) : the intrinsic vaiables of the houses sold had **significantly positive effects.**

  - *For the OLS model, if the living surface area increased by 1%, the price per square meter increased by 0.896%.*

- The **age of the houses** (except for those built between 1991 and 2000) had a **negative significant impact** on the sale price compared to houses built after 2000.

- **Neighborhood characteristics:**

  o the **population density** had a **significant positive impact** in the three models (OLS, SAR and SEM)



  o the **unemployment rate** had a **low negative impact in the three models** (OLS, SEM and SDM).

Discussion about the transport attributes

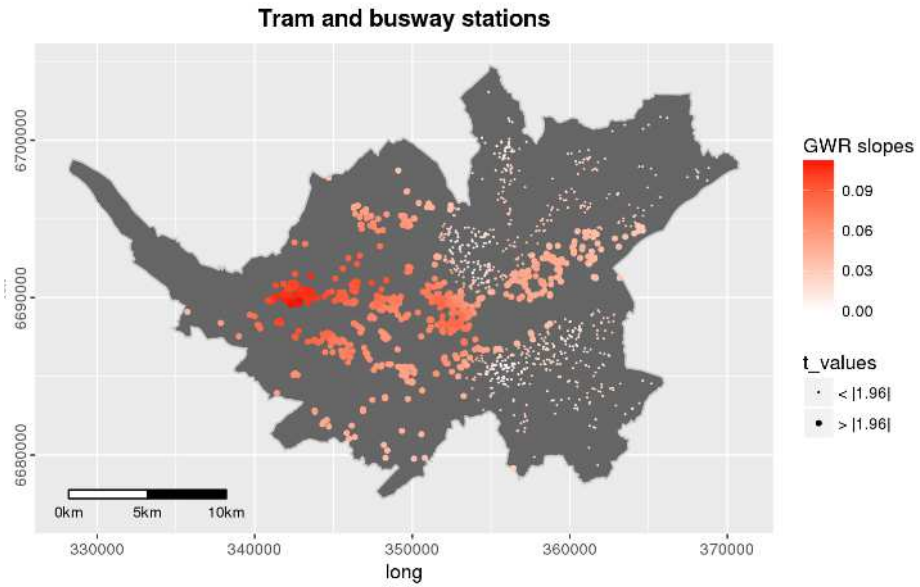
The **distance to the nearest tram station** (train station) had a **significant positive impact** in the three models (OLS, SAR and SEM).

- For example, in the OLS model, increasing the distance by 1% led to an increase of 0.064% in the sale price.

- The **negative externalities of tramways and the busway** (noise for example) **have a negative impact** on house prices (Pan, 2012; Efthymiou and Antoniou, 2013; Le Boennec and Salladarré, 2017).

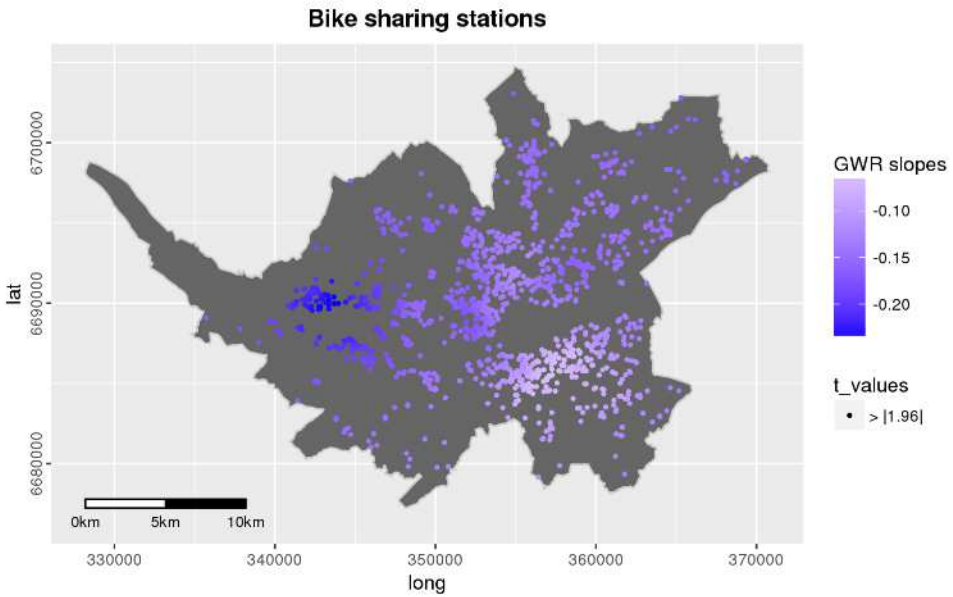
- However, the GWR model provided important information that questions this global result.
- We observed **spatial nonstationarity** for the tramway and busway variables.

GWR-Tram and trains



- The W-part was characterized by **significantly positive slopes**, while they were mostly non-significant in the E-part.
- Different impact within the urban area.
- It has been seen as an indication to implement local transport policy.

GWR-Bike-sharing



- The **distance to the nearest "Bicloo"** station had a **significant negative impact on house prices** in the three models (OLS, SAR, SEM).

- The GWR model showed that the **bike-sharing station variable was significantly negative everywhere** but exhibited **spatial patterning** in terms of intensity.

- Our results are consistent with El-Geneidy et al. (2016) who found that the presence of a bike-sharing system is expected to increase property values.

Results and discussion for the periurban and rural areas

The periurban models also outperformed the urban models

	OLS	SAR	SEM	SDM	GWR
AICc	**453.838**	**425.333**	**422.012**	**427.645**	**395.851**
Nagelkerke R^2	**-**	**0.606**	**0.607**	**0.616**	**-**
Adjusted R^2	**0.587**	**-**	**-**	**-**	**0.632**
Moran's I	**0.001**	**0.092**	**0.589**	**0.52**	**0.147**

- **Intrinsic variables**

The intrinsic characteristics of the houses (living surface area and land surface area) had **significantly positive effects.**

Except for houses built between 1991 and 2000, the construction period **had a negative significant impact** compared to houses built after 2000.

Neighborhood characteristics :

The results were the same as in the urban area.

- The population density **had a significant positive impact** in the three models (OLS, SAR and SEM)

- The **unemployment rate** had a **low negative impact** in the three models (OLS, SEM and SDM).

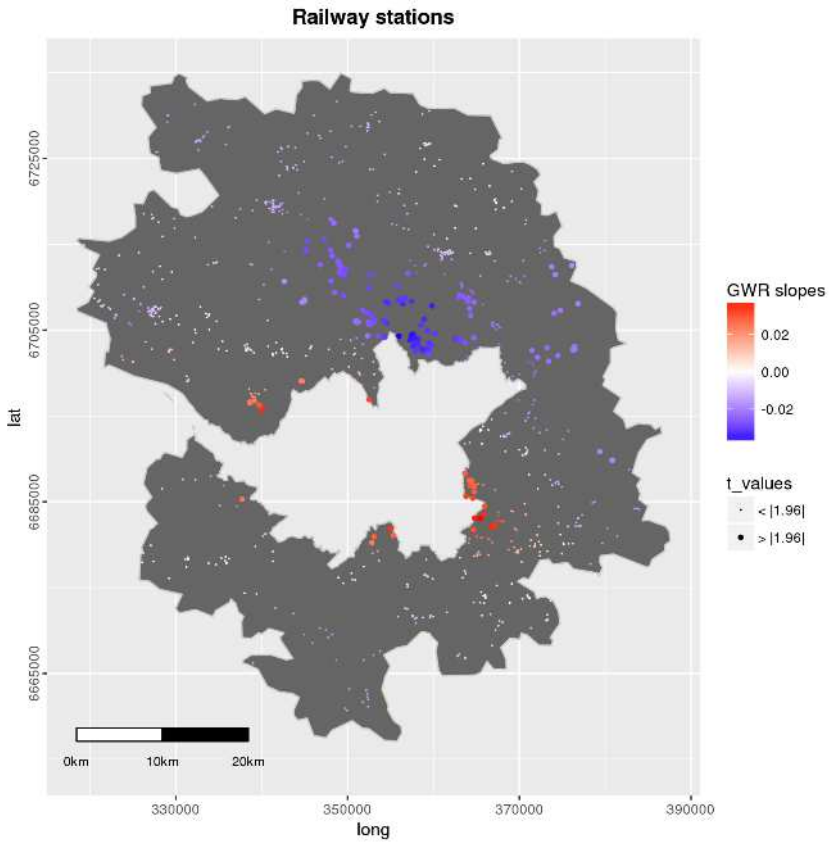
Sustainable transport attributes

- The distance to the **nearest railway** station had a **negative significant impact** in the three models (OLS, SAR, SEM)

- The **carpool area** was significant only in the OLS model. **Having a carpool area at least 1500 m from the house had a negative impact.**

- Having a **“Lila” bus station** around the house **had a positive significant impact** in the three models (OLS, SAR and SEM)
- In the OLS model, it increased the price by 7.1%.

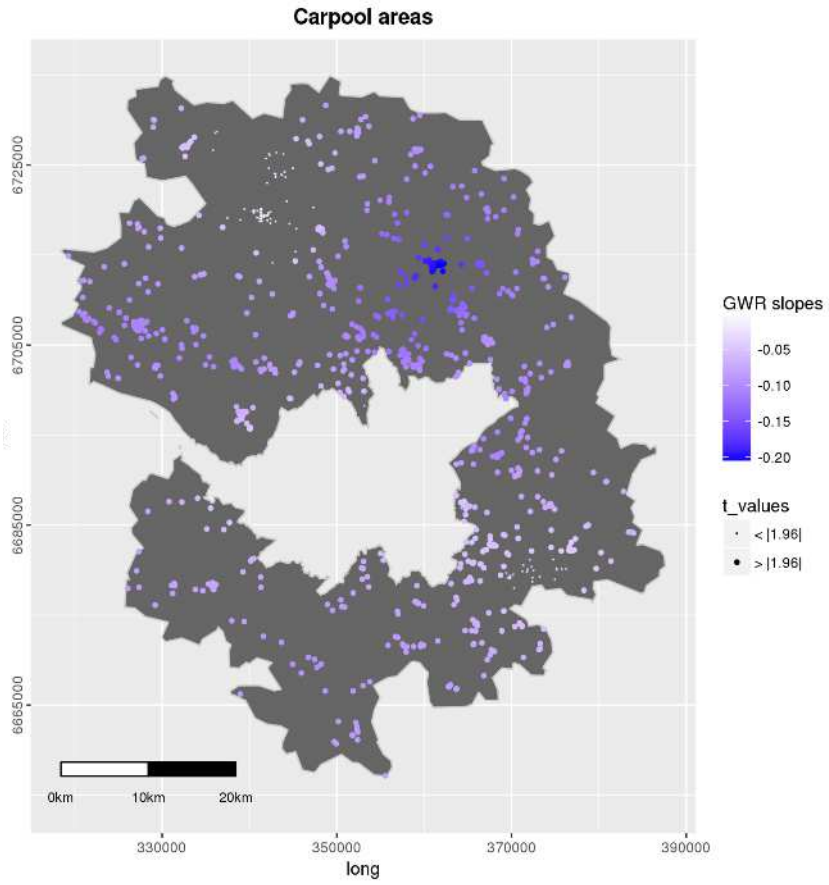
GWR-railway station



- The **distance to the nearest railway station** mainly revealed non-significant slopes, **except in the middle and northeastern part with significant negative values**.

- In those areas, being located near a railway station of the Châteaubriant-Nantes line (North) or the Ancenis-Nantes line (East) significantly **improves overall accessibility to Nantes;**

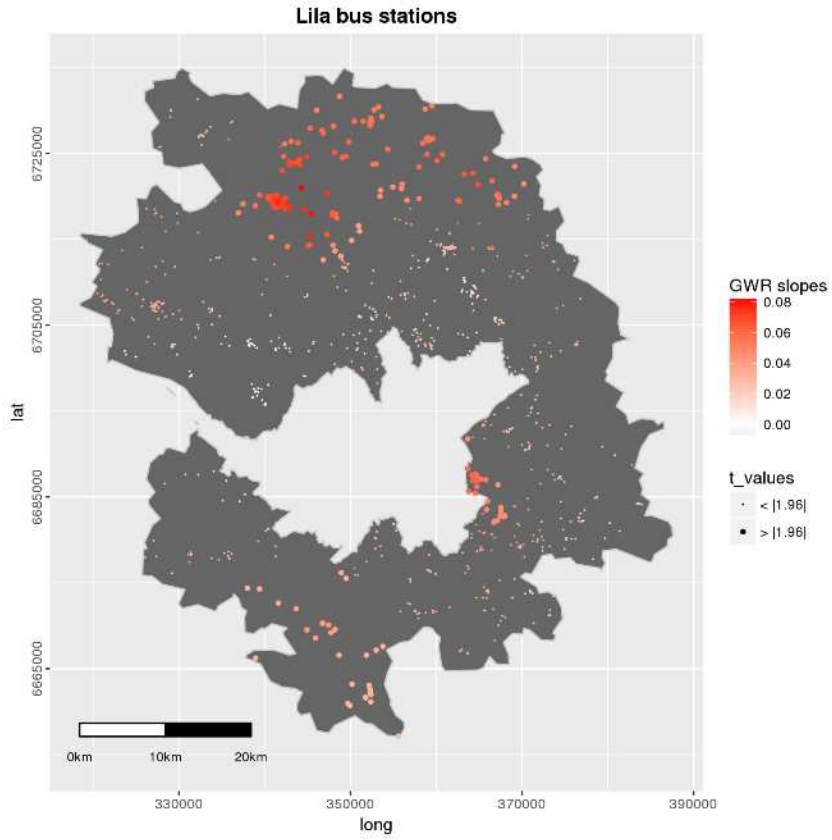
GWR-carpool areas



The GWR model exhibited negative slopes for carpool area and was **significant almost everywhere**, with a cluster of low values in the middle northern part.

Omission of a local variable ?

GWR-Lila bus stations



Slopes were **significant in the northern part** of the area, but **mostly non-significant elsewhere**, except in a few southern sectors.

This pattern (North) is consistent with the absence of alternative modes in the northern area until 2014, with the exception of carpool areas that were potentially under-utilized in 2012.

In the southeastern part of the periurban and rural areas, the “Lila” lines may be viewed as attractive by parents with children going to middle or high school within the urban area.

CONCLUSION

In 2004, Time Magazine named Nantes “**the most liveable city in Europe**” and in 2013 it held the title of **European Green Capital**.

Interest to study the sustainable offers

The major findings :

- some sustainable transportation solutions had no or counterintuitive effects
- but, above all, that these results exhibited **spatial variations throughout the study area.**

- The results of the global models were robust and those of the GWR model (local model) were enlightening,
  - these should be considered a first step in the analysis of sustainable mobility.
  - They give indications about the various alternatives to solo car use to be implemented in different types of territories.
- In order to implement a sustainable transport policy or sustainable urban development adapted to each neighborhood/territory : need qualitatives studies

Thank you !

Questions ? Comments?

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