European Research Area

EUROPEAN POLICYBRIEF

SustainCity: Case studies in Paris, Zurich and Brussels

SUMMARY

Objectives of the SustainCity research

This Policy Brief highlights the achievements in the three case studies which implement an land use transport interaction model for the given agglomeration. The case studies shall help to advance the state of the art of urban simulation models and to improve their diffusion among planners and decision-makers.

To develop a European-adapted version of the urban micro-simulation tool UrbanSim and to implement it in three European cities (Paris, Zürich, Brussels), was the aim of the project.

Scientific approach / Methodology of this deliverable

The methodology used is the agent-based microsimulation of land use and transportation. This includes:

- Data collection and analysis
  - Preparation of estimation data
  - Preparation of simulation data
- Estimation of discrete choice models
- Calibration of
  - The demographic model
  - The transport model
  - The urban model
  - The composite model
- Simulation of reference scenarios and policy scenarios
- Evaluation with a common indicator set

	The work package brings together the achievements in: ♦ The assessment of the state of the art ♦ Theoretical developments ♦ Demographic modelling ♦ Econometric guidance ♦ Integration of advanced agent-based transport models
New knowledge and/or European added value	The case studies show the successfully adaptation of the open source software UrbanSim to the European context (UrbanSimE). Knowledge is created in respect of available data and its analysis, empirical evidence of economic theory, integration of large scale microsimulation software and application of a new economic appraisal method. The knowledge and tools created can be used for the evaluation of policy packages aiming at sustainable urban development. The tools are extendable and adaptable to specific problems and regions.
Key messages for policy-makers, businesses, trade unions and civil society actors	The project produced three successful implementations of microsimulation land use transport interaction models in the cities of Paris, Zurich and Brussels using a suitably adopted land use transport model. The large scope and high detail of the simulations are resource intensive but allow for very detailed, flexible and consistent evaluation of policy packages aiming at sustainable urban development.

Introduction

The sustainable development of cities is crucial for our society because ever more people live in an urban environment. The SustainCity project provides knowledge and tools to help policy makers with their decisions towards sustainable development.

Since cities are acknowledged to be complex socio-economic systems, microsimulation is applied. The principle of this method is to build the system from very detailed components to study the outcomes on a more aggregate level. This bottom up approach allows investigating emergent phenomena and distributions of possible development paths.

The project looks in particular at the nexus of land use and transportation (Fig. 2). The attractiveness of locations depends on their accessibility which is a result of transport infrastructures in place and the relative distribution of points of interest for a specific economic actor. Economic actors base their location decisions on the attractiveness of the locations which results in new spatial distributions of origins and destinations of transport trips. Demand for transportation is consequently changed which manifests itself in new congestion patterns. The process start over, when congested areas are considered less attractive in terms of accessibility.

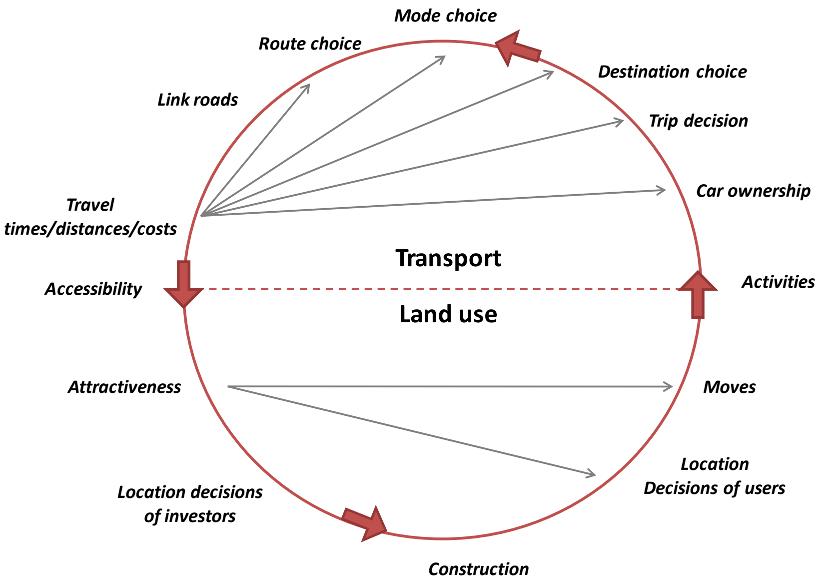

Figure 1: The land-use transport feedback cycle (Lautso and Wegener, 2007)

Spatial issues

The representation of space by LUTI models raises problems. The sources of geo-statistical biases in econometrical analyses are for example: the *definition of the urban agglomeration*, the *Modifiable Areal Unit Problem (M.A.U.P.), the border effects* and econometrical issues that deal with *spatial autocorrelation*, *endogeneity* and *sampling*. The relevance of these issues for the SustainCity Project has been empirically studied by the UCL (Thomas et al., 2013; Jones et al., 2013; Thomas et al., 2012; Jones et al., 2012).

Using the three SustainCity case studies, implications of these biases in operational applications were highlighted, and practical examples were provided, showing how these biases can influence the behaviour of UrbanSim for a given case study, and make the comparisons between the case studies difficult (Cotteels et al., 2013).

Within-case study issues were mainly illustrated using Brussels, and include:

- *Influence of the definition of the study area on model estimates:* sensitivity analyses of the land price model show that the determinants of land price are influenced by the size of the study area, which influences the urban model;
- *M.A.U.P*: as expected, estimated parameters of econometrical sub-models are affected by a change of the size of the BSU or basic spatial unit – attention must be paid to this, when interpreting parameter values. Location choice parameters, in particular, may vary with the scale;
- *Modelling strategy:* sensitivity analyses show that a simple econometrical model, with theoretically grounded variables performs as well as models based on "data crunching".

Further to that, inter-case study issues were based on an empirical comparison of Paris, Brussels and Zurich:

- *Comparison of the study areas (size and content):* different choices were made in Paris, Brussels and Zurich regarding the delineation of the study area. In addition to the underlying differences of size of these cities, it has lead to study areas varying dramatically in size;
- *Comparison of the city structures:* the internal structure of these three cities is also different, but these differences are difficult to disentangle from the differences of BAU chosen by each case study.

Case studies

The work for each case study was divided into the following tasks:

- Data collection and analysis
- Model calibration
- Scenario simulations

The first period, which covered a period of 18 months, was mainly dedicated to data collection, estimation of the models and general calibration.

The second period, which covered a period of 24 months, was dedicated to the refinement of the estimation, calibration of the composite models and the simulation of scenarios.

At the end of the project, each case study had developed a comprehensive UrbanSim model. The three case studies were starting at different stages of calibration; consequently, they also reach different calibration/validation levels. The Paris team started from an existing detailed model and has therefore developed a operational model faster than Brussels and Zurich teams, which started from scratch. However, the three case studies were able to simulate different policy scenarios, which was the main technical goal of the project.

The models developed for Brussels and Zürich are nevertheless not as comprehensive and as user-friendly as planned. This deviation can among others be explained by the underestimation of the technical difficulties (e.g. in the case of Brussels and Zürich setting the interface between land-use and transport models required much more time than planned), long runtimes that are a limiting factor for extensive testing, and the fact that UrbanSim is a microsimulation software implying very large databases (in microsimulation models, each individual of the population is explicitly modelled, which leads to databases with millions of data points).

All case studies simulated the business-as-usual scenario (baseline) and the common policy scenario of road pricing for central areas. The comparison of the scenarios was impractical due to the findings on spatial issues (page 3).

The particular progresses made and difficulties encountered in the case studies are described in more details in the next sections.

Paris case study

The main policy that has been evaluated by the UrbanSimE was the Grand Paris project. Grand Paris is a major public transportation and urban development project in Paris area. About 160 km automatic subway will be added to the existing subway network in the main around Paris city and the near suburbs. 75 new subway stations will be constructed. In comparison with currently active 220 km subway lines and 303 stations, the project is a considerable evolution in the public transportation system of the area. The total project investment is estimated at about 30 billion Euros over more than 20 years (up to 2035). The results provided at commune or 50 aggregate zones have been used in other socio-economic analyses and provide coherent results with other studies conducted by different authorities (Picard and Motamedi, forthcoming).

This case study has demonstrated that it is possible to develop and run a European version of UrbanSim which is consistent with all the specificities of the European context, and which provides an operational tool for policy evaluation.

A sample of results obtained for predicting the effect of the Grand Paris project is presented in Figure 2 and Table 1.

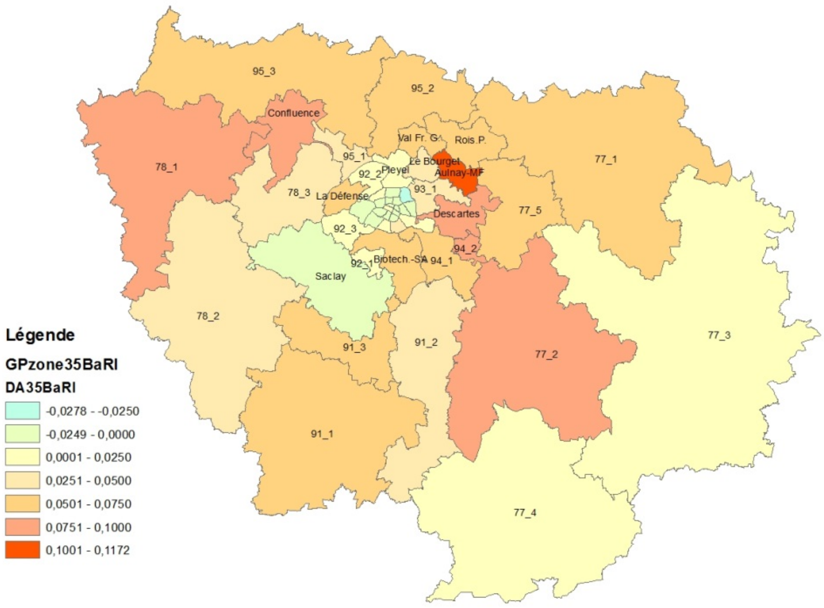

Figure 2: Difference of aggregate accessibility (users surplus) of aggregate zones between low impact and BAU scenarios

Grand Paris Zone	Ref	Low	High
Aulnay-Montfermeil	2 381	19 021	21 260
Biotechnologies Sei.	75 856	90 885	128 976
Confluence	28 296	27 116	28 931
Descartes	39 719	69 696	79 001
La Défense	96 097	139 625	143 918
Le Bourget	15 092	42 416	49 640
Pleyel	55 980	85 043	93 163
Roissy-pôle	29 014	84 130	126 819
Saclay	35 187	121 294	144 125
Val de France – Gon.	5 963	7 075	17 315
Paris	112 138	90 575	94 430
CDT	383 584	686 302	833 149

Table 1 : Results of integrated simulations, comparison of the number of additional jobs over period 2005 - 2035 in different scenarios

Zurich case study

Four scenarios are simulated, including the baseline. In the baseline scenario the status quo is maintained in respect of transport infrastructure and policies. The population development is micro simulated with the demography model (Turci et al., 2012), job numbers are given externally and we assume relocation rates for households and jobs. The simulations start in 2000 and end in 2030. Every fifth year a transport simulation is performed to update accessibility values of parcels and travel related indicators of persons such as chosen mode and travel time.

A cordon road pricing for the city of Zurich is the first and common policy simulated. A monetary payment of 5 euros is imposed on travellers crossing the cordon towards the city centre from 2015 onwards. The results (Table 2 on page 9) show 4% reductions in car mode choice and consequently time and distance decreases for car travel by 1.5% and 1% respectively for the whole simulation area. In terms of land use we see attraction of jobs and reduction of households respective to the cordon area.

The second policy scenario assumes higher allowed floor area densities in central locations. The policy is again applied in 2015. Car mode choice decreases by 1%, which reduces car travel time by 1% and travelled distance by 0.7%. Allowing higher floor area ratios in central locations of settlements leads to more built space in these areas. As a consequence about 18% more households locate in central areas.

Relative effects [%]	Road pricing	Densifi-cation	Road pricing and densification
Travel indicators			
Travel time in study area	5.1	0.3	4.3
Travel time in cordon crossing traffic	5.3	0.3	4.6
Travel time of inhabitants of densification zones	10.2	24.0	30.2
Distance travelled by car in study area	-1.0	-0.7	-1.9
Distance travelled by car in cordon crossing traffic	-3.2	0.0	-3.5
Distance travelled by car by residents of Zurich	-1.9	3.1	-1.4
Travel time by car in study area	-1.3	-1.0	-1.9
Travel time by car in cordon crossing traffic	-3.5	-0.2	-3.6
Travel time by car by residents of Zurich	-1.7	2.8	-0.6
Car share in study area	-4.0	-0.6	-4.1
Car share in cordon crossing traffic	-4.5	-0.2	-4.5
Car share of residents of Zurich	-2.4	-0.2	-2.7

Land use indicators			
Number of households in Zurich	-0.7	1.0	-0.1
Number of jobs in Zurich	4.9	-0.9	4.1
Number of living units in Zurich	-0.6	0.9	-0.1
Number of households in densification zones	-0.6	18.3	16.8
Number of jobs in densification zones	1.1	0.8	2.3

Table 2: Effects in main indicators compared to baseline

The third policy scenario is the combination of the two ones. The results show that the combination of road pricing and densified land use reduces car travel most. Overall travel time and distance reduction is almost 2%. Reduction in car mode choice is also about 4%. There is no notable difference in the number of households within the municipality of Zurich. It seems like the effects of both policies balance themselves in the region where both policies are applied. There are about 4% more jobs locating in the municipality of Zurich compared to the baseline. This is less than in the densification scenario, which shows that disadvantages of road pricing are more than compensated by advantages of central locations.

Calibration of all main models (Demography, transportation and land use) was done ad hoc. A thorough methodology to calibrate a composite model is still lacking.

The transport model only simulates commuting trips from home to work and back home. The integration of further trip purposes such as leisure and shopping would improve the transport simulation substantially.

In respect of road pricing the transport simulation would benefit of adding choices about trip making, car pooling and other modes. The simulation of public transport does not include additional costs with more demand. This leads to a mode share shift towards public transport which is optimistic and substantial costs are neglected.

The relocation decision of households does not depend on the simulated situation. One would expect higher probability of relocation for policy affected households.

The land development model would benefit from a coupling to real estate prices and simulated economical assessments of construction projects. An appropriate model would need a more consistent reproduction of sub-markets which also requires additional price models.

All models implemented models would benefit from further optimization in terms of data used for estimation, definition of model variables and the estimation or modelling methodology. Especially the workplace choice and employment location choice models are lacking observations for estimation and had to be estimated using the distribution in the census data.

In most cases models had to be estimated using the base year data which represents the current distribution and not active location choices.

Brussels case study

Scenario definition

The following policies were simulated in the Brussels case study: business-as-usual scenario (horizon 2020), cordon pricing scenario, densification scenario. The latter scenarios are further detailed below.

Cordon pricing scenario

The cordon is located just outside the Ring road (orbital highway) which surrounds the Brussels-Capital Region and some adjacent communes. Every car entering the area inside the cordon during the morning peak period (i.e. between 6 am and 10 am) has to pay an additional 5€.

Densification scenario

The objective of this scenario was to test the effects of household and job densification in the zones defined as having a high accessibility. The population densification was implemented by increasing the housing supply in the zones having a high accessibility. These zones "highly accessible" were located in 36 communes classified as the "centre" and the "agglomeration" according to Van Hecke et al. (2009). The job densification was focused on the tertiary sector and was implemented by increasing the available office floor space located in the zones having a high accessibility by public transport. The selection of the zones highly accessible was based on the "ABC policy" approach, coming from The Netherlands (Dijst, 1997).

Scenario simulation and evaluation

Each scenario was simulated from 2001 to 2020 and compared with the business-as-usual scenario. The road traffic model was run every fifth year to update accessibility values of the different zones and travel related indicators of persons (chosen mode and travel time).

Both land use and transport indicators were computed. The key indicators used to assess the effect of the policies were as follows:

- number of households in the Brussels-Capital Region
- number of households located inside the cordon (for the cordon pricing scenario)
- number of households located inside the target area for densification (for the densification scenario)
- number of jobs in the Brussels-Capital Region
- number of jobs located inside the cordon (for the cordon pricing scenario)
- number of jobs located inside the target area for densification (for the densification scenario)
- average modal shares (car, public transport and walk) for the all day and in the morning peak hours, for the whole study

area and the Brussels-Capital Region
- average travel time (all modes, car, public transport and walk)
- average home-work travel distance.

The main achievements of the Brussels case study are the development of an UrbanSim model and the simulations which were run with the model. The results of the cordon scenario show a decrease in the car share compared with the business-as-usual scenario (from 67.5% to 66.4%). Consequently, average car travel times and home-to-work distances also decrease. The results of the densification scenario show that increasing housing supply and office floor space in “highly accessible” locations leads to a relocation of households and jobs in Brussels-Capital Region (respectively + 7% and + 2%).

Although the UrbanSim and MATSim models still have weaknesses, the case study shows that, provided that data are available, a land-use/transport model can be calibrated. However the model is not fully operational, among others because the resulting elasticities (magnitude of the policy effects) have not yet been validated and in some cases are difficult to be interpreted.

Another important result is that the Brussels case study points out some fields requiring improvements and further research.

In SustainCity, and in particular in the Brussels case study, all the models (household location choice, job location choice, hedonic price model,..) have been estimated with observed data, in which correlations may exist (and probably exist). It is therefore difficult to estimate with accuracy the effect of a given x explanatory variable on the y independent variable. One solution would be to estimate the parameter values using “stated preference surveys”, i.e. surveys were scenarios are presented to the respondents, with uncorrelated variables, so that the effect of each variable on their choices may be derived with much higher accuracy. The collection of such data could provide an important improvement to the calibration of the UrbanSim submodels, particularly the location choice models, were variables such as price, surface, number of rooms, etc, may intervene, all being correlated in the reality. More generally further research should be dedicated to the issues of correlation and endogeneity in the calibration of these models.

Another field requiring further research is the validation of the models, e.g. by plausibility analysis, back casting, inter-city comparisons, inter-models comparisons or other means.

Technical improvements are required as well, such as a reduction of the computing time, to allow a better exploration of the stochastic variations (in microsimulation, each run provides a different result and a whole set of runs is necessary to provide an average result).

Conclusion - Key messages for policy-makers, businesses, trade unions and civil society actors

The case studies fulfilled the main objective of the project which was to elaborate a **land use transport interaction model adapted to the European context**. All three case studies developed a location specific model and were able to run a common scenario as well as case study specific scenarios. The following lessons were learned:

Microsimulations are very data hungry which makes **considerable efforts necessary in data acquisition, storage, preparation, integration and actualisation**. Well maintained data warehouses increase the usability of the data and make these assets more valuable. The harmonisation of data across regions will allow for comparison of regions.

The following difficulties were faced and resolved:

- Updating imperfect or incomplete data by intelligent imputation
- Data exchange between different model systems (in particular between the three main parts covering demography, transport and land use simulation)
- Development of a common set of Measures of Effectiveness for the comparison of results

The project allowed adapting the software of choice for land use simulation (UrbanSim) to the European context. This includes the specification of the models using general areal units (zones, parcels), the consideration of budget constraints in behavioural models and the introduction of family decisions. A **European version (UrbanSimE) is now available.**

Agent-based microsimulation proved to be **valuable in terms of consistency.** All the models have their foundation in micro economic principles which allows for a consistent welfare analysis. The methodology allows to respects regional and even individual diversity.

The large scope of modelling paired with enforced consistency via microsimulation is the basis for **more accurate accounting of costs and benefits**. One example is the consideration of travel time savings and land values. The simulations developed allow not only specifying the overall effect but also where it finally occurs. In doing so double counting is avoided, e.g. if increased value of property is included some of the travel time saving benefit is transferred to the landlords and should therefore not be included under the heading of travel time savings.

The methodology **allows addressing the effects of urban process dynamics**, i.e. the effects due to different process speeds. When microsimulating economic decisions we are talking about different frequencies of decision making in respect of certain goods. E.g. households decide less frequently on there place to live than which mode of transport to use. The theoretical work on that topic showed (de Palma et al., 2012) that more research is needed before sound statements can be made.

	PROJECT IDENTITY
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	PROJECT IDENTITY

Website	www.sustaincity.eu
Further readings	Cotteels, C., J. Jones, D. Peeters and I. Thomas (2013) Paris, Brussels and Zurich: same cities?, *SustainCity Working Paper*, UCL, Brussels. Dijst, M. (1997) Spatial policy and passenger transportation, *Netherlands journal of housing and the built environment*, **12** (1) 91–111. Van Hecke, E., J.-M. Halleux, J.-M. Decroly and B. Mérenne-Schoumaker (2009) Noyaux d'habitat et Régions urbaines dans une Belgique urbanisée, Monographies, Direction générale Statistique et Information écono mique, Brussels. Jones, J., D. Peeters and I. Thomas (2012) Monocentric City, Polycentric City: An Empirical Comparison through Scales, paper presented at *52nd conferences of the European Regional Science Association*, Bratislava, August 2012. Jones, J., D. Peeters and I. Thomas (2013) Scale Effect Biases in Policy Evaluations by Land Use and Transport Interactions Models, paper presented at *BIVEC/GIBET Transportation research days 2013*, Luxembourg, May 2013. Lautso, K. and M. Wegener (2007) Integrated Strategies for Sustainable Urban Development, in S. Marshall and D. Banister (eds.), *Land Use and Transport*, Elsevier, Oxford. De Palma, A., S. Proost and S. van der Loo (2012) A small model for equilibrium mechanisms in an agglomeration, *SustainCity Working Paper*, **3.4**, ENS-Cachan, France. Picard, N. and K. Motamedi (forthcoming) Paris Case Study, in R. Hurtubia, M. Bierlaire, P. Waddell and A. de Palma (eds.), *Handbook on Integrated transport and land use modeling for sustainable cities*, xx–xx, EPFL Press, Lausanne. Thomas, I., C. Cotteels, J. Jones and D. Peeters (2012) Revisiting the extension of the Brussels urban agglomeration: new methods, new data… new results?, *Belgeo. Revue belge de géographie*, (1-2). Thomas, I., J. Jones and D. Peeters (2013) Are LUTI models results geographically robust? Some illustrations with Brussels, paper presented at *NECTAR Conference*, Ponta Delgada, June 2013. Turci, L., S. Pennec, L. Toulemon, A. Bringé, E. Morand and R. Baggio (2012) Demographic Model User Guide, *SustainCity Working Paper*, **4.4**, INED, Paris.
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