Differentiating the value of land from that of real estate to better understand the impacts of NNLT on housing affordability

THE ADDED VALUE OF COMPLEX MODELLING

Research Methods III: Seminar in Advanced Research Methods – RePIC master

Charlotte Bernier – 19 November 2024

Context

The NNLT target: a European ambition

- Communication from the European Commission in 2011 & 2023
- **« No Net Land Take »** by 2050 ➔ Stop artificialisation

… locally declined

- In Flanders, with the “Bouwshift” policy
- In Wallonia, with the “Schéma de Développement Territorial”
- Drastic limitation of soil artificialization (“Stop-concrete”)
- Meet the growing demand for housing (↗ number of households)

How to reconcile land restrictions and housing affordability ?
(in Belgium/Wallonia)

How to answer our question?

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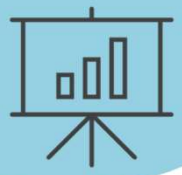
Housing affordability

Different issues

- Description of household expenditure
- Analysis of housing market trends
- Predicting a household's ability to pay its rent or mortgage
- Match between the type of housing and the type of household that occupies it
- Defining housing needs for public policy purposes…



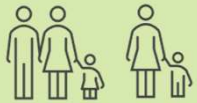
Several dimensions

- Financial accessibility
- Quality standards
- Sanitation, decency
- Access in terms of mobility
- Spatial justice
- Socio-spatial segregations…

Underlying questions

- What type of housing?
- Owners? Tenants?
- For who ?

…



Several dimensions

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One dimension of housing affordability

Suspected as the most impacted dimension by the land restrictions of the NNLT policy

How to answer our question?

How to reconcile land restrictions and housing affordability (in Belgium/Wallonia)?

Focus = Financial access to housing

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1) **What are the main causes of the increase in values/prices?**
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Causes of increases in values?

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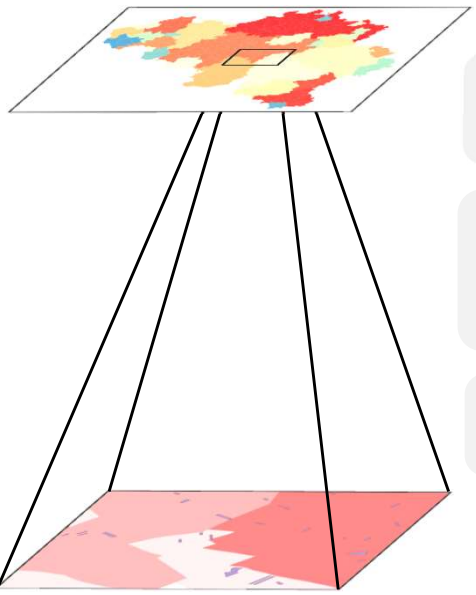


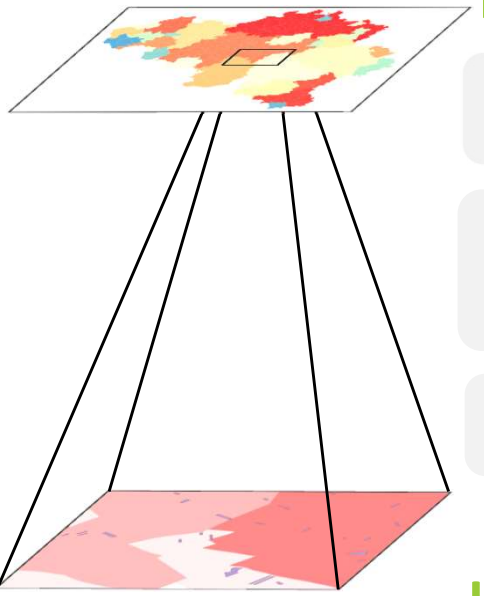
Inter-market scale: macroeconomic factors

↗ **Demand** (↗ number of households ; ↗ income ; ↘ borrowing rate)

Inelasticity of supply (scarcity of land, too long delays in obtaining permits, etc.)

Socio-economic disparities (↗ income or wealth gaps…)

Causes of increases in values?



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Socio-economic disparities (↗ income or wealth gaps…)

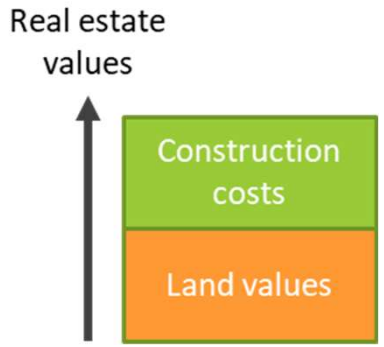
Intra-market scale: housing, a combinatorial good

Build structure

Living surface area, quality and age of construction…

Land

Localisation, accessibility, quality of the physical and social neighborhood, relief…

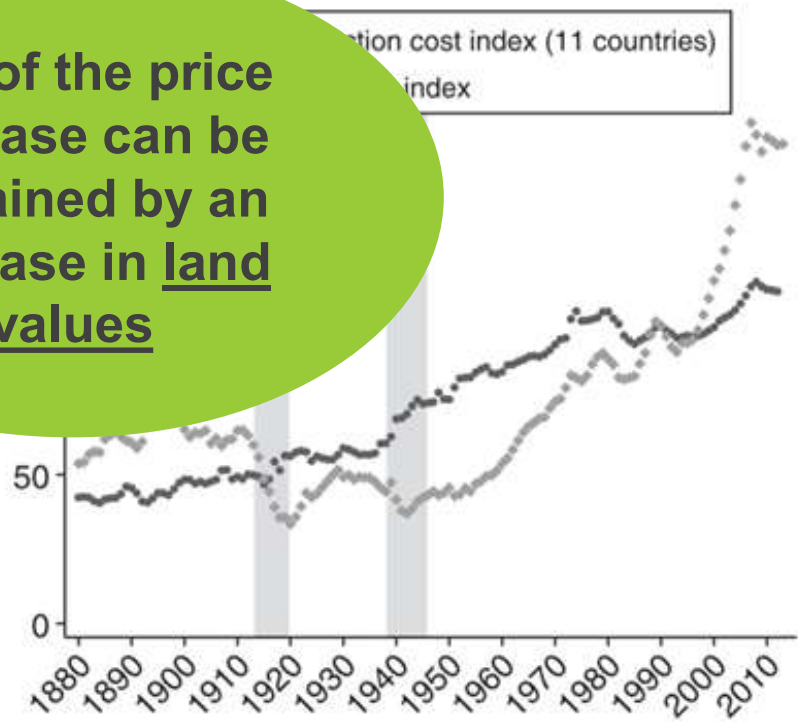


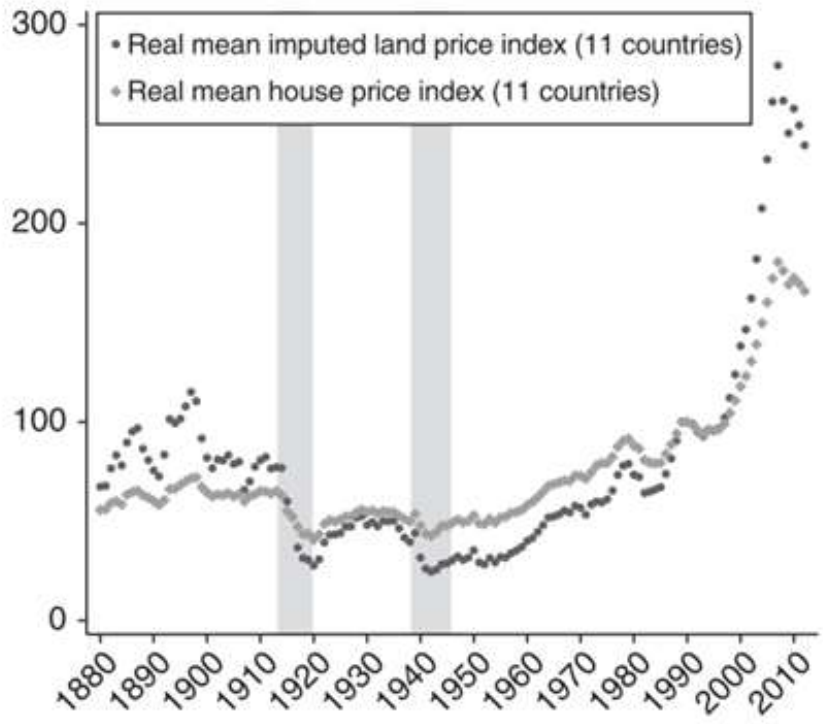
What share of the land?

Construction costs
versus
House prices

Land prices
versus
House prices

80% of the price increase can be explained by an increase in land values





Decomposition of land prices and construction costs in 11 OECD countries (Knoll *et al.,* 2017, p. 345)

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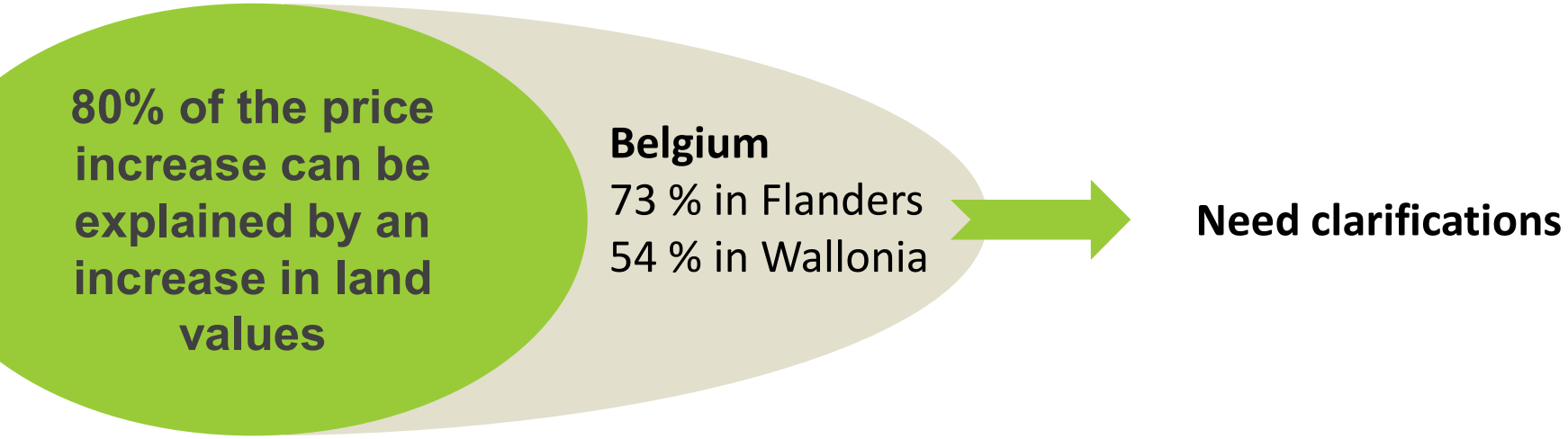

Impact of land supply restrictions?

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Norway, England…

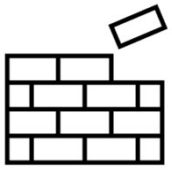
1945-1950 **1980**

Compact city model, containment of urban areas…

Continued ↗ increase in demand

Committed housing policy

Political disengagement in housing



Construction of many social housing

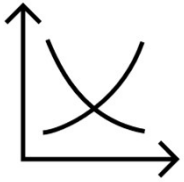
(Regulation of housing prices)

➔ Housing affordability

Neoliberal turning point

Market strategy and increasing reliance on the private sector to provide housing

(Deregulation of housing prices)



↗ increasing issues of housing affordability, socio-spatial segregation, socio-spatial polarizations and spatial justice

(mainly Bibby *et al.*, 2020a; 2020b; Cavicchia, 2021)

Impact of land supply restrictions?

Liberalized market context

+

Underdeveloped policy instruments for affordable housing

↗ issues of already existing problems of housing affordability, socio-spatial segregation, socio-spatial polarization and spatial justice

Importance of a good inventory and a detailed understanding of the dynamics

(mainly Bibby *et al.*, 2020a; 2020b; Cavicchia, 2021)

How to answer our question?

How to reconcile land restrictions and housing affordability (in Belgium/Wallonia)?

Focus = Financial access to housing

1) **What are the main causes of the increase in values/prices?**
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A <u>contextualized</u> and detailed understanding of :

- the share of land in housing prices
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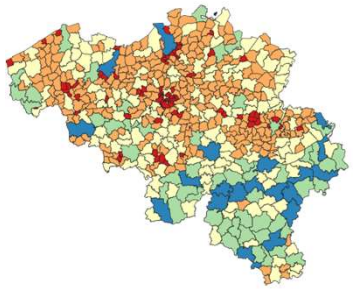
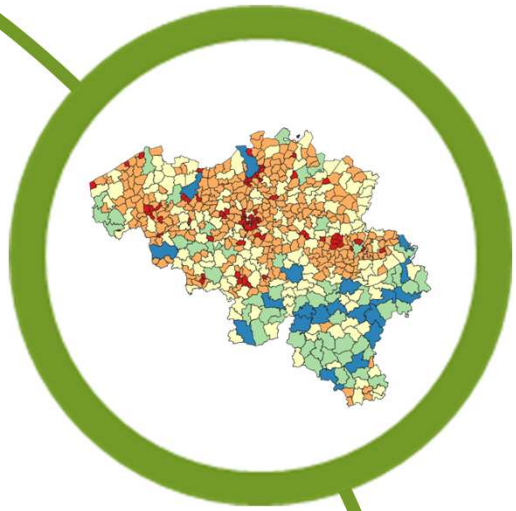


Detailed mapping of real estates and above all, of <u>land</u> values



Mapping values

Why ?

A mapping of land values for a better understanding of the residential real estate market in Belgium/Wallonia

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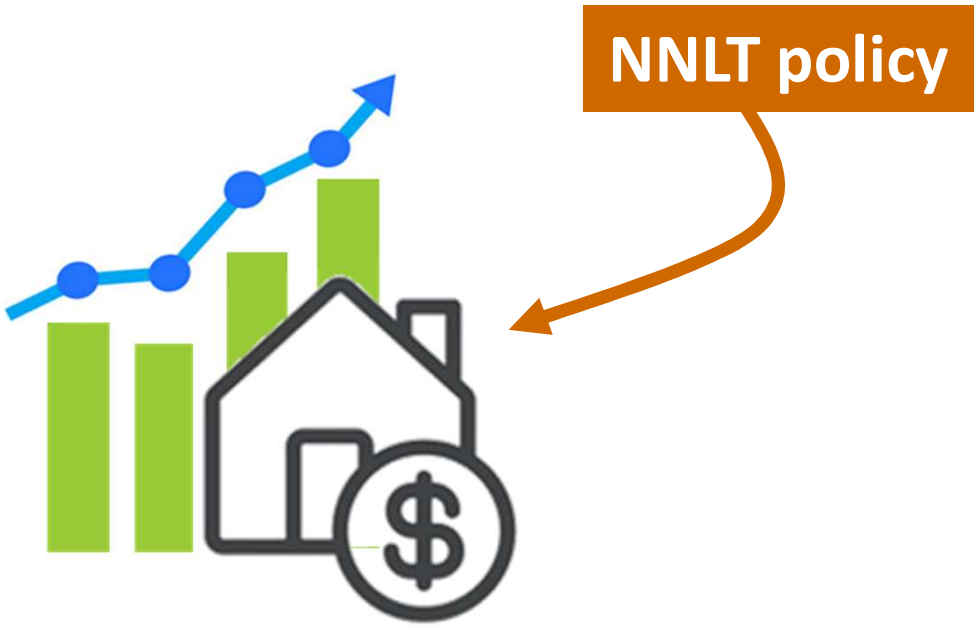

Why ?

A mapping of land values for a better understanding of the residential real estate market in Belgium/Wallonia

NNLT policy

=

Built Structure
Living surface area, quality and age of construction…

+

Land
Localisation, accessibility, quality of neighborhood, relief

Why ?

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NNLT policy

Price of housing = **Price of construction** + **Price of land**

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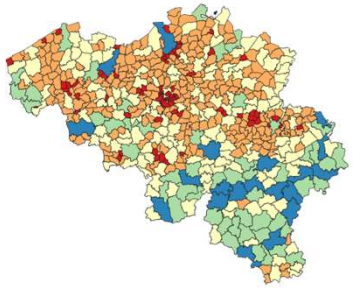

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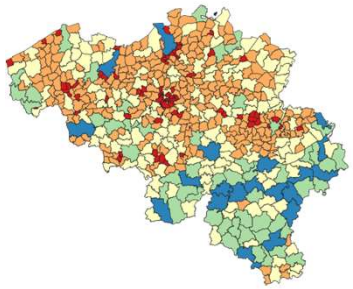

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Price of housing = **Built Structure** (Living surface area, quality and age of construction…) + **Land** (Localisation, accessibility, quality of neighborhood, relief, **land availability**)

Price of housing = **Price of construction** + **Price of land**

=

Evaluate the share of land in housing prices

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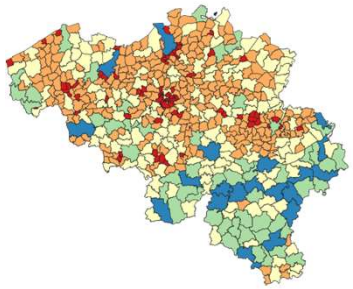

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=

Evaluate the share of land in housing prices

Why ?

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NNLT policy

Price of housing **=**

Built Structure
Living surface area, quality and age of construction…

+

Land
Localisation, accessibility, quality of neighborhood, relief, **land availability**

=

Price of construction **+** **Price of land**

= **Evaluate impact**

II

Evaluate the share of land in housing prices

Why ?

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NNLT policy

Simulate impact

Price of housing = **Built Structure** Living surface area, quality and age of construction… + **Land** Localisation, accessibility, quality of neighborhood, relief, **land availability**

Price of housing = **Price of construction** + **Price of land** = Evaluate impact

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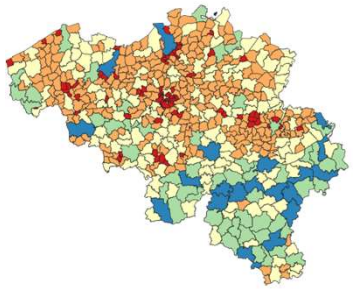

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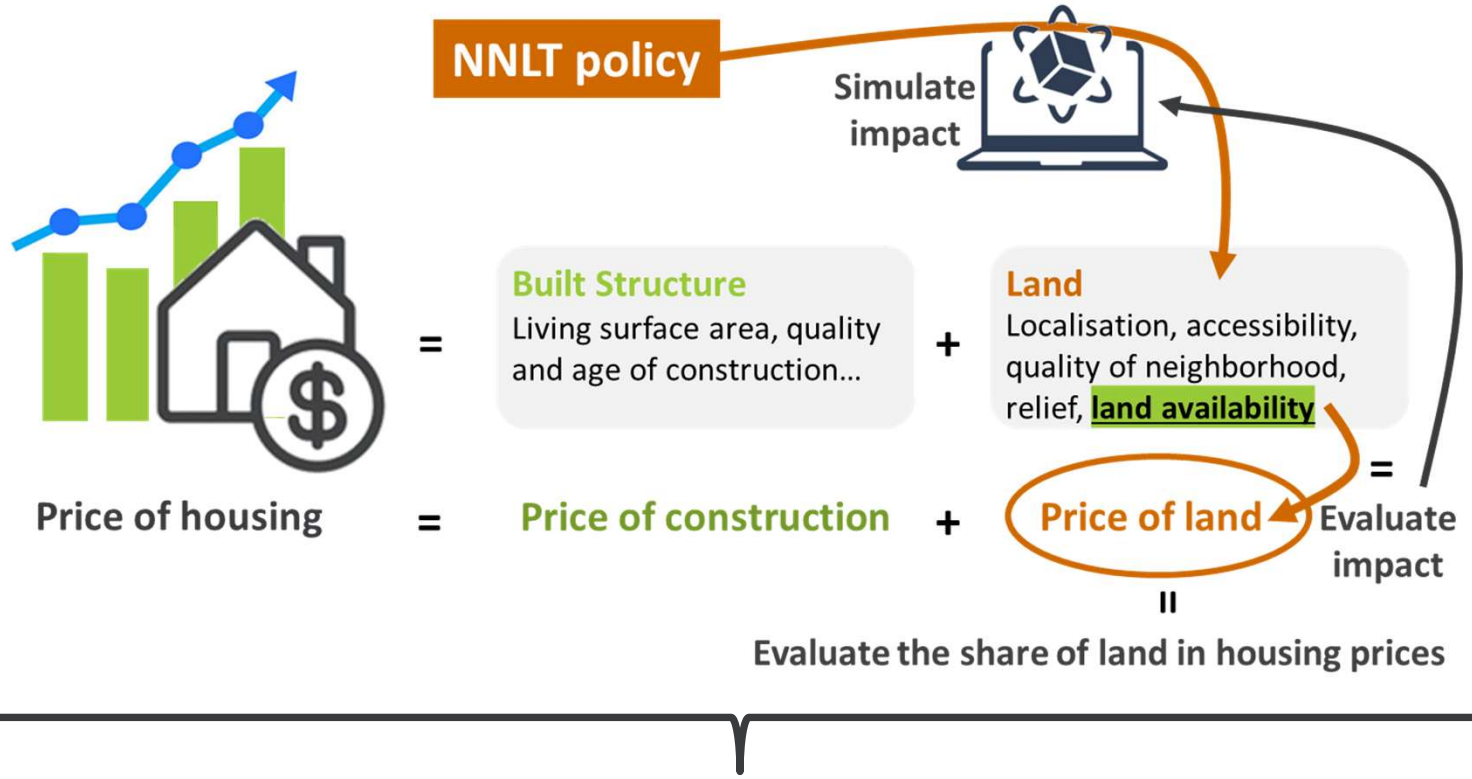

Evaluate the impact of land and construction characteristics on housing prices through space in the context of Belgium !

Why ?

A mapping of land values for a better understanding of the residential real estate market in Belgium/Wallonia

➔ **Does land <u>actually</u> drive the increase in real estate prices ?**

- If so, to what extent and what are the regional differences ?
- Has this trend changed over time?
- Better understanding of the effects of influencing factors (inter/intra-market scales, spatial variability of these effects, etc.) ➔ **<u>Real estate dynamics</u>**

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➔ **Since the NNLT is likely to have significant effects on the price of housing and the problems already present, knowing the initial situation correctly seems essential**

- **What effects does land availability have on the price** ?
- Can we **simulate the effects of NNLT** on the price and therefore on housing affordability ?

Why ?

A mapping of land values for a better understanding of the residential real estate market

➔ **The little extra:**

The common point of many measures to promote affordable housing is the **difficulty of their implementation without knowing the value of the land, even for built plots**. Without this, how can we …

- Implement land value capture;
- Set up new forms of taxation based on land prices;
- Negotiate prices to set up a land production policy;
- Monitor the effective impact of the implementation of the NNLT by monitoring the value over time and space;
- …

Concrete objectives

Does land actually drive the increase in real estate prices ?

- **Differentiate** land and real estate values**, even for plots already built**

➔ **Have a map of land values**

- Better understanding of the effect of variables on price over time and space, **including land availability**

What are the effects of NNLT? What initial situation?

- So far, what effects has land availability had on the price?
- **Simulate the implementation of the NNLT by modifying the land availability variable**

How ?

Differentiate land and real estate values, even for plots already built

➔ Having a map of land values ➔ EVALUATE

How ?

German, Finnish, Taiwanese experiences

- Need for greater transparency in real estate markets;
- Use of this knowledge to set up new tax systems such as split rate.

BUT

➔ Evaluations carried out by local experts ➔ slow and expensive…

Land valuation in Nordrhein-Westfalen

Variables and data

=

Built Structure

- Living surface area
- House *vs* appartement
- Number of bathrooms
- Number of garage
- Energy efficiency
- Age of construction
- 2-3-4 facade ?
- Quality of material
- …

+

Land

- Geographic position
- Plot area
- Slope of the plot
- Noise
- Access to work possibilities
- Access to services (shop, schools, healthcare…)
- Access to bus/train stations (by foot, bicycle, car…)
- Socio-economic quality of neighborhood (criminality, revenue, employment rate…)
- Access to nature
- Land availability
- …

Variables and data

Variables and data

LEVEL I – Scale of the plot – Whole of Belgium

Sales data (2009 to 2020) obtained from SPF Finances/FOD Financiën with characteristics of the property and the plot (m², number of facades, rooms, garden, etc.)

Only houses datas

No energy efficiency datas

Bad quality of living area datas

Alternative ?

Web scrapping from sales website !

BUT

- Need to be done during a long time période to be accurate
- Not the ACTUAL sales prices
- Not the official datas ➔ the method could not be institutionalized

Variables and data

LEVEL I – Scale of the plot – Whole of Belgium

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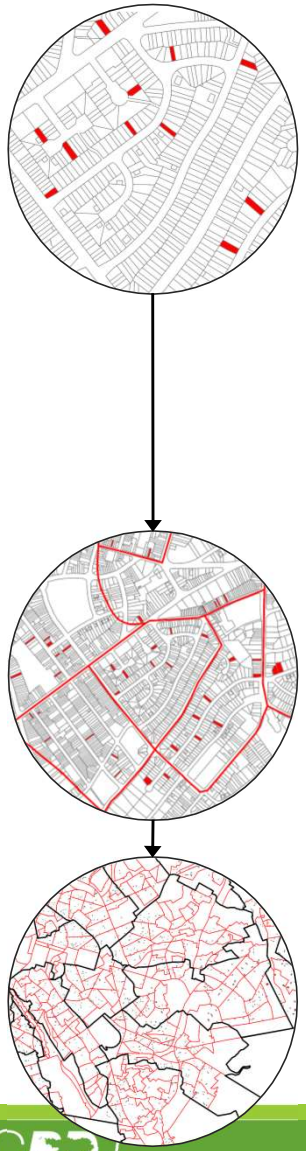
Various sources : noise pollution, accessibility to the employment center, to a train station, slope of the land, land availability, etc.

Variables and data



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LEVEL II – Statistical sector /neighborhood :

Various sources : income, quality of buildings, environment, nature, various aspects of social development, etc.

LEVEL III – Municipalities :

Various sources : social and economic context, etc.

Variables and data

15 variables **tested** to explain the price of the plot of land

22 variables **tested** to explain the price of real estate (7 construction variables + 15 land variables)

How ?

Differentiate land and real estate values, even for plots already built

➔ Having a map of land values ➔ EVALUATE ➔ **Econometric models**

Data driven Method

Concrete objectives

Differentiate land and real estate values, even for plots already built

➔ Having a map of land values ➔ EVALUATE ➔ **Econometric models**

Data driven Method

$$y = \beta x + \varepsilon$$

Concrete objectives

Differentiate land and real estate values, even for plots already built

➔ Having a map of land values ➔ EVALUATE ➔ **Econometric models**

Data driven Method

$$y = \beta x + \varepsilon$$

$$y = \beta_{c1}x_{c1} + \beta_{c2}x_{c2} + \cdots + \beta_{t1}x_{t1} + \beta_{t2}x_{t2} + \cdots + \varepsilon$$

Price of housing — Construction related variables — Land related variables

$$y = y'_{construction} + y'_{land} + \varepsilon$$

Price of housing — Modelized price of construction — Modelized price of land

Concrete objectives

Differentiate land and real estate values, even for plots already built

➔ Having a map of land values ➔ EVALUATE ➔ **Econometric models**

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Price of housing

Sales data

X = Construction related variables

X = Land related variables

β = Impact of the variable on price

Model = finding the β

Concrete objectives

Differentiate land and real estate values, even for plots already built

➔ Having a map of land values ➔ EVALUATE ➔ **Econometric models**

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Price of housing — Construction related variables — Land related variables

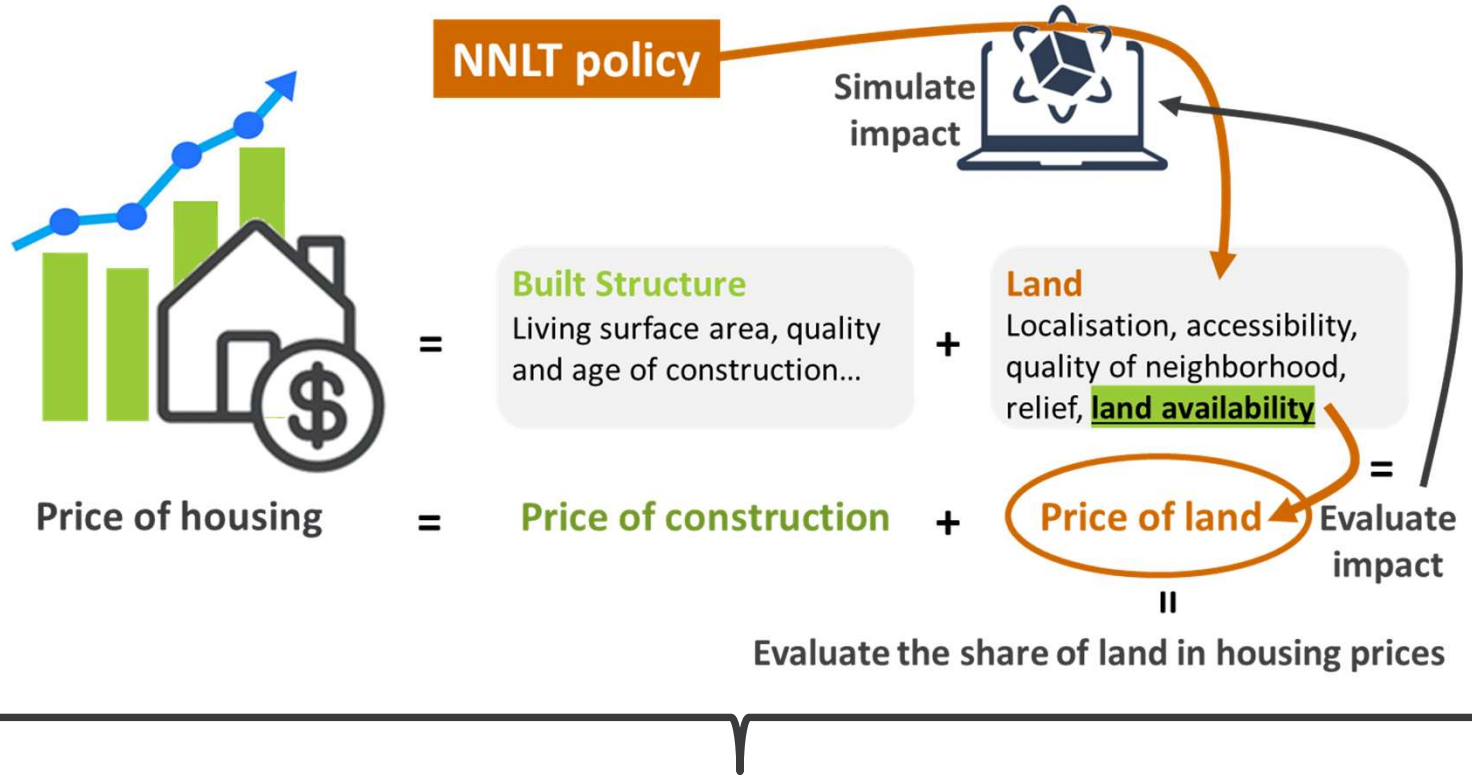
$$y = y'_{construction} + y'_{land} + \varepsilon$$

$$y'_{land} = y - y'_{construction} - \varepsilon$$

Modelized price of land = **Price of housing** − **Modelized price of construction** − **Residuals from modelisation**

Why ?

A mapping of land values for a better understanding of the residential real estate market in Belgium/Wallonia



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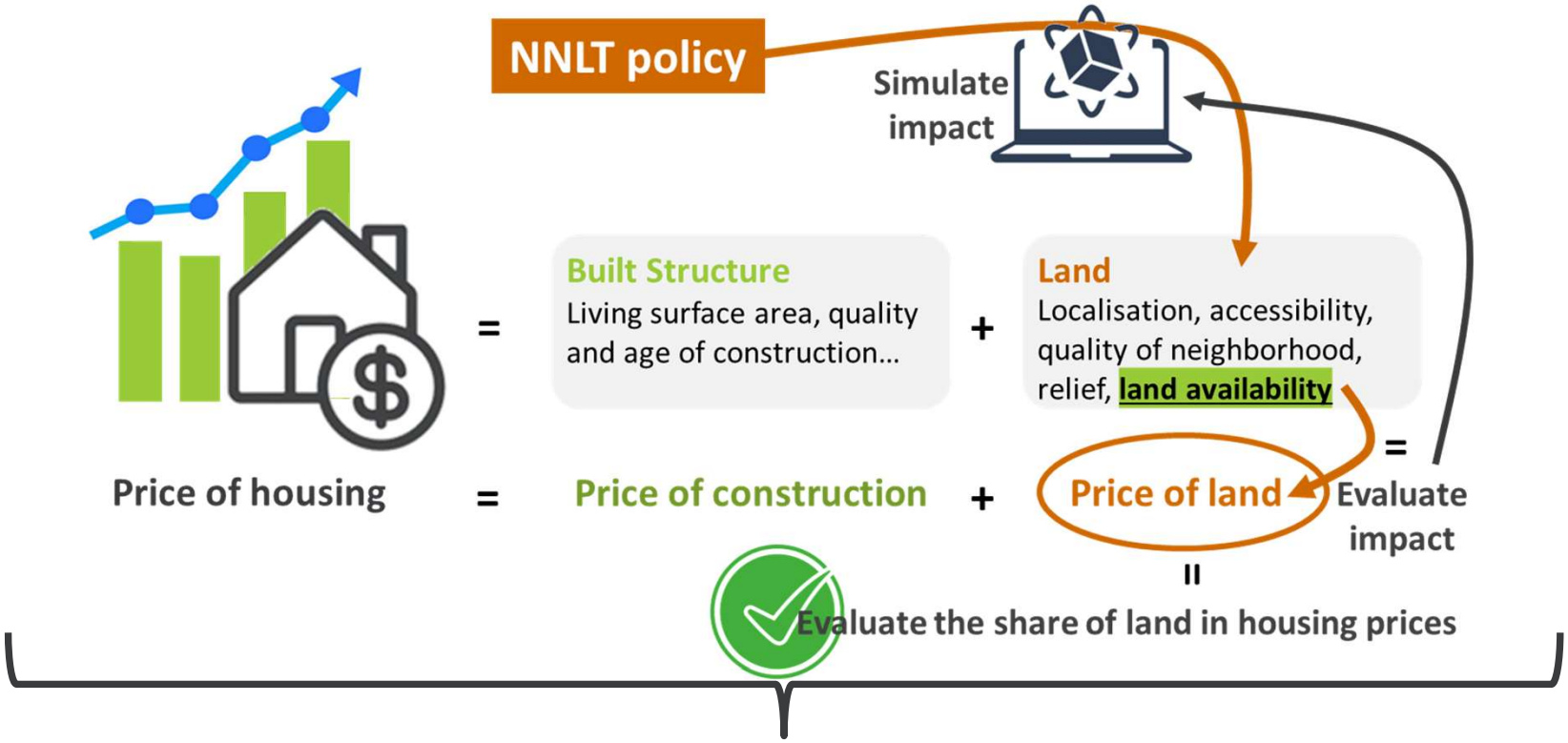

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Price of housing

Construction related variables

Land related variables

Concrete objectives

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Price of housing

Construction related variables

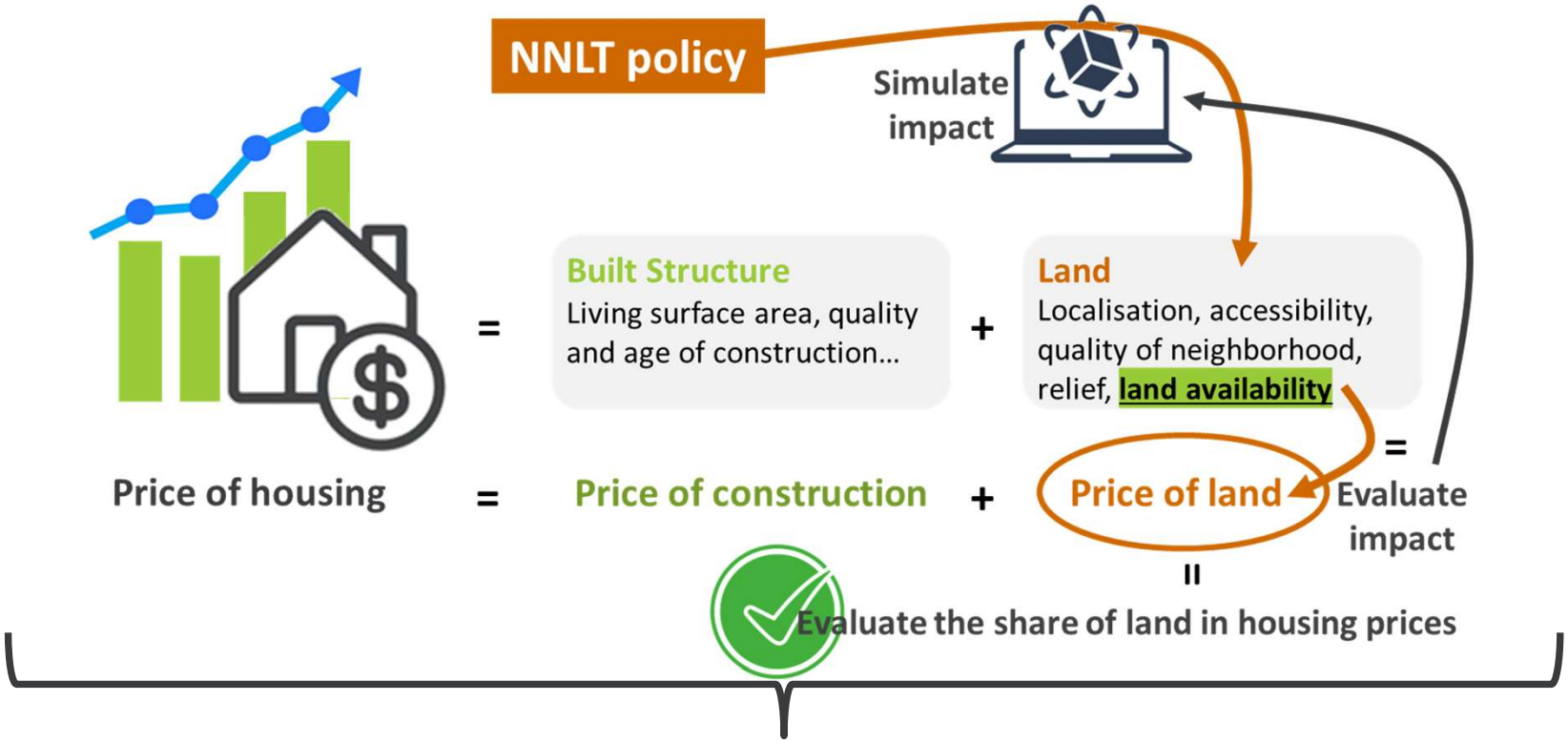
Land related variables

Land availability

Enough & accurate characteristics

Why ?

A mapping of land values for a better understanding of the residential real estate market in Belgium/Wallonia



Evaluate the impact of land and construction characteristics on housing prices through space in the context of Belgium !

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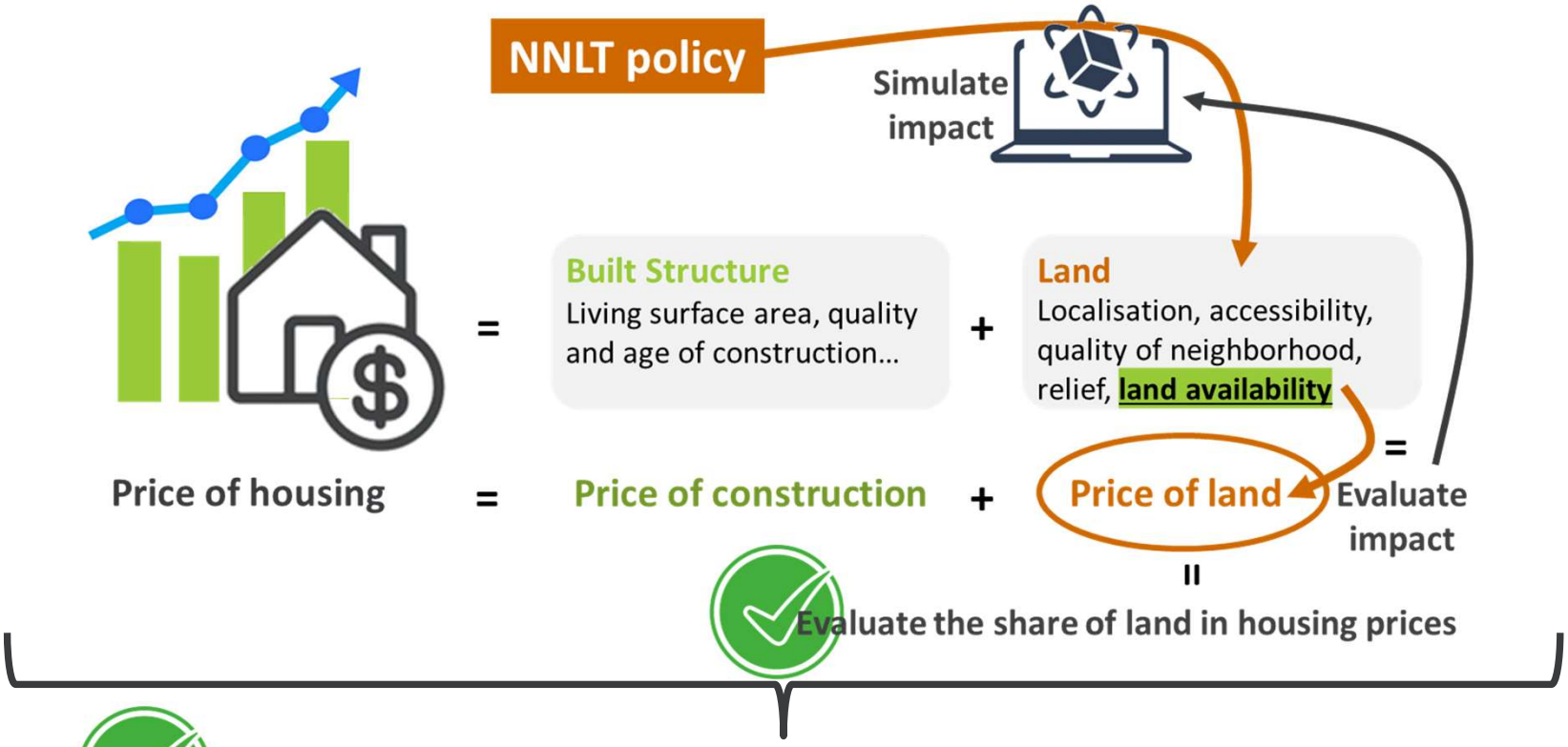

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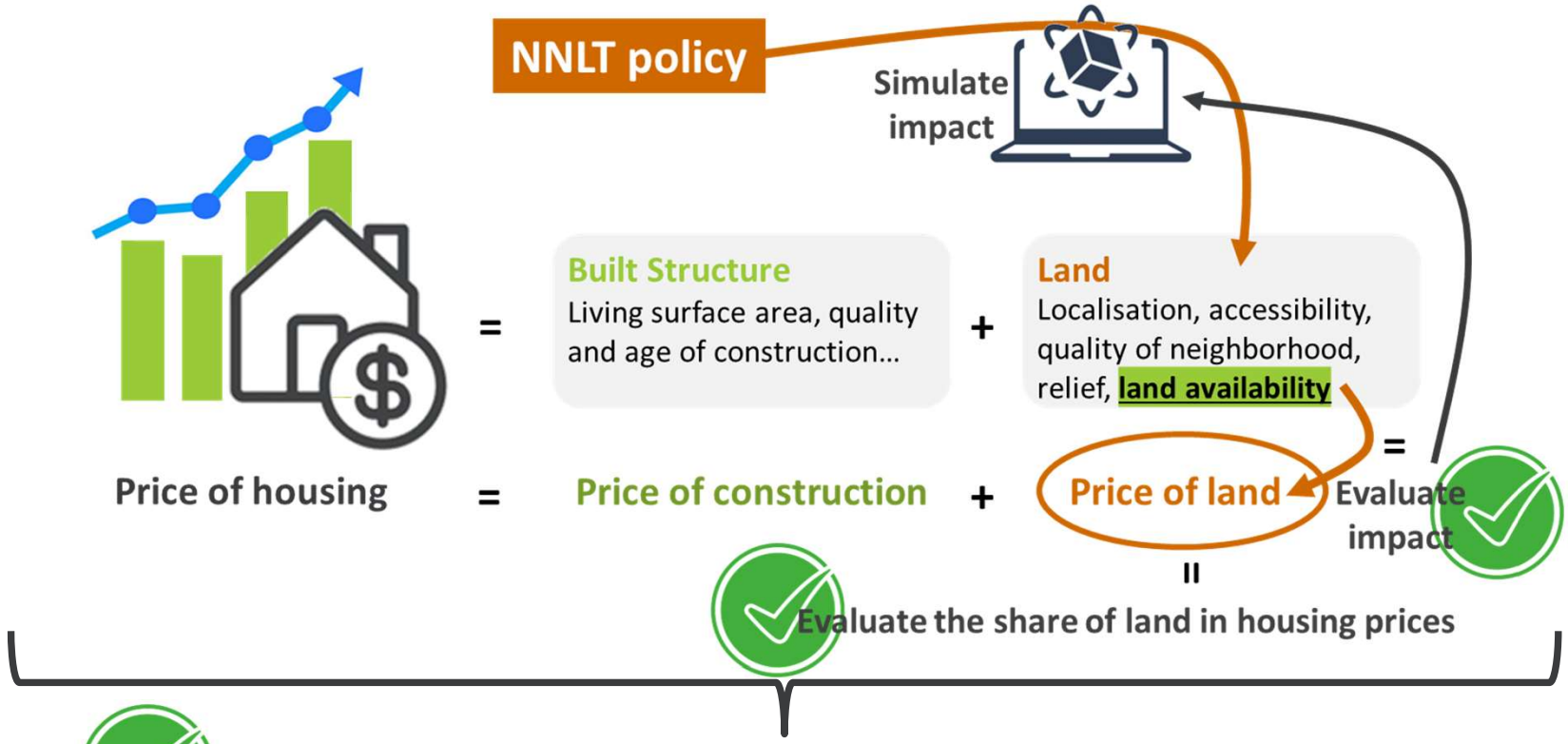

Evaluate the impact of land and construction characteristics on housing prices through space in the context of Belgium !

Concrete objectives

Differentiate land and real estate values, even for plots already built

➔ Having a map of land values ➔ EVALUATE ➔ Econometric models

Data driven Method

$$y = \beta_{c1}x_{c1} + \beta_{c2}x_{c2} + \cdots + \beta_{t1}x_{t1} + \beta_{t2}x_{t2} + \cdots + \varepsilon$$

Price of housing

Construction related variables

Land related variables

Model 1 « direction »

$$y = y'_{construction} + y'_{land} + \varepsilon$$

Price of housing

Modelized price of construction

Modelized price of land

REAL Land availability

Model 1 = finding the β

Concrete objectives

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Price of housing — Construction related variables — Land related variables

Model 1 « direction »

$$y = y'_{construction} + y'_{land} + \varepsilon$$

Price of housing — Modelized price of construction — Modelized price of land

REAL Land availability

Model 1 = finding the β

Model 2 « direction »

$$y' = y'_{construction} + y'_{land} + \varepsilon$$

Price of housing with NNLT — Modelized price of construction — New modelized price of land

NNLT Land availability

Model 2 = keep the β, change X, Find new prices

Concrete objectives

Differentiate land and real estate values, even for plots already built

➔ Having a map of land values ➔ EVALUATE ➔ Econometric models

Data driven Method

$$y = \beta_{c1}x_{c1} + \beta_{c2}x_{c2} + \cdots + \beta_{t1}x_{t1} + \beta_{t2}x_{t2} + \cdots + \varepsilon$$

Price of housing — Construction related variables — Land related variables

Model 1 « direction »

$$y = y'_{construction} + y'_{land} + \varepsilon$$

Price of housing — Modelized price of construction — Modelized price of land

REAL Land availability

X LOW to see impact on prices!

Model 2 « direction »

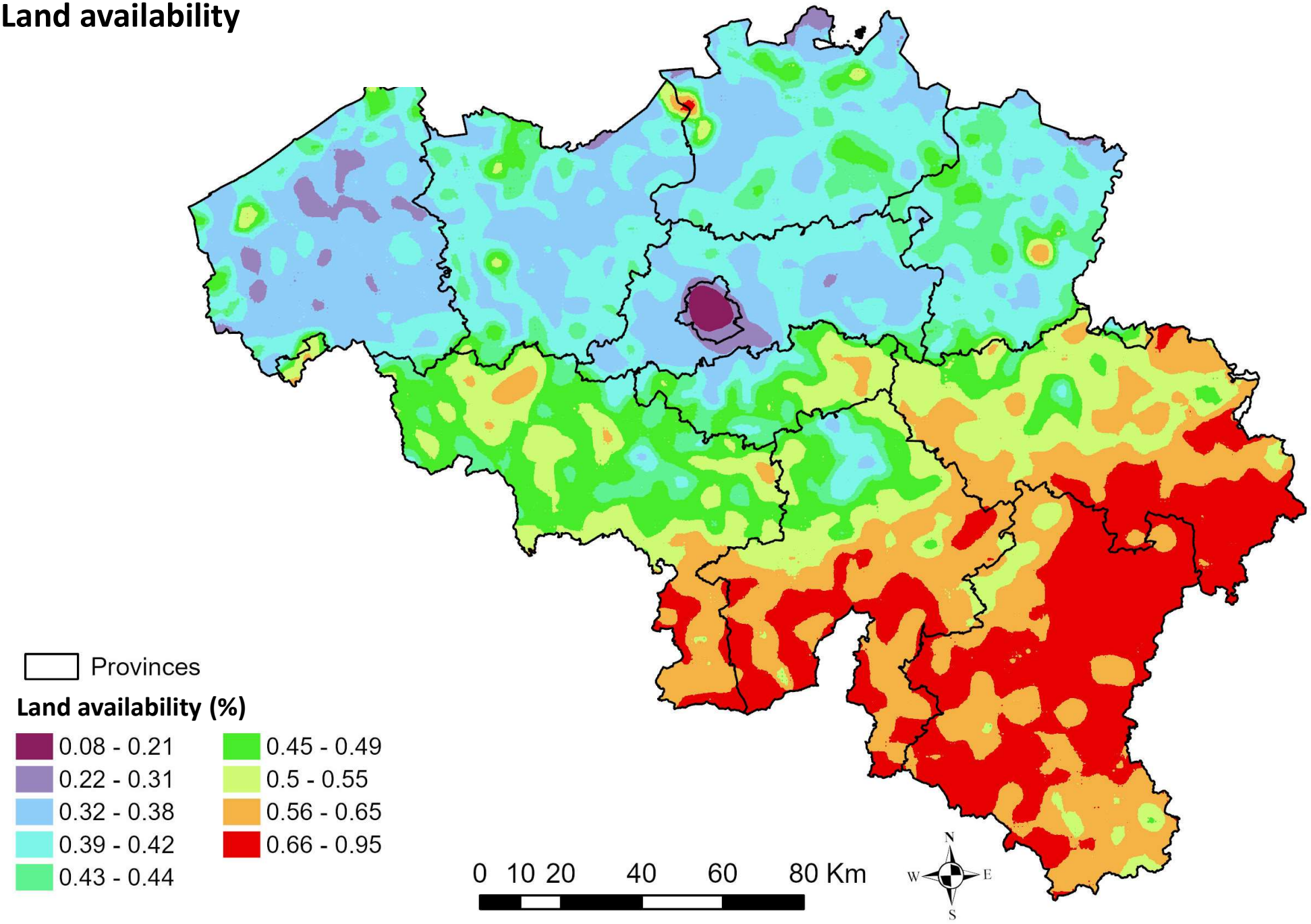
$$y' = y'_{construction} + y'_{land} + \varepsilon$$

Price of housing with NNLT — Modelized price of construction — New modelized price of land

NNLT Land availability

Model 2 = keep the β, change X, Find new prices

Land availability



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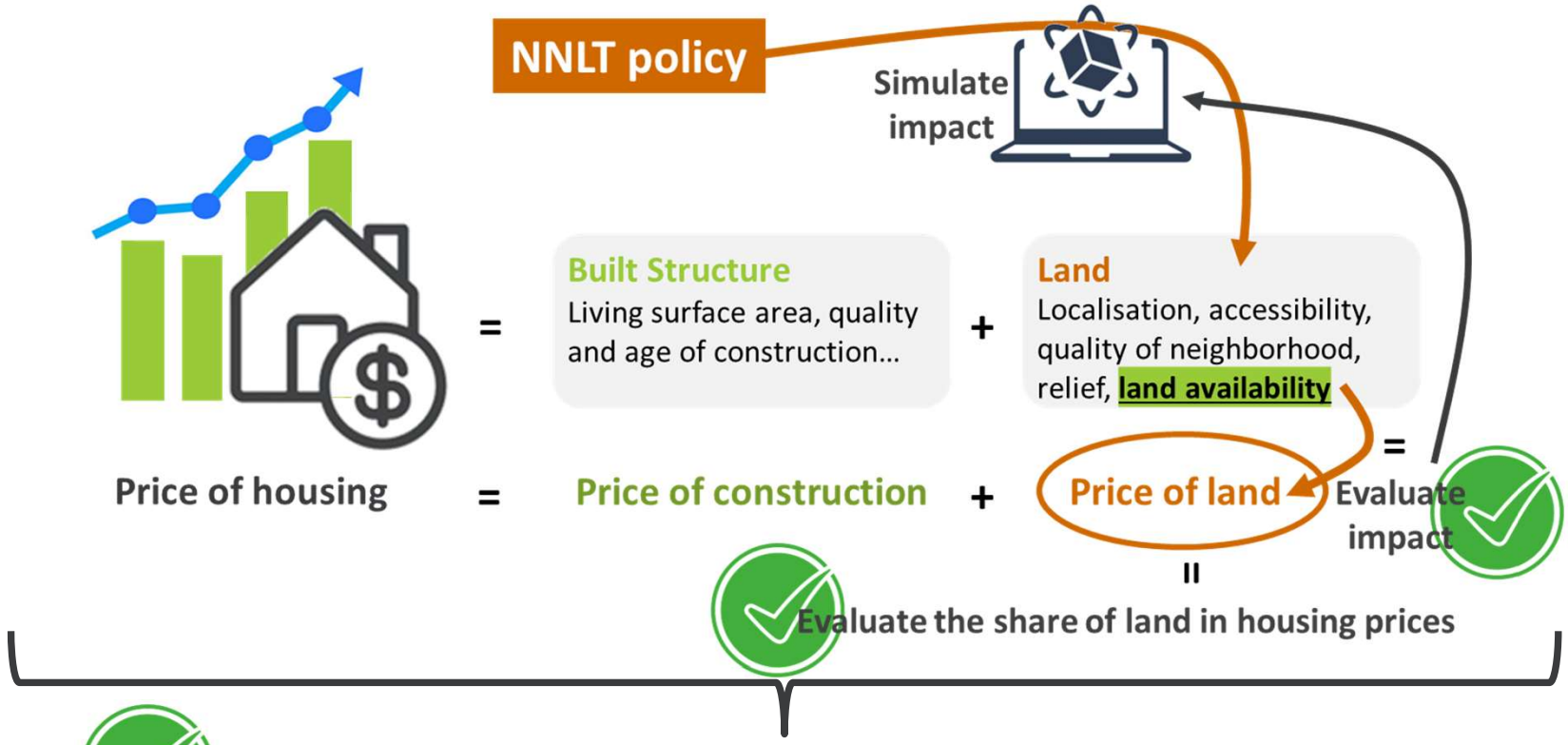

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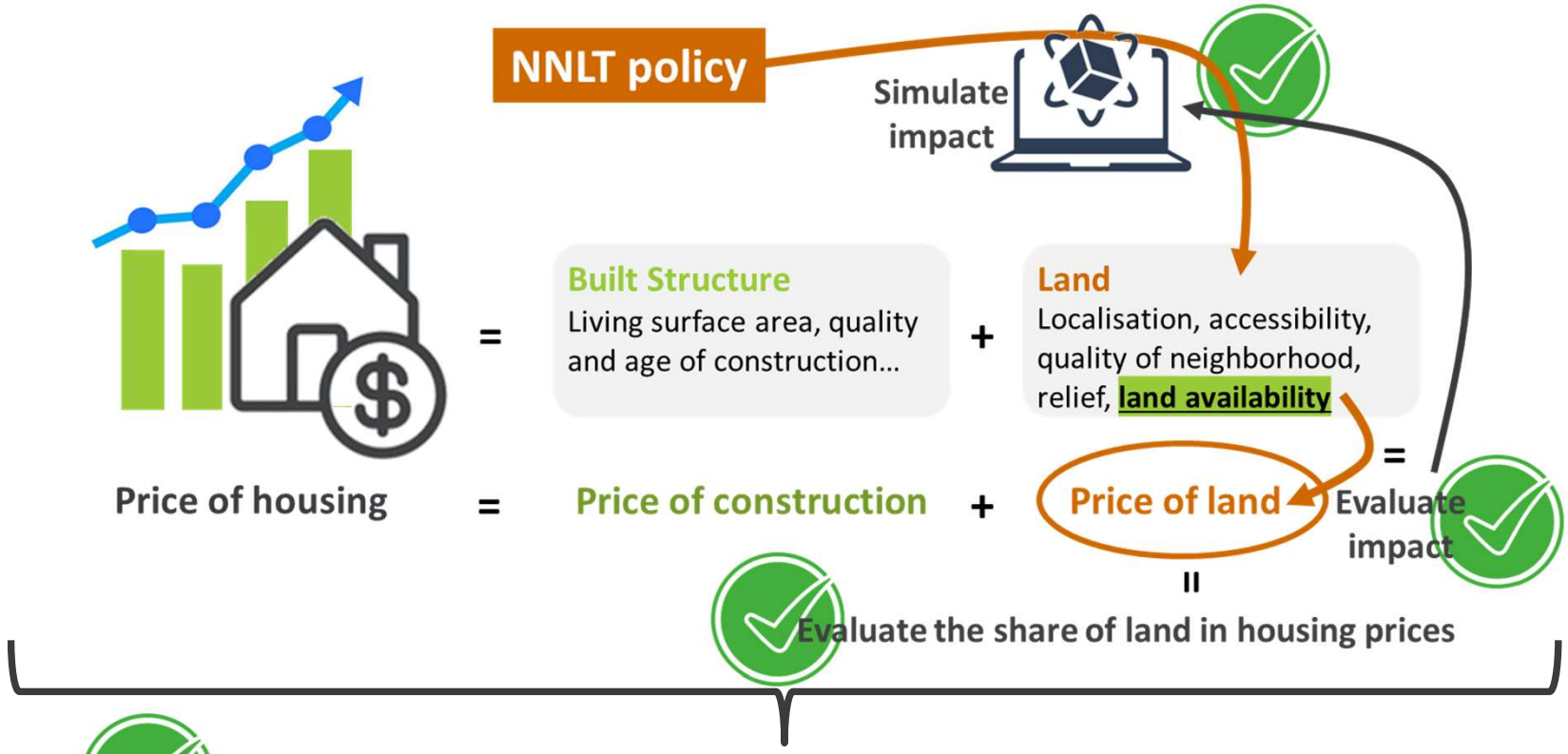

Evaluate the impact of land and construction characteristics on housing prices through space in the context of Belgium !

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➔ Having a map of land values ➔ EVALUATE ➔ Econometric models

Data driven Method

$$y = \beta x + \varepsilon$$

$$y = \beta_{c1}x_{c1} + \beta_{c2}x_{c2} + \cdots + \beta_{t1}x_{t1} + \beta_{t2}x_{t2} + \cdots + \varepsilon$$

Price of housing

Construction related variables

Land related variables

Residuals from modelisation

Accurate prices data

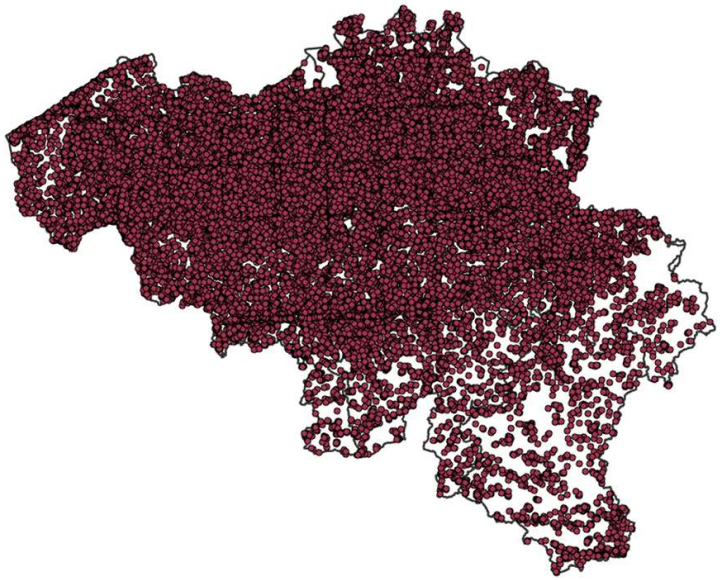
Accurate variables/datas

As small as possible

Problems to solve

Data issues

- Belgian land registry data (sales data) of low quality and not often updated
- Different scales of data
- **Non-uniformity of the spatial distribution** of observations



Problems to solve

Data issues

- Belgian land registry data of low quality and not often updated
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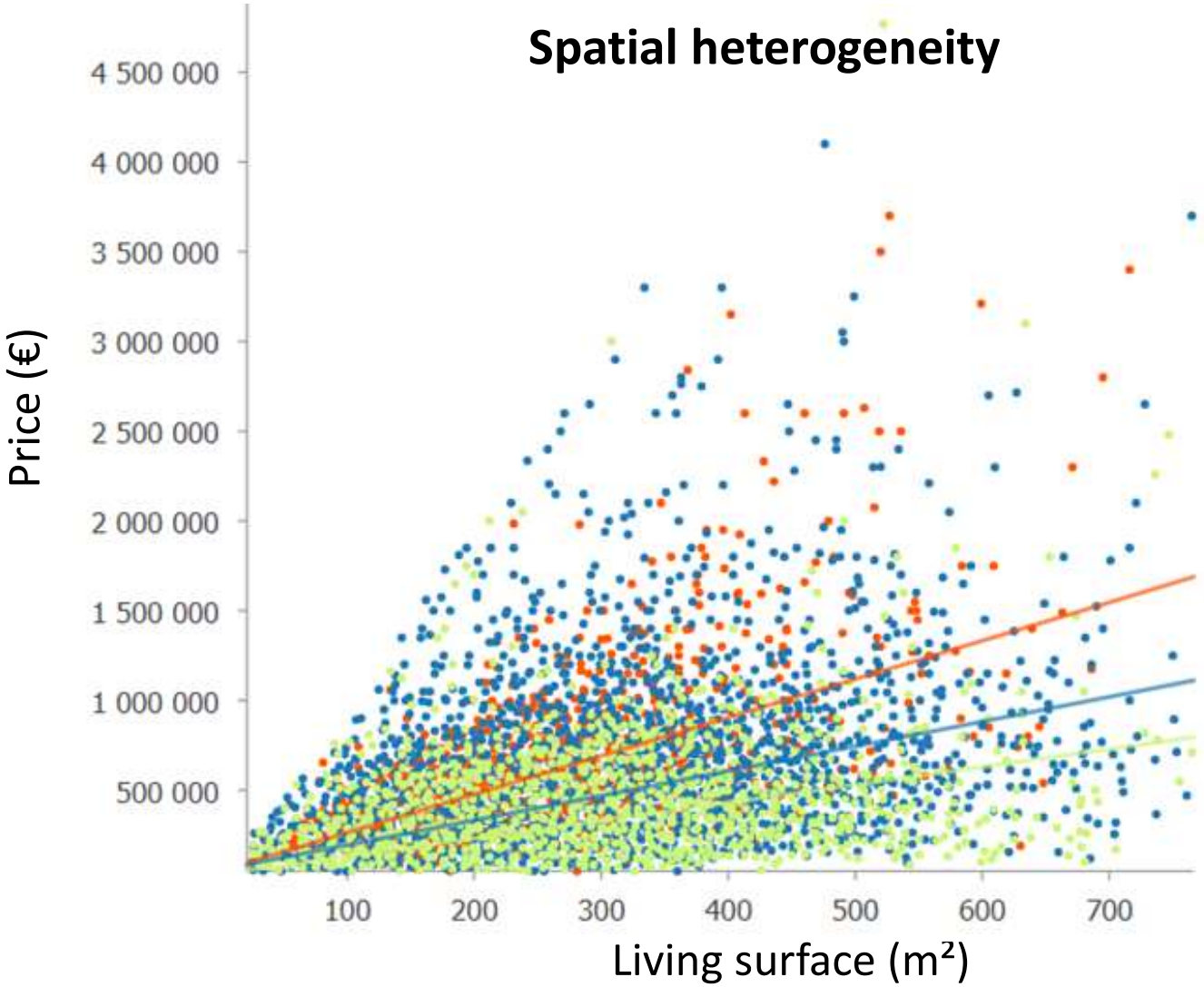
- **Non-uniformity of the distribution** of observations

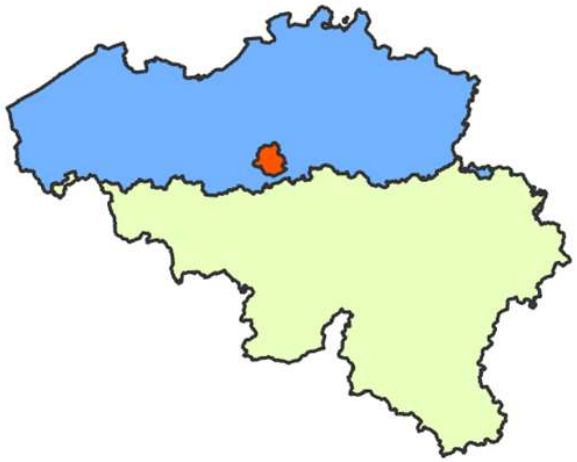
Issues related to the use of classic OLS

- **Spatial heterogeneity** of the effect of certain variables on the price of housing (e.g., plot size)

Problems to solve

Spatial heterogeneity





Datas sources : SPF Finances – Calculation : C.Bernier

Problems to solve

Data issues

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- **Spatial heterogeneity** of the effect of certain variables on the price of housing (e.g., plot size)
- No consideration of the greater probable “resemblance” between two close entities than between two distant entities

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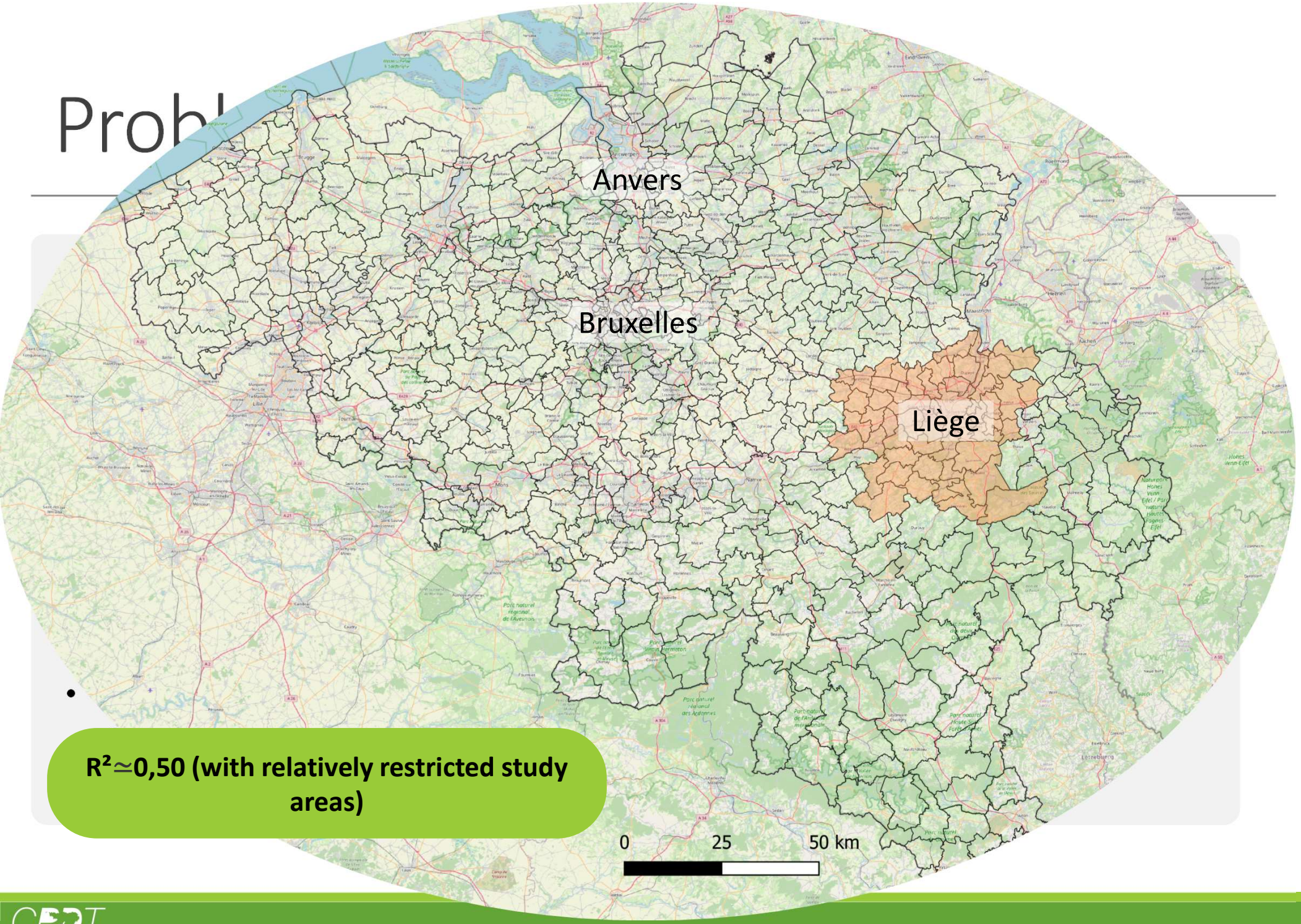
➔ Need to define the extent of the real estate market studied *a priori*

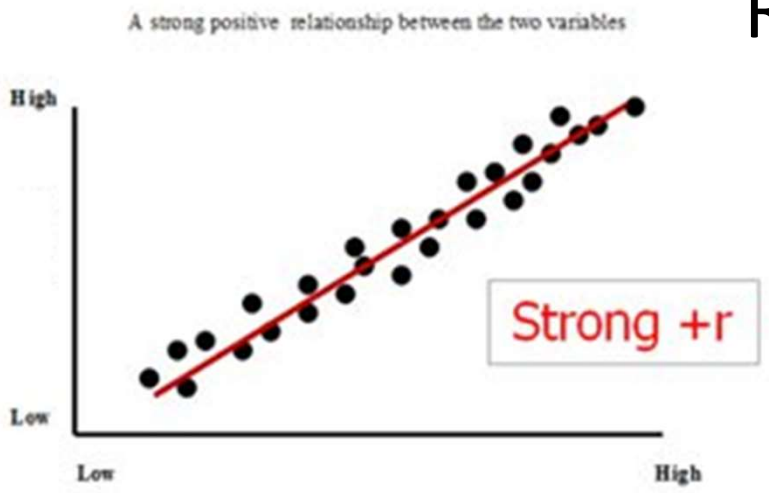
Prob



-

$R^2 \simeq 0{,}50$ (with relatively restricted study areas)

Quick R^2 explantation



$R^2 \approx$ How well does the model explain the variability of the independant variable = the price

$\approx$ How well does the model fit to the datas

R	Interpretation
0.00-0.199	Very weak
0.20-0.399	Weak
0.40-0.599	Medium
0.60-0.799	Strong
0.80-1.00	Very strong

So a $R^2 \simeq 0{,}50$ is pretty bad for such a small area

Problems to solve

Data issues

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➔ Need to define the extent of the real estate market studied *a priori*

GWR models

GWR

- Allows **variation of regression coefficients** β_j
- Calibrates a separate regression model at each point using a "data borrowing" system that weights observations serving as regression points based on their distance from each other

$$y_i = \sum_{j=0}^{m} \beta_j(u_i, v_i) x_{ij} + \varepsilon_i$$

With n observations where $i \in \{1,2, \dots, n\}$ localised in (u_i, v_i)

x_{ij} being the j^{th} independant variable and $\beta_j(u_i, v_i)x_{ij}$ the j^{th}coefficient

ε_i the error term

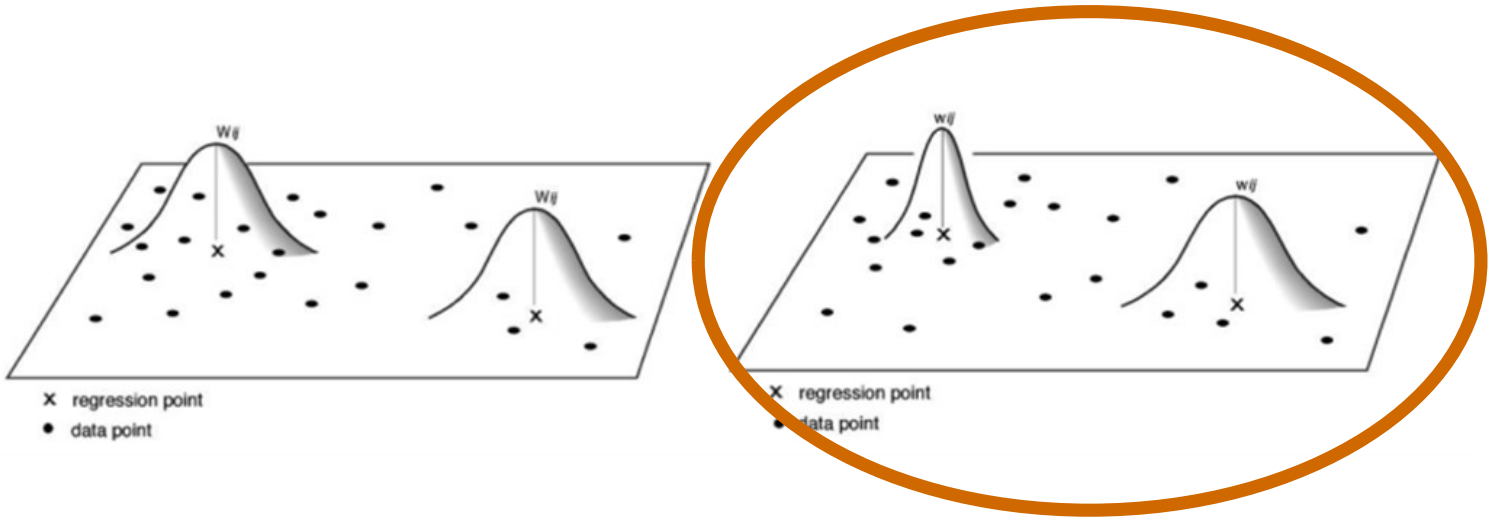
y_i the dependent variable (here the price)

(Fotheringham *et al.*, 2017)

GWR models

GWR

Adaptive Bandwidth Kernel



- **Calculation of ONE optimal bandwidth/number of nearest neighbors**
- Better handles irregularly shaped study areas, **non-uniform spatial distributions of observations**, and boundary effects

GWR = ONE unique bandwidth size/number of neighbors for all independent variables

(Fotheringham *et al.*, 2017)

(M)GWR models

MGWR

Allows variation of regression coefficients

AND a different bandwidth for all the variables considered

$$y_i = \sum_{j=0}^{m} \beta_j(u_i, v_i) x_{ij} + \varepsilon_i \quad \Rightarrow \quad y_i = \sum_{j=0}^{m} \beta_{bwj}(u_i, v_i) x_{ij} + \varepsilon_i$$

Where bwj indicates the bandwidth used to calculate β

Using the Python Package :
https://mgwr.readthedocs.io/
See as well :
https://github.com/pysal/mgwr

(Fotheringham *et al.*, 2017)

Exemple

- 10 299 land plot for Belgium
- 9 variables + intercept

OLS

R^2 = 0,15

GWR

Number of neighbors : 152

R^2 = 0,61

Taking into account spatial heterogeneity

MGWR

R^2 = 0,76

Variables	Number of neighbors
Employement	10298
Land availability	566
Plot Surface	15
Noise	2507
Flood risk	10298
Prop_nature	348
SocioEco 1	17
SocioEco 2	10298
SocioEco 3	221

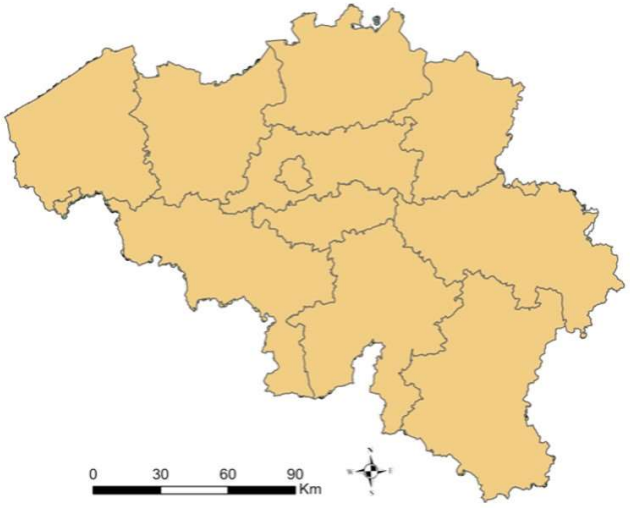
Taking into account the different scales of influence of the variables

OLS

GWR

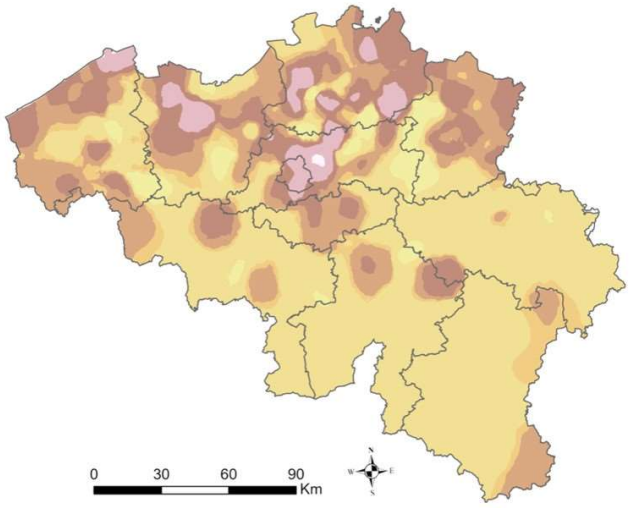
MGWR

β global – Plot Surface



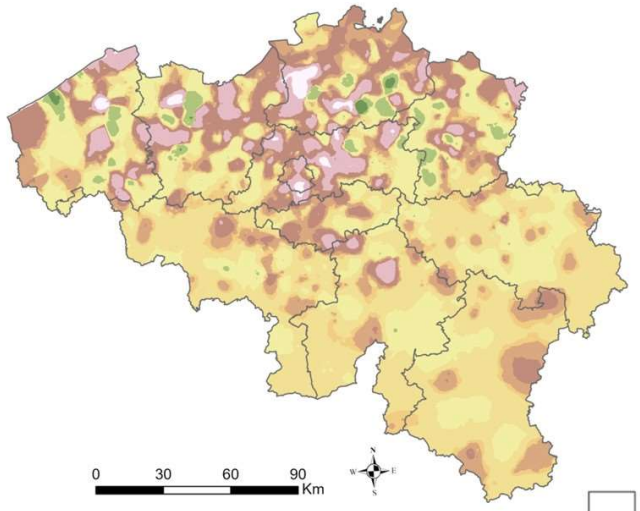
β local – Plot Surface

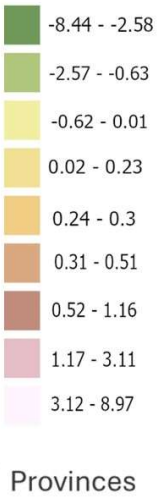
Number of neighbors = 152



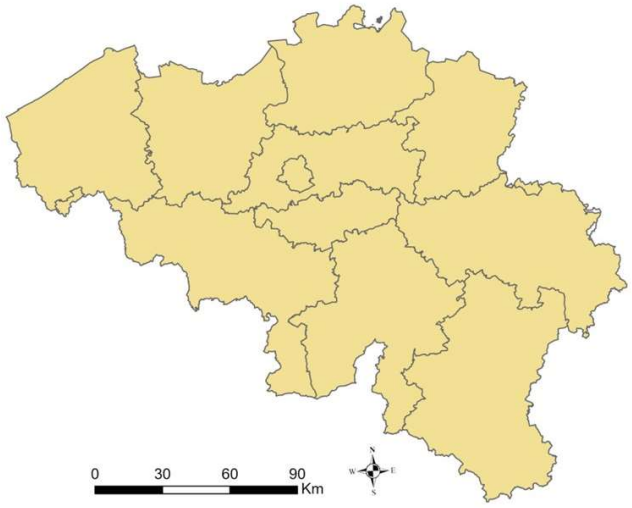
β local – Plot Surface

Number of neighbors = 15





β global – Land availability



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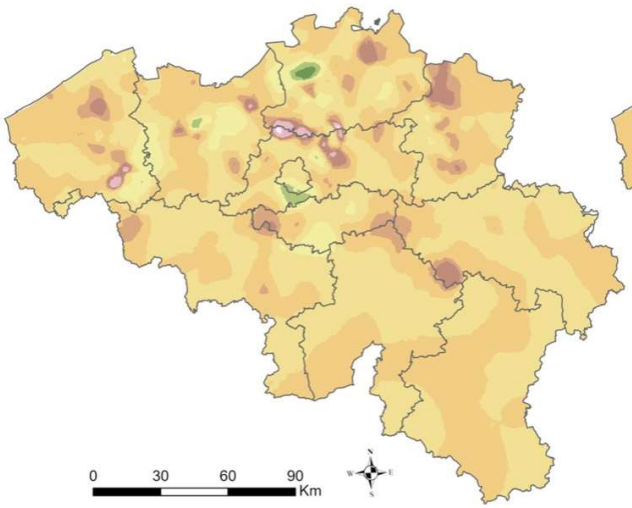
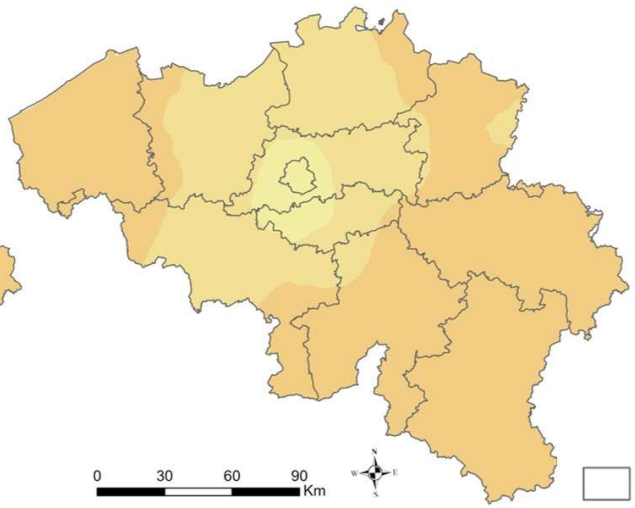
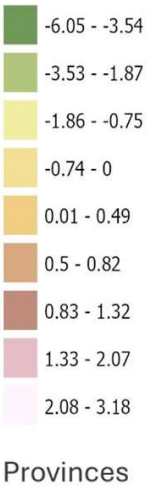


β local – Land availability

Number of neighbors = 566





Example

- 6783 houses
- 19 variables + intercept

OLS

R^2 = 0,53

GWR

Number of neighbors : 624

R^2 = 0,62

MGWR

R^2 = 0,71

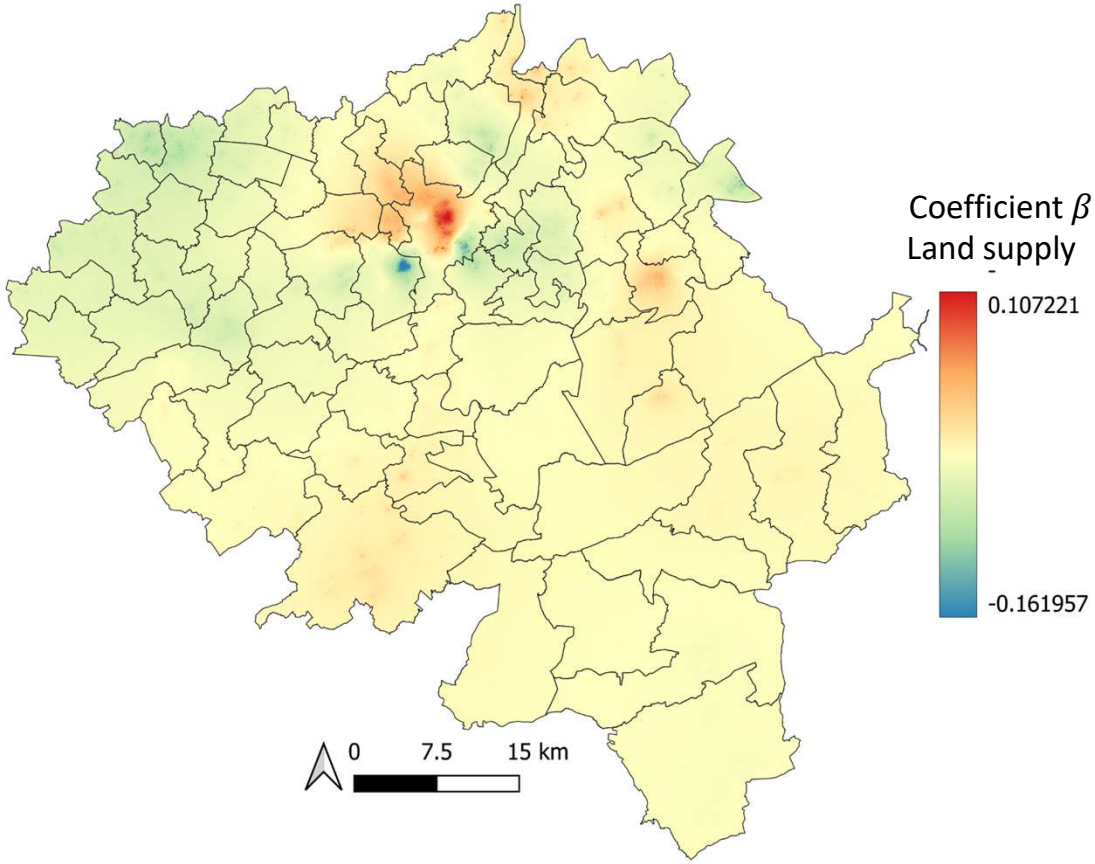
Variables	Number of neighbors
car_main_train	199
car_BXL	4846
car_GDL	4612
time_foot	6097
land_supply	6482
prop_nature	6782
noise	6751
socioEco1	2863
socioEco2	1227
socioEco3	6782
shape_Area	236
Slope_land	5798
Flood_zone	6782
living_surface	60
nb_facades	2096
age	866
garages	236
bathroom	1070
nb_housing	769

Example

GWR

Number of neighbors : **624/6783**

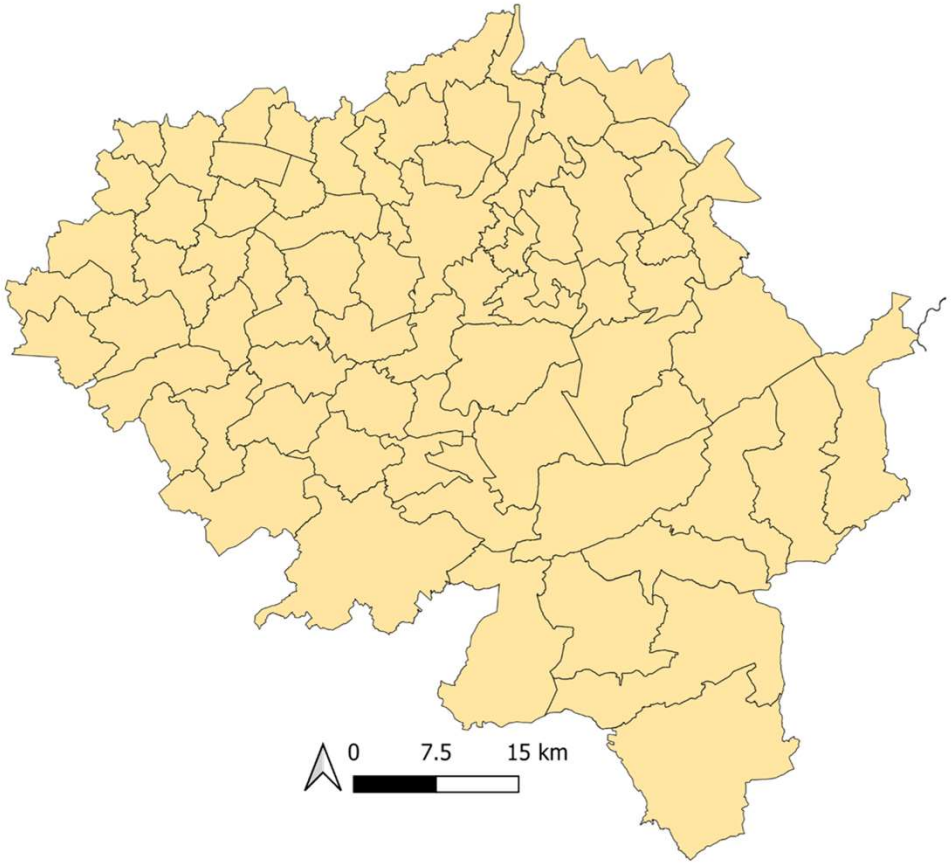
R^2 = 0,62



MGWR

Number of neighbors : **6482/6783**

R^2 = 0,71

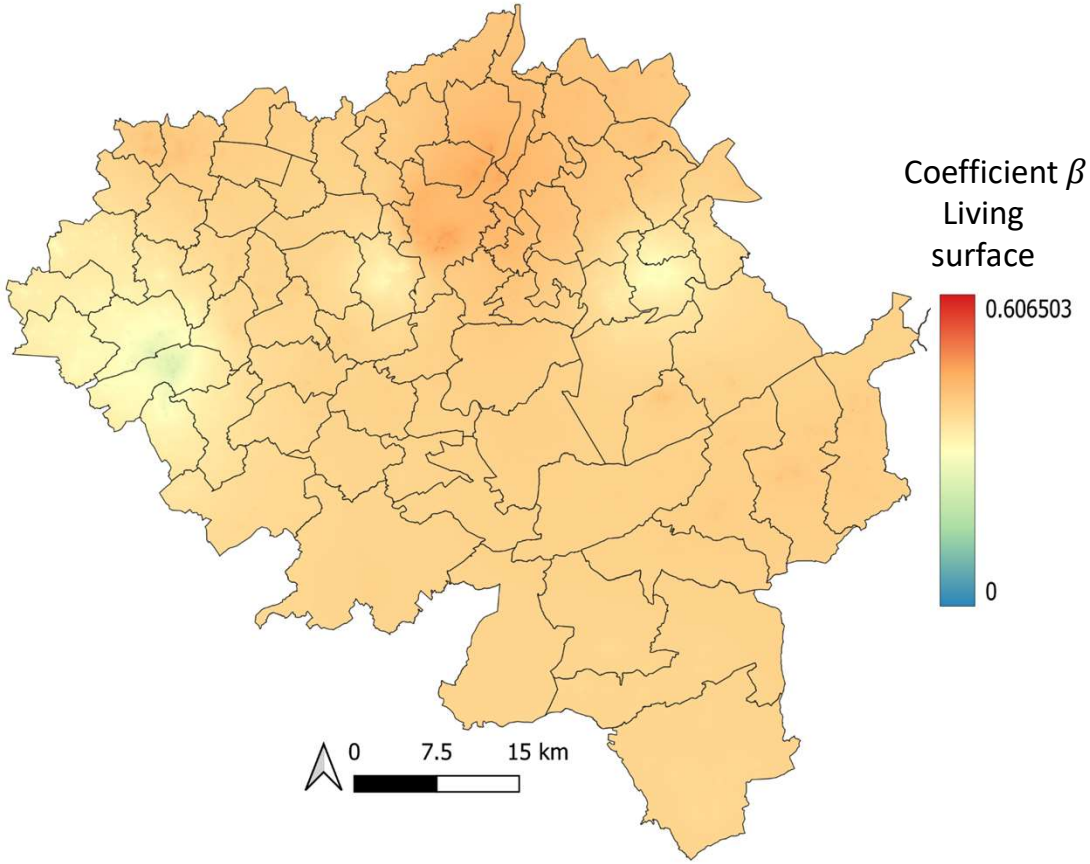


Example

GWR

Number of neighbors : **624/6783**

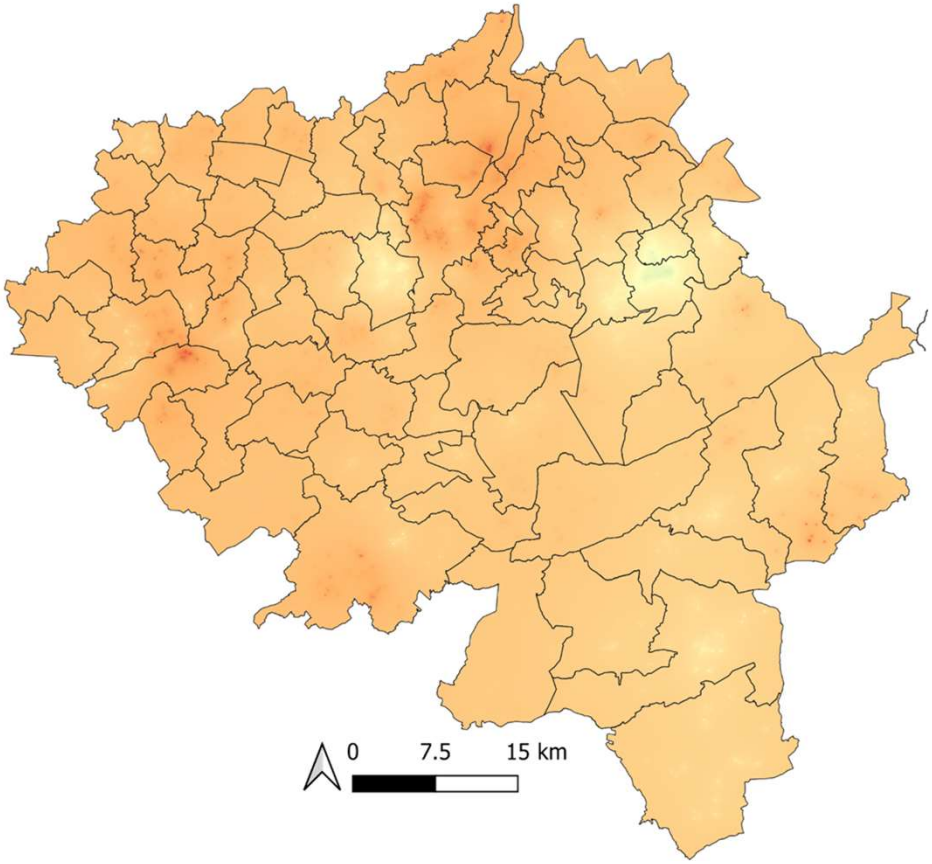
$R^2 = 0,62$



MGWR

Number of neighbors : **60/6783**

$R^2 = 0,71$



The problems of MGWR

MGWR

Although more efficient, MGWR models are however **very demanding in terms of calculation** and therefore time.

As an example - 16 CPU Server

- 14 600 plots of land (2019) + 15 variables

  = 6 days of treatment

- 92 000 real estate properties (2019) + 21 variables

  > 30 days of treatment

  1TB of RAM required…

Identifying bandwidths is the longest part

Possible solutions

MGWR

Although more efficient, MGWR models are however **very demanding in terms of calculation**

Identifying bandwidths is the longest part

Verifying bandwidth stability with a restricted land price model ➔ ok

Extrapolation of bandwidths found for land sold in 2019 for 2018 and 2017 data AND for houses datas ➔ ok, 2 days instead of 6 !

Possible solutions

MGWR

Although more efficient, MGWR models are however **very demanding in terms of calculation**

Extrapolation of bandwidths found for land sold in 2019 for 2018 and 2017 data AND for houses datas ➔ ok

Still we had to reduce our sample for houses from 90,000 to 18,000 houses...

Good results for 2019 : R^2 = 0,77 !

Pretty good evaluation of the land prices for built plot… still in progress

Variables and data

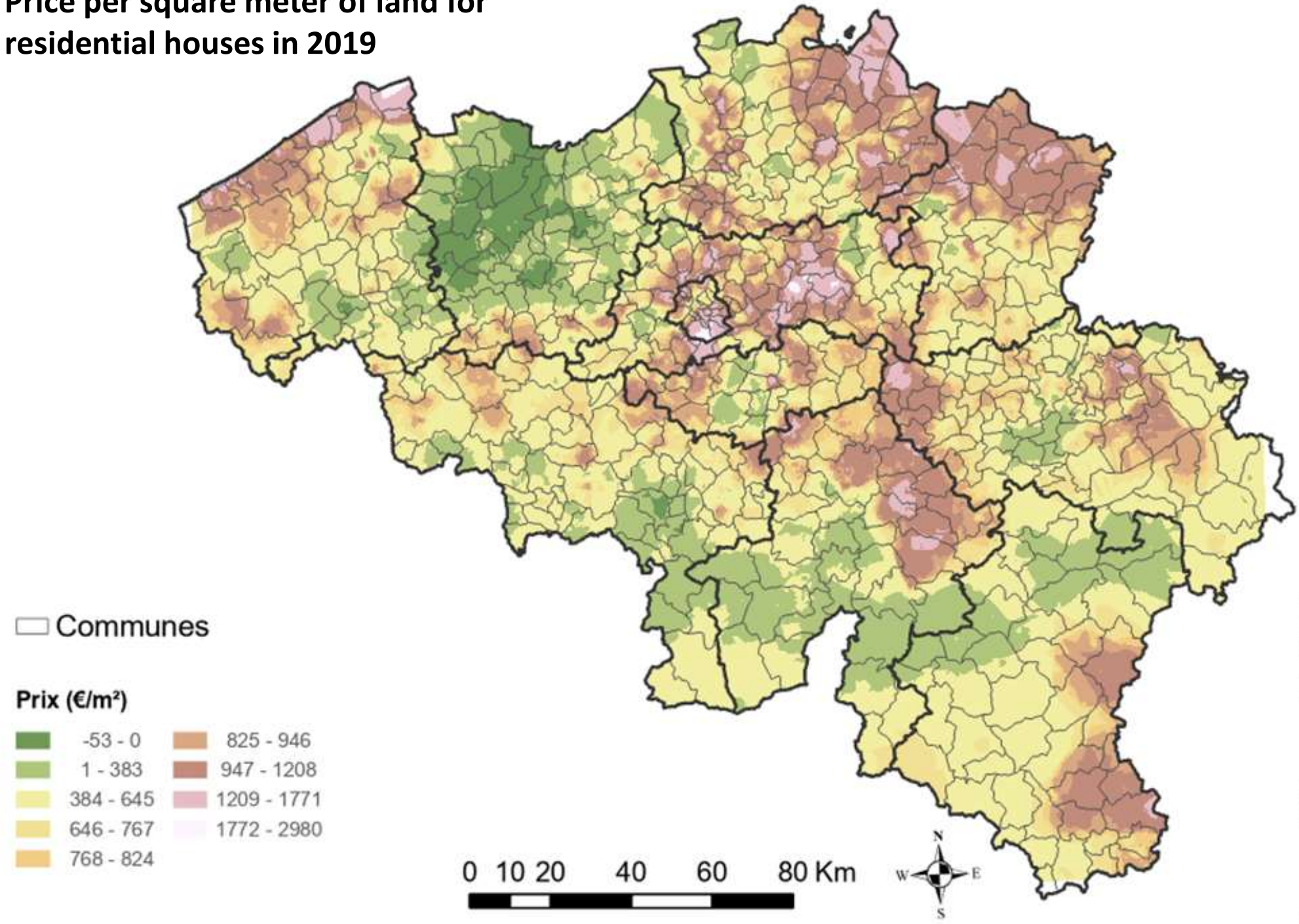
15 variables **tested** to explain the price of the plot of land

9 in the final model

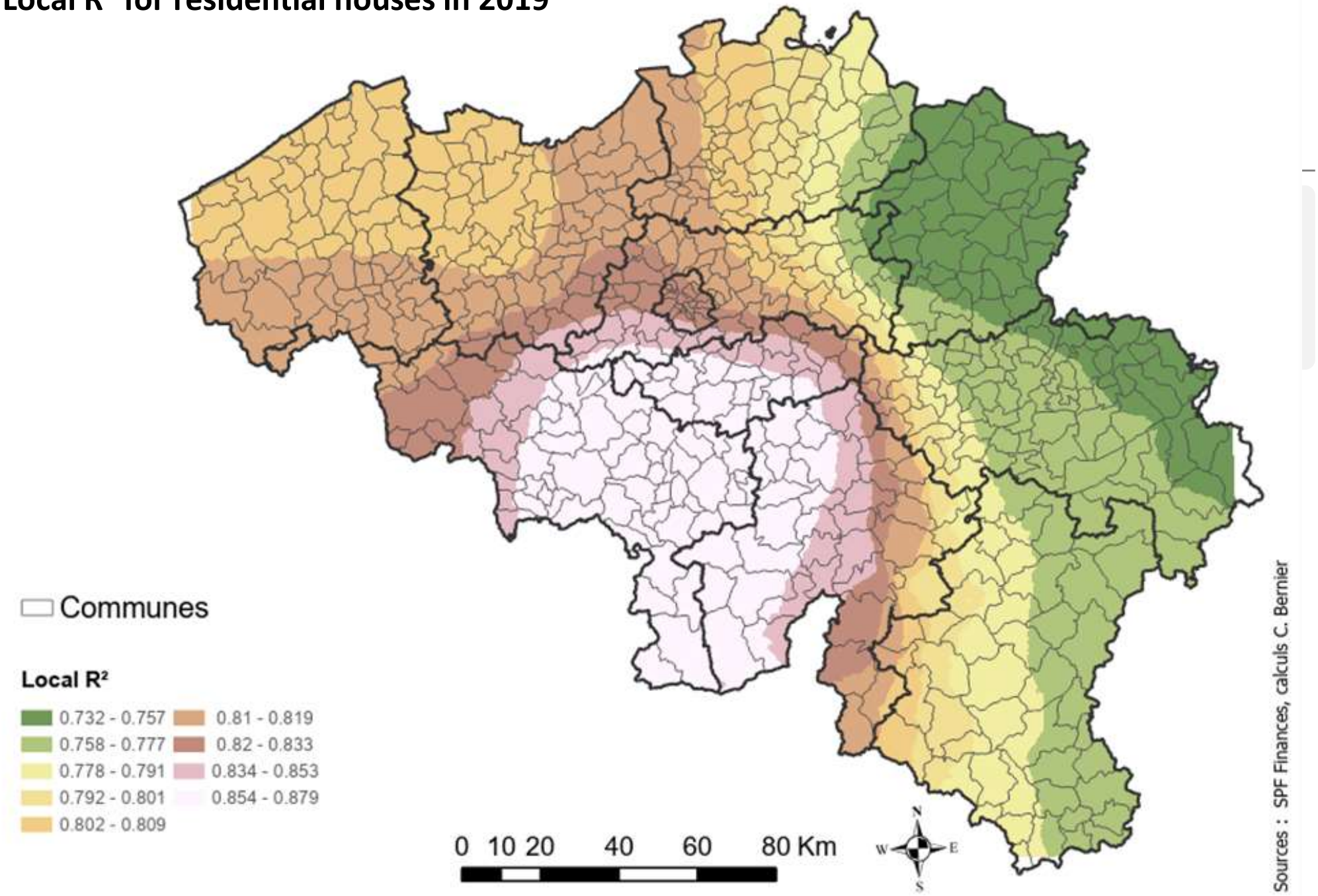
22 variables **tested** to explain the price of real estate (7 construction variables + 15 land variables)

7 construction variables and 9 land variables in the final model

Price per square meter of land for residential houses in 2019



Local R^2 for residential houses in 2019



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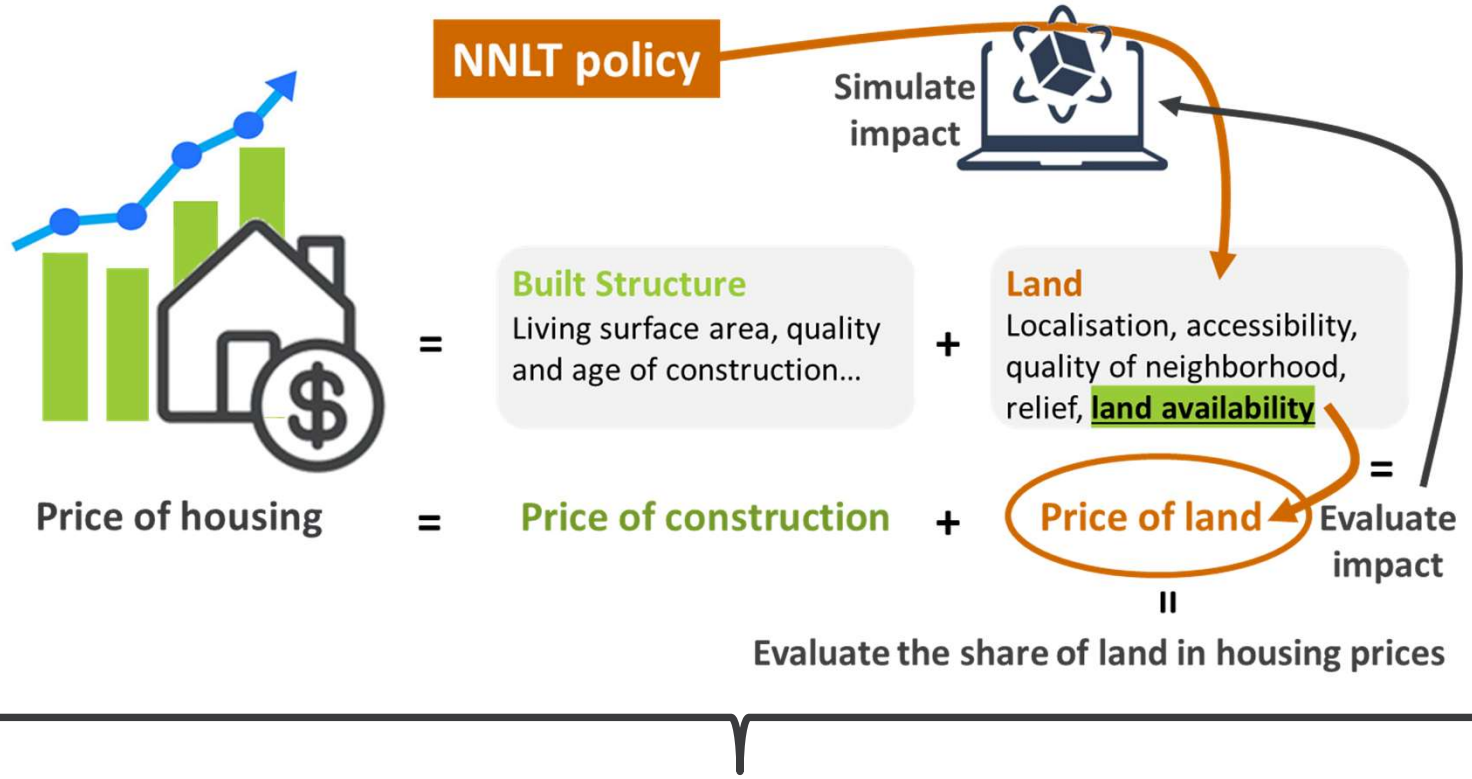

Evaluate the impact of land and construction characteristics on housing prices through space in the context of Belgium !

To conclude

How to … : Research design and methodology

What do we want to know ?
What do we already know ? ➔ Litterature
What else do we wanna know ? ➔ What datas do we have ?
What can we do with that ? ➔ Search and choose a method
Then …

Current/future objectives

1. **MGWR and GWR models for 2019**
   ➔ Determination of bandwidths and analysis of improvements with MGWR models
2. **Determination of a "*Best Model »*** (removing unnecessary variables)
   ➔ Possible differentiation between the price of land and the price of real estate
3. **MGWR for land and real estate for 2016, 2013, 2010**
   ➔ Evolution of the significance of variables in time and space
4. **Try a simulation of the implementation of the ZAN**
   ➔ Study of the effects on the price of land and real estate
5. **Exploration of the *Repeat Sales*** ➔ New insights into previous analyzes

CPDT
Conférence Permanente du Développement Territorial

Thank you for your attention !

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