SustainCity

Brussels case study
Progress status

Leuven, 18-19 February 2013

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Outline

❖ **Models : final version of the estimations**

❖ **Check on 2001 and validation on 2007**

❖ **Check on the road traffic model**

❖ **Check on the home2work matrix**

❖ **Mode choice model**

❖ **Test scenario : cordon pricing**

❖ **Policies to be tested**

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Models : final version of the estimations

❖ The sub-models have been estimated by EPFL (real-estate price, household location choice, employment location choice, residential and non-residential development location choice)

❖ Updates :

- The instrument variable "property tax" has been included to the REPM
- The units of all the "density" variables are per hectare
- The models have been modified according to the suggestions of Stratec

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Models : final version of the estimations

TABLE 1 Real Estate Price Model

Houses (n=14835)

Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
constant	-			11.5407	0.0135	857.94
$\beta_{car\text{-}acc}$	Car accessibility	zone	%	0.0020	0.0005	4.09
β_{green}	Green area score	commune	0 to 1	0.1349	0.0125	10.81
$\beta_{income\text{-}high}$	Percentage of high income (>3) households	commune	%	0.0260	0.0004	60.02
β_{tax}	Housing tax	commune	%	-0.0681	0.0014	-47.75
$\beta_{pop\text{-}den}$	Logarithm of population density	commune	ln(pop/hectare)	0.0591	0.0011	56.33
β_{sqm}	Surface	building	m^2	0.0005	5.29e-05	8.751
$R^2=0.59$						

Apartments (n=4945)

Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
constant	-			11.2914	0.0306	368.69
$\beta_{car\text{-}acc}$	Car accessibility	zone	%	0.0046	0.0011	4.09
β_{green}	Green area score	commune	0 to 1	0.4128	0.0290	14.24
$\beta_{income\text{-}high}$	Percentage of high income (>3) households	commune	%	0.0225	0.0010	22.67
β_{tax}	Housing tax	commune	%	-0.0334	0.0033	-10.13
$\beta_{pop\text{-}den}$	Logarithm of population density	zone	ln(pop/hectaree)	0.0020	0.0011	1.82
β_{sqm}	Surface	building	m^2	0.0002	0.0001	1.89
$R^2=0.31$						

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Models : final version of the estimations

TABLE 2 Household Location Choice Model
(n=48526)

Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
$\beta_{car\text{-}access}$	Households with car * Car accessibility	household * zone	0 or 1 * (logsum)	0.0106	0.0036	2.95
β_{educ}	Household with high education level * Ratio of university degree holders in zone	household * zone	0 or 1 * ratio	3.6401	0.1301	27.97
β_{green}	Green area score	commune	0 to 1	0.1924	0.0733	2.62
$\beta_{income\text{-}low}$	Households at income class 1 or 2 * Ratio of hh with high income over all hh	household * zone	0 or 1 * ratio	-2.8948	0.2206	-13.12
$\beta_{income\text{-}high}$	Households at income class 4 or 5 * Ratio of hh with high income over all hh	household * zone	0 or 1 * ratio	4.8074	0.3712	12.95
$\beta_{workers}$	Households with workers * Log distance from CBD	household * zone	0 or 1 * ln(meters)	-0.1453	0.0117	-12.44
β_{rail}	Households without cars * Distance from rail station <1000m	household * zone	0 or 1 * meters	0.3681	0.0287	12.82
β_{price}	Logarithm of transaction price	building	log(euros)	-1.0298	0.0354	-29.09
ASC_{BCR}	Central Brussels area (central communes)	commune	0 or 1	0.8738	0.0196	44.64
Log-likelihood=−95751						

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Models : final version of the estimations

TABLE 3 Employment Location Choice Model

Industry (n=13943)

Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
$\beta_{\text{job-den}}$	Logarithm of jobs density	zone	ln(jobs/hectaree)	-0.0627	0.0084	-7.43
β_{sam}	Logarithm of non residential surface	building	ln(m^2)	1.2514	0.0105	118.65
$\beta_{\text{ind-den}}$	Density of jobs in industry sector	commune	jobs/hectaree	0.0782	0.0028	27.47

Log-likelihood=-13634

Office (n=14937)

Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
$\beta_{\text{gov-den}}$	Density of jobs in public sector	commune	jobs/hectare	-0.0212	0.0033	-6.36
$\beta_{\text{off-den}}$	Density of jobs in private sector (office)	commune	jobs/hectare	0.0152	0.0031	4.93
$\beta_{\text{job-den}}$	Logarithm of jobs density	zone	ln(jobs/hectare)	0.6641	0.0094	70.19
$\beta_{\text{pop-den}}$	Population density	commune	pop/hectare	-0.0057	0.0005	-12.08
β_{sqm}	Logarithm of non residential surface	building	log(m^2)	0.5227	0.0072	72.36

Log-likelihood=-22791

Retail (n=3886)

Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
$\beta_{\text{car-access}}$	Car accessibility	zone	logsum	0.0384	0.0110	3.50
$\beta_{\text{ret-den}}$	Density of jobs in retail sector	commune	jobs/hectare	0.1643	0.0371	4.43
$\beta_{\text{job-den}}$	Logarithm of jobs density	zone	ln(jobs/hectare)	0.0780	0.0153	5.09
$\beta_{\text{pop-den}}$	Population density	commune	pop/hectare	-0.0036	0.0016	-2.19
β_{sqm}	Logarithm of non residential surface	building	ln(m^2)	0.8906	0.0174	51.24

Log-likelihood=-6443

Hotels/Bar/Restaurants (n=2013)

Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
$\beta_{\text{car-access}}$	Car accessibility	zone	logsum	0.0427	0.0133	3.21
$\beta_{\text{job-den}}$	Logarithm of jobs density	zone	ln(jobs/hectare)	0.3854	0.0169	22.82
$\beta_{\text{pop-den}}$	Population density	commune	pop/hectare	-0.0076	0.0011	-7.10
β_{sqm}	Logarithm of non residential surface	building	ln(m^2)	0.3377	0.0142	23.73
$\beta_{\text{hbr-den}}$	Density of jobs in hotels/bar/restaurants	commune	jobs/hectare	0.2018	0.0193	10.44

Log-likelihood=-4923

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Models : final version of the estimations

TABLE 3 Employment Location Choice Model

Government and public service (n=8471)

Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
$\beta_{\text{off-den}}$	Density of jobs in private sector	commune	jobs/hectare	0.0125	0.0019	6.69
$\beta_{\text{job-den}}$	Logarithm of jobs density	zone	ln(jobs/hectare)	0.7523	0.0129	58.37
$\beta_{\text{pop-den}}$	Logarithm of population density	commune	ln(pop/hectare)	-0.0045	0.0006	-7.69
β_{sqm}	Logarithm of non residential surface	building	ln(m^2)	0.5081	0.0115	44.25

Log-likelihood=-10973

Education (n=3775)

Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
$\beta_{\text{edu-den}}$	Density of jobs in education sector	commune	jobs/hectare	0.2208	0.0157	14.08
$\beta_{\text{job-den}}$	Logarithm of jobs density	zone	ln(jobs/hectare)	0.1824	0.0161	11.37
$\beta_{\text{pop-den}}$	Population density	commune	pop/hectare	-0.0075	0.0010	-7.65
β_{sqm}	Logarithm of non residential surface	building	ln(m^2)	0.8405	0.0183	46.04

Log-likelihood=-5995

Health (n=5099)

Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
$\beta_{\text{high-inc}}$	Percentage of households in high income scale (>3)	commune	%	0.0564	0.0057	9.86
$\beta_{\text{hea-den}}$	Density of jobs in health sector	commune	jobs/hectare	0.1832	0.0107	17.10
$\beta_{\text{job-den}}$	Logarithm of jobs density	zone	ln(jobs/hectare)	0.3708	0.0116	32.00
$\beta_{\text{pop-den}}$	Population density	commune	pop/hectare	-0.0129	0.0010	-13.04
β_{sqm}	Logarithm of non residential surface	building	ln(m^2)	0.4908	0.0119	41.29

Log-likelihood=-10493

Leisure activities (n=1315)

Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
$\beta_{\text{high-inc}}$	Percentage of households in high income scale (>3)	commune	%	0.0837	0.0127	6.58
$\beta_{\text{leiz-den}}$	Density of jobs in leisure sector	commune	jobs/hectare	0.2978	0.0181	16.43
$\beta_{\text{pop-den}}$	Population density	commune	pop/hectare	0.0133	0.0012	11.17
β_{sqm}	Logarithm of non residential surface	building	ln(m^2)	0.6327	0.0230	27.56

Log-likelihood=-2349

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Models : final version of the estimations

TABLE 4 Residential Development Project Location Choice Model

Detached (n=59558)

Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
β_{price}	Logarithm of price	building	euros	1.5334	0.0259	59.31
β_{units}	Logarithm of number of detached house units	building	ln(sum)	1.6578	0.0049	338.21

Log-likelihood=-160082

Semi-detached and Attached (n=20119)

Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
β_{price}	Logarithm of price of semi-detached and attached houses	building	ln(euros)	0.3013	0.0427	7.06
β_{units}	Logarithm of number of semi-detached and attached house units	building	ln(sum)	1.1172	0.0068	164.97
$\beta_{pop-den}$	Population density	commune	pop/hectare	0.4097	0.0109	37.48

Log-likelihood=-58729

Apartments (n=5119)

Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
β_{price}	Logarithm price of apartments	building	ln(euros)	0.1823	0.0764	2.38
β_{units}	Logarithm of number of apartment units	building	ln(sum)	0.1823	0.0764	2.38
$\beta_{pop-den}$	Population density	commune	pop/hectare	1.0609	0.0124	85.62

Log-likelihood=-12286

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Models : final version of the estimations

TABLE 5 Non-Residential Development Project Location Choice Model

Industry (n=2770)

Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
$\beta_{car\text{-}access}$	Car accessibility	zone	logsum	-0.0659	0.0106	-6.25
$\beta_{ind\text{-}den}$	Density of jobs in industrial sector	commune	jobs/hectare	-0.0705	0.0068	-10.32
$\beta_{ln\text{-}jobs\text{-}zone}$	Logarithm of total number of jobs	zone	ln(sum)	0.4251	0.0128	33.19
Log-likelihood=-10949						

Office (private sector) (n=767)

Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
$\beta_{car\text{-}access}$	Car accessibility	zone	logsum	0.0906	0.0251	3.61
$\beta_{off\text{-}den}$	Density of jobs in private sector	commune	jobs/hectare	0.0269	0.0081	3.32
$\beta_{pop\text{-}den}$	Population density	commune	pop/acre	-0.0318	0.0054	-5.86
$\beta_{ln\text{-}jobs\text{-}zone}$	Logarithm of total number of jobs	zone	ln(sum)	1.1741	0.0341	34.43
$\beta_{ln\text{-}pop\text{-}zone}$	Logarithm of total number of population	zone	ln(sum)	-0.1460	0.0275	-5.30
Log-likelihood=-1953						

Shops (n=1466)

Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
$\beta_{ln\text{-}jobs\text{-}zone}$	Logarithm of total number of jobs	zone	ln(sum)	0.4451	0.0204	21.84
$\beta_{ln\text{-}pop\text{-}zone}$	Logarithm of total number of population	zone	ln(sum)	0.3899	0.0309	12.62
Log-likelihood=-5451						

Hotels, bar, restaurants (n=107)

Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
$\beta_{car\text{-}access}$	Car accessibility	zone	logsum	0.2219	0.0812	2.73
$\beta_{hbr\text{-}den}$	Density of jobs in hotels/bar/restaurants	commune	jobs/hectare	0.1600	0.1027	1.56
$\beta_{pop\text{-}den}$	Population density	commune	pop/hectare	-0.0365	0.0126	-2.89
$\beta_{ln\text{-}jobs\text{-}zone}$	Logarithm of total number of jobs	zone	ln(sum)	0.7093	0.0805	8.81
Log-likelihood=-359						

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Models : final version of the estimations

TABLE 5 Non-Residential Development Project Location Choice Model

Government and public service (n=264)

Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
$\beta_{\text{ln-jobs-zone}}$	Logarithm of total number of jobs	zone	ln(sum)	0.7184	0.0461	15.57
$\beta_{\text{ln-pop-zone}}$	Logarithm of total number of population	zone	ln(sum)	0.1059	0.0472	2.24

Log-likelihood=-932

Education (n=140)

| Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
$\beta_{\text{ln-jobs-zone}}$	Logarithm of total number of jobs	zone	ln(sum)	0.3591	0.0578	6.21
$\beta_{\text{ln-pop-zone}}$	Logarithm of total number of population	zone	ln(sum)	0.3539	0.0613	5.77

Log-likelihood=-533

Health (n=225)

| Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
$\beta_{\text{ln-jobs-zone}}$	Logarithm of total number of jobs	zone	ln(sum)	0.3523	0.0646	5.45
$\beta_{\text{ln-pop-zone}}$	Logarithm of total number of population	zone	ln(sum)	0.5394	0.0715	7.55

Log-likelihood=-840

Leisure activities (n=970)

Variable	Interpretation	Level	Unit	Coefficient	SE	t-values
$\beta_{\text{car-access}}$	Car accessibility	zone	logsum	-0.0240	0.0141	-1.70
$\beta_{\text{lei-den}}$	Density of jobs in leisure sector	commune	jobs/hectare	3.2041	0.3811	8.41
$\beta_{\text{ln-jobs-zone}}$	Logarithm of total number of jobs	zone	ln(sum)	0.2371	0.0213	11.14

Log-likelihood=-3867

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Check on 2001 : population

Population 2001
Nombre d'habitants
- · 1 982 - 15 000
- ○ 15 001 - 25 000
- ○ 25 001 - 50 000
- ○ > 50 000

Population 2001
Différence relative modélisé-observé
- < -3%
- -3% - 0%
- 0%
- 0% - 5%
- 5% - 15%
- > 15%

0   5   10 km

→ Not perfect match between observed and modelled population

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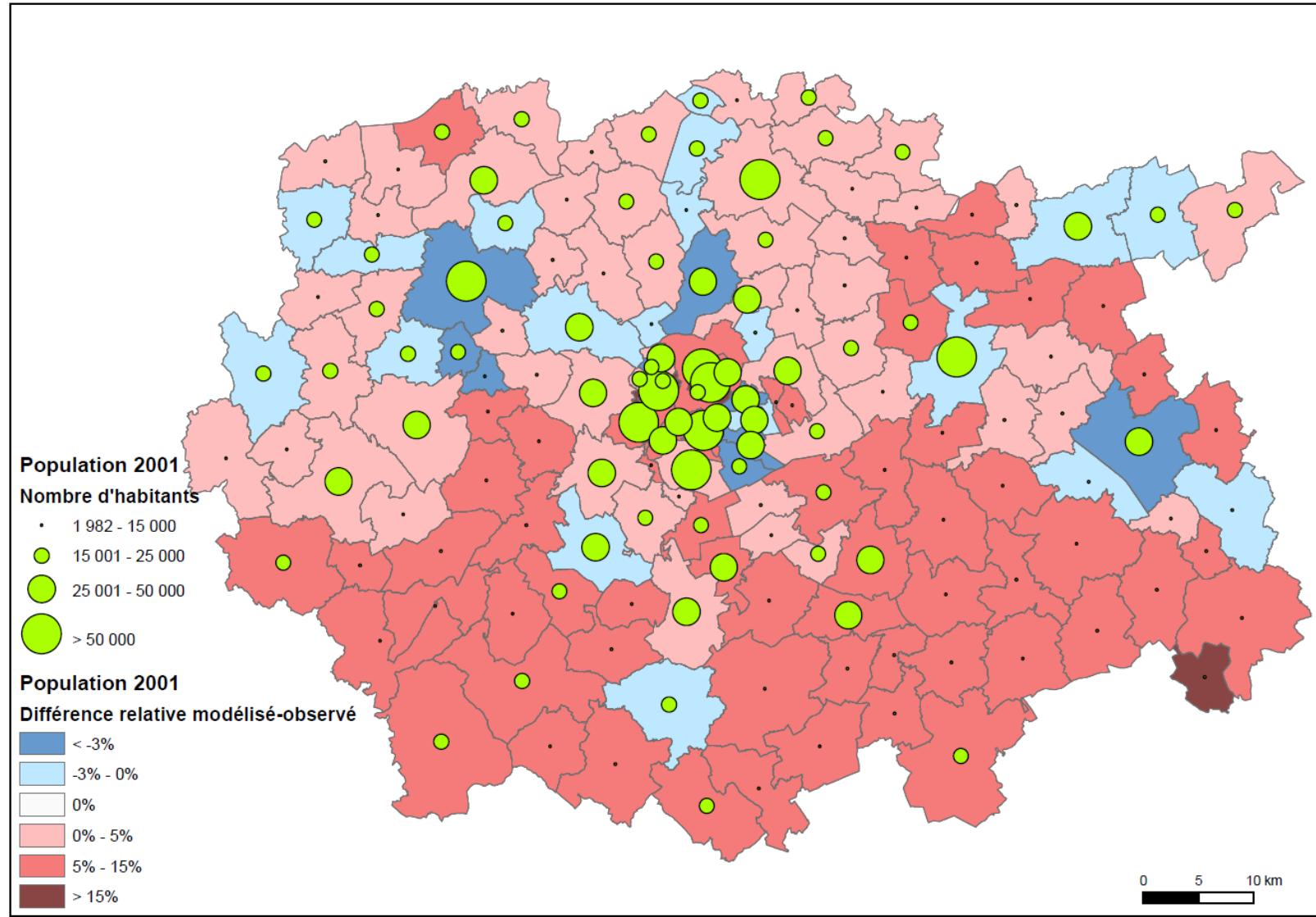
Check on 2001 : employment

Emploi 2001
Offre
- · < 10 000
- ○ 10 001 - 35 000
- ○ 35 001 - 70 000
- ○ > 70 000

Emploi 2001
Différence relative modélisé-observé
- ■ < -0,5%
- ■ -0,5% - 0%
- □ 0%
- ■ 0% - 0,5%
- ■ > 0,5%

0   5   10 km

→ **Good match between observed and modelled employment**

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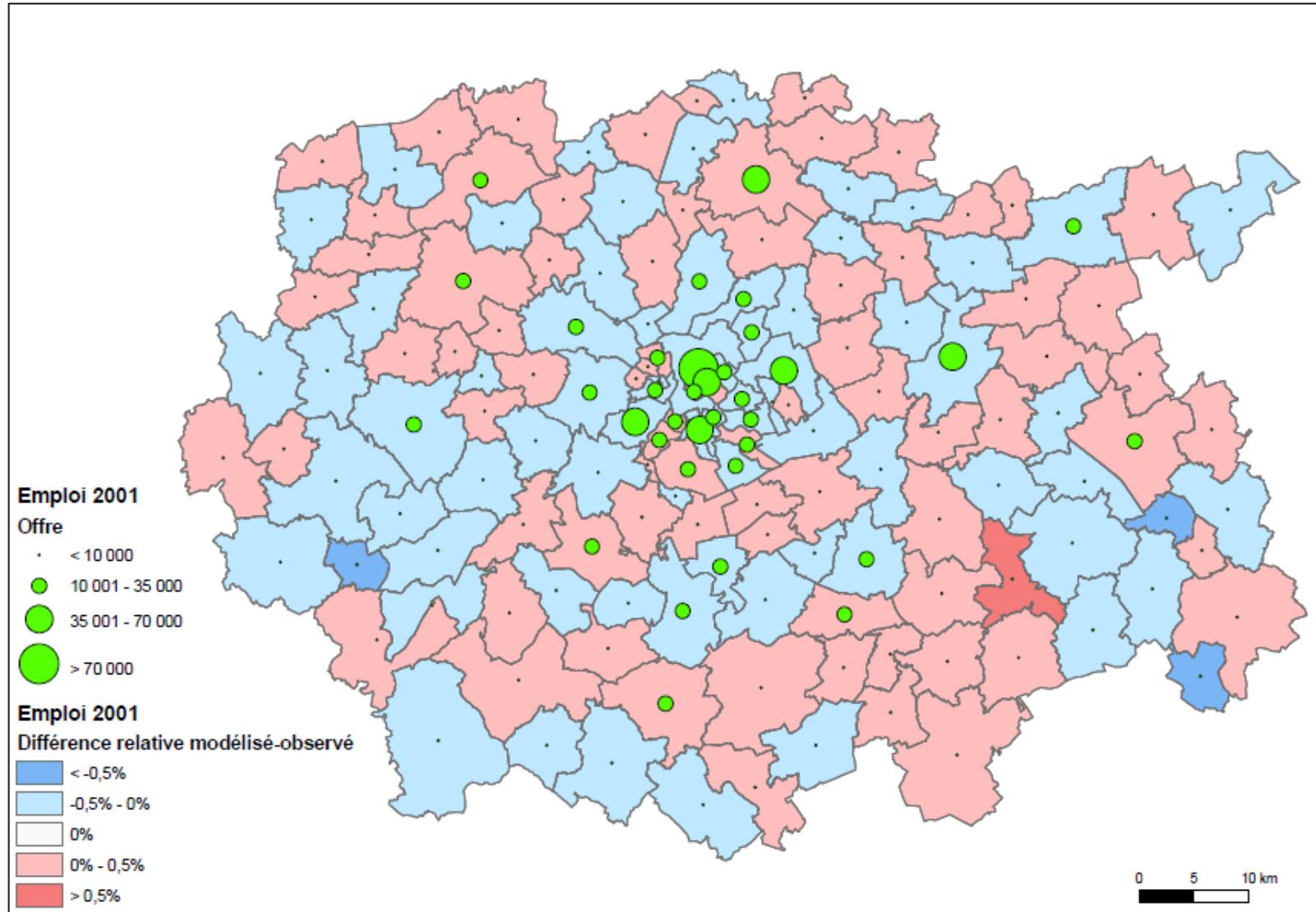
Validation on 2007 : population

Population 2007
Nombre d'habitants

- ·   2 058 - 15 000
- ○   15 001 - 25 000
- ○   25 001 - 50 000
- ○   > 50 000

Population 2007
Différence relative modélisé-observé

- < -5%
- -5% - 0%
- 0%
- 0% - 5%
- 5% - 15%
- > 15%

0   5   10 km

→ Not perfect match between observed and modelled population

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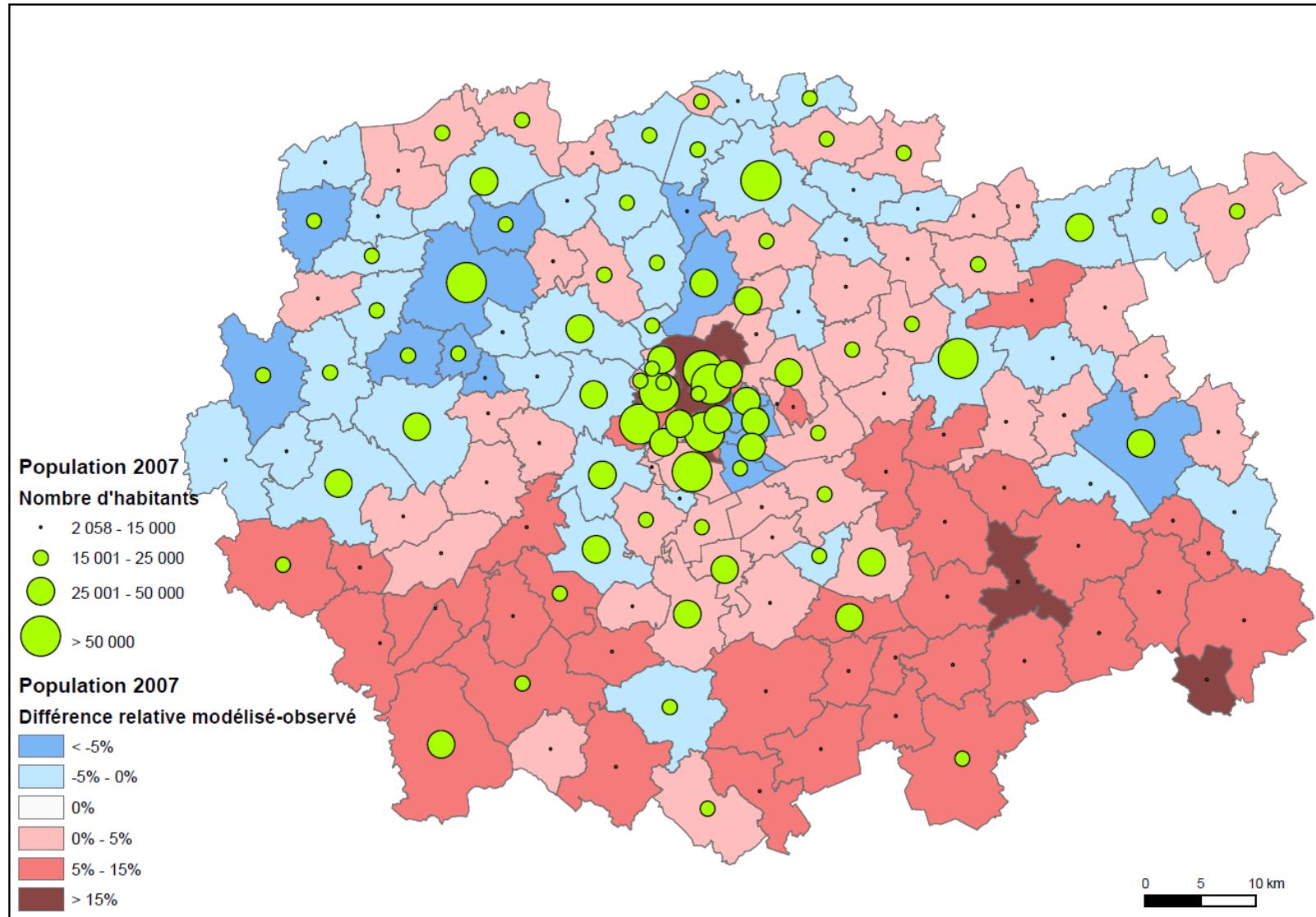
Validation on 2007 : employment

Emploi 2007
Offre
- ·   < 10 000
- ●   10 001 - 35 000
- ●   35 001 - 70 000
- ●   > 70 000

Emploi 2007
Différence relative modélisé-observé
- < -30%
- -30% - -10%
- -10% - 0%
- 0% - 10%
- 10% - 30%
- > 30%

0   5   10 km

→ Not perfect match between observed and modelled employment   stratec
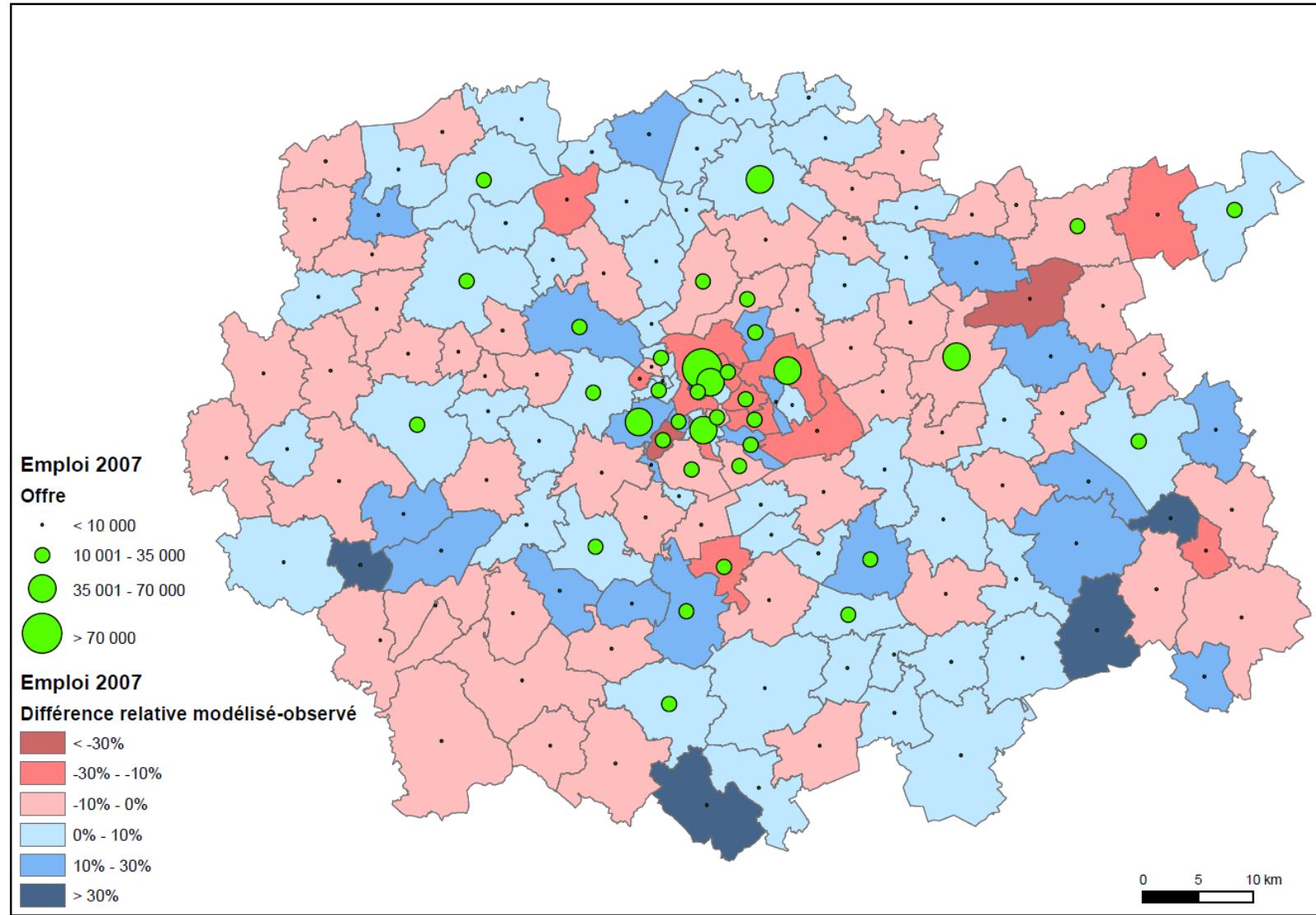
Check on the road traffic model

❖ Comparison of car travel times from MATSim and SATURN

MATSim	Pentagone	1ère couronne	2ème couronne	1ère périphérie	2ème périphérie	Couronne RER	Autres
Pentagone	9.46	10.4	17.62	19.42	22.14	29.65	38.23
1ère couronne	23.95	21.53	24.54	24.91	26.52	34.48	43.97
2ème couronne	37.24	32.81	29.58	27.24	27.42	36.93	45.25
1ère périphérie	38.86	34.65	32.28	27.47	27.55	36.56	45.15
2ème périphérie	40.11	36.81	35.92	31.51	28.42	38.58	48.38
Couronne RER	48.28	45.53	45.62	42.42	41.08	44.27	55.33
Autres	61.96	58.42	52.25	46.22	46.55	52.59	26.41

Intra-BCR
Incoming
Outcoming

SATURN	Pentagone	1ère couronne	2ème couronne	1ère périphérie	2ème périphérie	Couronne RER	Autres
Pentagone	5.56	15.83	27.80	36.55	44.55	65.99	91.20
1ère couronne	19.52	26.04	34.31	41.99	51.04	72.43	96.75
2ème couronne	35.55	38.41	37.66	41.95	49.11	72.54	94.49
1ère périphérie	51.79	50.04	43.95	36.95	47.14	69.75	87.66
2ème périphérie	80.61	80.50	71.81	64.95	64.45	82.75	101.50
Couronne RER	123.25	124.19	119.03	113.22	108.37	112.25	123.11
Autres	162.51	159.71	149.26	140.81	139.08	131.41	128.58

Absolute difference	Pentagone	1ère couronne	2ème couronne	1ère périphérie	2ème périphérie	Couronne RER	Autres
Pentagone	3.90	-5.43	-10.18	-17.13	-22.41	-36.34	-52.97
1ère couronne	4.43	-4.51	-9.77	-17.08	-24.52	-37.95	-52.78
2ème couronne	1.69	-5.60	-8.08	-14.71	-21.69	-35.61	-49.24
1ère périphérie	-12.93	-15.39	-11.67	-9.48	-19.59	-33.19	-42.51
2ème périphérie	-40.50	-43.69	-35.89	-33.44	-36.03	-44.17	-53.12
Couronne RER	-74.97	-78.66	-73.41	-70.80	-67.29	-67.98	-67.78
Autres	-100.55	-101.29	-97.01	-94.59	-92.53	-78.82	-102.17

→ Proper consideration of congestion?

Relative difference	Pentagone	1ère couronne	2ème couronne	1ère périphérie	2ème périphérie	Couronne RER	Autres
Pentagone	70%	-34%	-37%	-47%	-50%	-55%	-58%
1ère couronne	23%	-17%	-28%	-41%	-48%	-52%	-55%
2ème couronne	5%	-15%	-21%	-35%	-44%	-49%	-52%
1ère périphérie	-25%	-31%	-27%	-26%	-42%	-48%	-48%
2ème périphérie	-50%	-54%	-50%	-51%	-56%	-53%	-52%
Couronne RER	-61%	-63%	-62%	-63%	-62%	-61%	-55%
Autres	-62%	-63%	-65%	-67%	-67%	-60%	-79%

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Check on the home2work matrix

❖ Comparison of the home2work matrices from UrbanSim/MATSim and INS (in number of active persons)

UrbanSim/MATSim	Pentagone	1ère couronne	2ème couronne	1ère périphérie	2ème périphérie	Couronne RER	Autres	Total
Pentagone	11 942	6 990	4 358	1 691	1 000	806	29	26 816
1ère couronne	25 108	37 820	17 043	4 782	3 328	2 549	107	90 737
2ème couronne	27 090	25 973	33 556	5 243	3 845	2 936	141	98 784
1ère périphérie	19 073	15 607	14 864	24 867	7 932	5 148	118	87 609
2ème périphérie	11 988	10 308	9 539	9 262	20 607	8 549	227	70 480
Couronne RER	41 422	28 813	21 290	20 541	22 733	204 339	4 545	343 683
Autres	5 913	3 741	2 568	2 183	1 558	13 637	23 144	52 744
Total	142 536	129 252	103 218	68 569	61 003	237 964	28 311	770 853

INS 2001	Pentagone	1ère couronne	2ème couronne	1ère périphérie	2ème périphérie	Couronne RER	Autres	Total
Pentagone	11 673	6 852	4 296	2 179	536	766	28	26 330
1ère couronne	24 584	37 261	16 700	5 804	2 152	2 563	104	89 168
2ème couronne	24 246	23 347	29 592	5 725	2 423	2 486	113	87 932
1ère périphérie	20 121	16 742	15 777	30 276	5 740	5 742	134	94 532
2ème périphérie	12 656	11 017	10 030	10 967	21 419	9 267	212	75 568
Couronne RER	42 776	29 204	21 588	25 680	19 418	227 794	4 402	370 862
Autres	5 148	3 135	2 184	2 409	982	11 367	21 676	46 901
Total	141 204	127 558	100 167	83 040	52 670	259 985	26 669	791 293

| Relative difference	Pentagone	1ère couronne	2ème couronne	1ère périphérie	2ème périphérie	Couronne RER	Autres	Total
Pentagone	2%	2%	1%	-22%	87%	5%	4%	2%
1ère couronne	2%	2%	2%	-18%	55%	-1%	3%	2%
2ème couronne	12%	11%	13%	-8%	59%	18%	25%	12%
1ère périphérie	-5%	-7%	-6%	-18%	38%	-10%	-12%	-7%
2ème périphérie	-5%	-6%	-5%	-16%	-4%	-8%	7%	-7%
Couronne RER	-3%	-1%	-1%	-20%	17%	-10%	3%	-7%
Autres	15%	19%	18%	-9%	59%	20%	7%	12%
Total	1%	1%	3%	-17%	16%	-8%	6%	-3%

Mode choice model
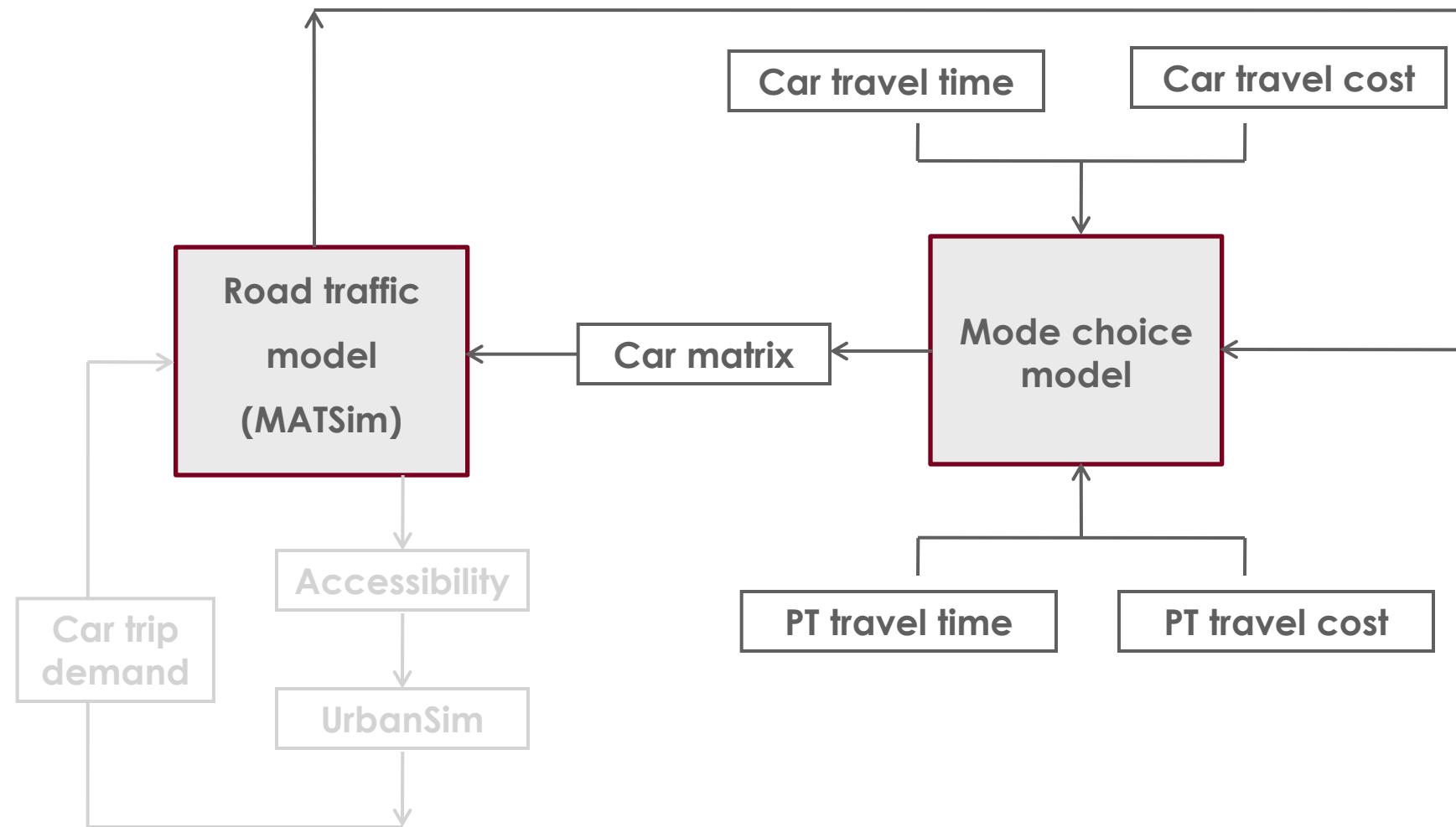
Mode choice model

❖ **To do** :

- Set the marginal utilities for travel time and travel cost (car + PT) based on an existing model for Brussels
- Set the mode constants (calibration)

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Test scenario : cordon pricing

Ring R0 - cordon de tarification
Résau routier
Région Beuxelles-Capitale

0   5   10 km
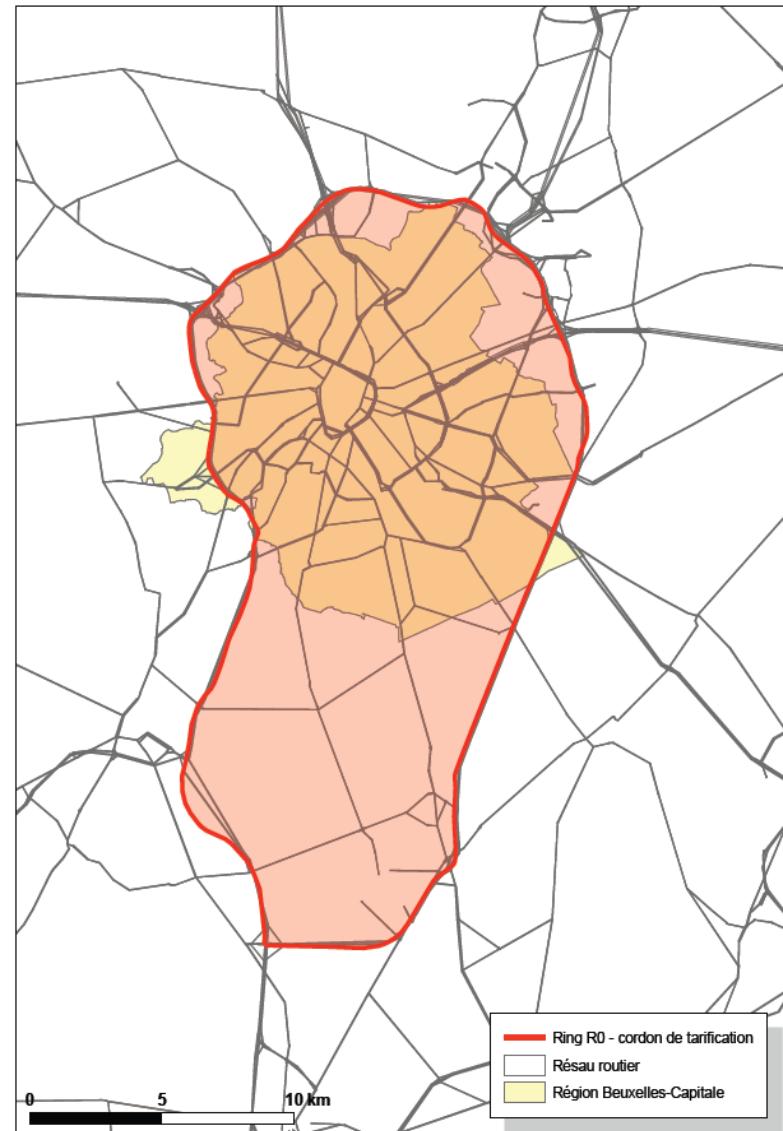
- ❖ **City centre** defined as Brussels Capital Region ("19 communes") and the orbital motorway (Ring)

- ❖ Tool for modelling pricing schemes in MATSim4Urbansim not yet available

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Policies to be tested

❖ **Transport policies**

- Urban road pricing
- Increase of capacity of the orbital motorway (Ring): + 2 lanes in each direction

❖ **Land use policies**

- Densification policies

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Policies to be tested

❖ Urban road pricing

- **Distance toll** applied on **Brussels Capital Region** and on the **Ring** with a flat fee fare = **0,43€/pcu-km**

- 0,43€/pcu-km = mean optimal pricing that internalises the marginal external costs during morning peaks (6h-10h)

  (estimation by Stratec, according to IMPACT unit values)

Coûts externes marginaux par EVP en RBC en heure de pointe du matin (8-9h)

Etude relative à l'introduction d'une tarification à l'usage en Région de Bruxelles-capitale

Coûts externes marginaux (cents€2000/km) par EVP

0	à	0,001
0,001	à	0,1
0,1	à	0,5
0,5	à	2,5
2,5	à	5
5	à	25
25	à	50
50	à	100
Plus de 100		

Communes en RBC
RBC

Policies to be tested

❖ **Densification policies**

- **Goals :**
    - Tertiary employment concentrated in the zones easily accessible (ABC theory)
    - Population concentrated in the "communes" classified as centre and agglomeration

- **Measure :**
    - increase the residential units and the non-residential sqft (buildings table) in the target zones

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