European Research Area

EUROPEAN POLICYBRIEF

SustainCity: Using land-use/transport models for sustainable policy making

This Policy Brief makes part of the WP6 of the SustainCity Project.

SUMMARY

Objectives of the SustainCity research	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).
Scientific approach / Methodology of this deliverable	The object of this Policy Brief is to highlight why and how Land-use Transportation Integrated models (LUTI models) are helpful for policy making. In this context, we look to the interactions between land-use and transport within a city and we show how they are taken into account in these models. We present how these models achieve policy assessment, what is their specific contribution to policy assessment that other tools cannot provide. We also review the possible impacts of different policy measures on several economic, social and environmental aspects and show that many of them can be assessed using these models.
New knowledge and/or European added value	There are many papers on LUTI models and reviews of models and of families of models. The specific objective of this paper is to fill a gap between experts and academic modellers, on one side, and urban planners and decision-makers, on the other side, i.e. to explain why and how LUTI models can help in building sustainable urban policies.

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Key messages for policy-makers, businesses, trade unions and civil society actors	Integrated land-use/transport models are a unique tool for policy evaluation and for anticipating trends in the evolution of cities. The development of a European modelling platform built upon the UrbanSim software will provide an adequate and validated tool for policy makers. Land-use/transport models allow to: (i) better understand mechanisms and interactions (in other words: they are a way to catch as far as possible the complexity of cities), (ii) test policies on a city simulator (the model), (iii) calculate a whole set of long-term impact indicators, (iv) assess policies against pre-defined (social, economic, environmental) targets and classify them according to pre-defined criteria, using these indicators, (v) elaborate, not a single policy, but a consistent package of policies, whose impacts are reinforcing or compensating each other.

Objectives of the SustainCity research

The objectives of the SustainCity research are to advance the state of the art of urban simulation models, to develop an European-adapted version of the urban micro-simulation tool UrbanSim, to implement it in three European case studies (Paris, Zürich, Brussels), and eventually to improve the diffusion of the urban simulation models among planners and decision-makers.

The modelling platform adapted for the context of European cities will be based on the existing software UrbanSim, which was originally developed for cities in the United States. (In the project reports, the adapted platform is referred to as "UrbanSim-E".)

UrbanSim-E, developed within SustainCity, will provide the means to evaluate the impacts of policy measures in European cities. With the sustainable development objective in mind, UrbanSim-E will provide a quantitative assessment of the trade-off between economic, environmental or social objectives.

Scientific approach / methodology

The aim of this project is to address the modelling and computational issues of integrating modern mobility simulations with the latest micro-simulation land use models. The project intends to advance the state-of-the-art in the field of the micro-simulation in prospective integrated models of Land-Use and Transport (LUTI). On the modelling side, the main challenges are to integrate a demographic evolution module, to add a firmographic module (birth and death of firms), a module representing the decision process in households with two active members, with regard to the household location choice, to add an environmental module, to improve the overall consistency and, last but not least, to deal with the multi-scale aspects of the problem: several time horizons and spatial resolutions are involved.

The SustainCity project includes also three case studies to take advantage of the achievements of the other tasks in order to undertake an empirical analysis on three European urban regions (Paris/Ile-de-France, Brussels and Zurich).

Reports (project deliverables) and working papers describing in more details the methodological approach are available on the project website www.sustaincity.eu.

1. Introduction

Across Europe, cities face the challenge of reaching a sustainable development, i.e. to maintain economic growth while taking into account environmental and social aspects of a globalized world, in order to improve the quality of life in urban communities.

In the scope of this challenge, the SustainCity research project aims to develop an urban modelling platform for European cities, based on UrbanSim. This platform will be tested in three case studies: Paris, Zurich and Brussels.

The object of this Policy Brief is to highlight why and how land-use/transport (LUTI) models are helpful for policy making. The next section of this Policy Brief is dedicated to the interactions acting in a city and notably the interactions between land-use and transport within a city. Then some topical issues in relation with the future of cities are highlighted, issues which can effectively be analysed with the help of LUTI models. More generally, we review the possible impacts of different policy measures on several economic, social and environmental aspects and show that many of them can be assessed using these models. To illustrate how LUTI models can help in assessing policies (against pre-defined targets) and in building a consistent package of policies, results of former research projects are also presented.

2. Interactions in the urban systems

Cities are systems. By definition, a system is a set of interdependent elements (often called “components”) interacting with each other according to some principles or rules and forming an integrated whole. Roughly, a system is determined by: (i) the nature of its components, (ii) the interactions between these components, (iii) and the boundary between the system and its environment (i.e. the criteria which determine whether an entity belongs to the system or on the contrary makes part of its environment). These few definitions show that “interactions” are at the very core of the city definition. That is why it is crucial to catch things all together, in a systemic way and not on a sector basis (isolating housing, employment, transport, pollution, social segregation, safety, quality of life, etc), when analysing cities, their problems and the potential solutions.

In the LUTI models, land-use and transport are the two main components and the interactions between these components are at the core of the models. This interaction is illustrated in the figure below.

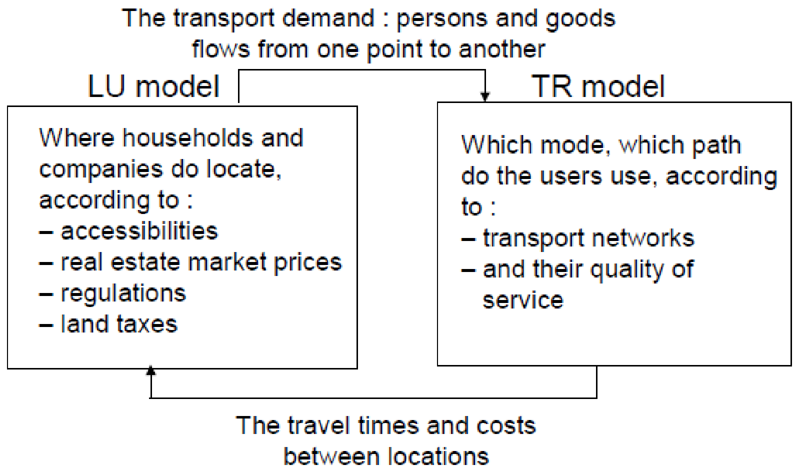


Fig. 1: The basic land-use/transport interaction which is at the core of the land-use/transport models

It is well known that land-use, the spatial separation of human activities, creates the need for travel and influences then transport supply. The reverse impact where transport systems influence location decisions of agents (firms, households, investors) is slightly less known.

As Lautso and Wegener (2007) describe it, trip and location decisions co-determinate each other. These authors summarise the set of relationships between the transport sector and the land use sector through the notion of the "land use transport feedback cycle" represented by the figure below[1].

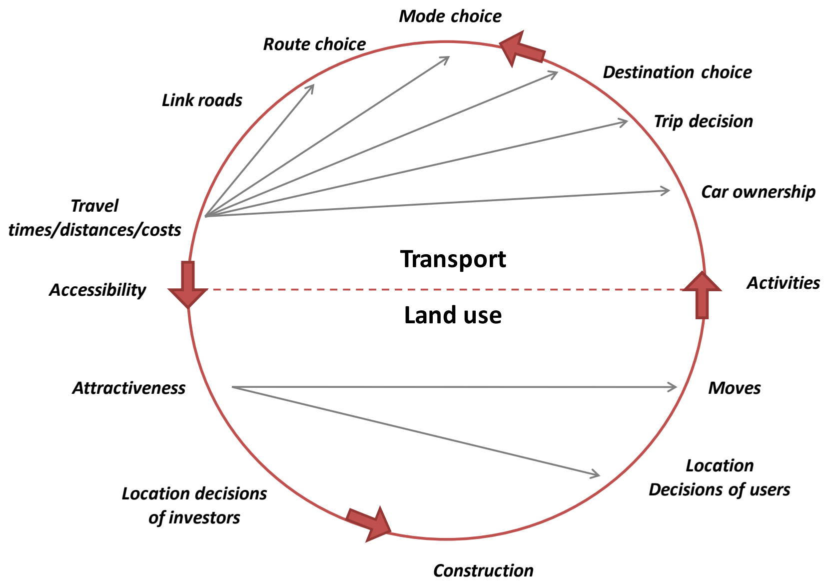


Fig. 2: The land-use transport feedback cycle (source: Lautso, K. and Wegener, M., 2007)

[1] In this scheme, "accessibility" is related to travel time and travel cost (for a given location, the lower these travel time and cost are to/from other places, the higher is the accessibility of the location), while "attractiveness" is related to how much a location is attractive as a location for an activity, e.g. as a residential location or a location for an economic activity. Accessibility is therefore one component of the attractiveness of a location but from far is not the single one.

The feedback cycle can be read as follow:

- residential, industrial or commercial land uses distribution in the urban area determines the locations of human activities
- the distribution of human activities in the area induces trips and creates a demand (and supply) for trips in the transport system to overcome the distance between the locations of activities
- the supply of infrastructure in the transport system creates opportunities for spatial interactions, measured as accessibility.
- the distribution of this accessibility in space influences location decisions and provokes changes of the land use system.

Beyond these particular interactions between land-use and transport, Wegener (2007) emphasises how important it is to have a clear understanding of how urban systems work, with all its interactions and feedbacks, in order to identify which policies are most effective to achieve a given objective: as Wegener says, “understanding these interactions and feedbacks is necessary to assess the secondary and indirect effects of policy measures, which in some cases reinforce the effect expected from a policy measure but sometimes also act as negative, undesirable side effects”.

Wegener has summarised the short-, medium- and long-run interactions between urban change processes in one table, which is resumed here below.

The rows of this table represent causes and the columns represent the effects that occur in urban systems over time. Note that each process can be both cause and effect.

Only the direct effects are explicitly indicated in the table, while there exists also indirect effects which sometimes may be of a larger magnitude than the direct effects. Secondary and indirect effects are not explicitly indicated in the table but they can be easily deduced by following the circular structure of the table, as every effects (column) is also a potential cause (row): e.g. transport supply affects location and travel decisions; existing buildings affect environment and location decisions for further development of buildings; firms and households affect each other and create demand for vehicles purchase, good transport and travel; transport and travel decisions affect the environment; environmental impacts affects location and travel decisions.

As Wegener (2007) points out, these processes may also be ordered by speed of change, from the most permanent ones, changing very slowly and having a lifetime of several decades to the most versatile ones susceptible to change very rapidly, for example every few years or even daily. From that perspective, the ordering is the following one:

(i) transport networks
(ii) buildings
(iii) agents, such as firms, households and individuals (whose needs change through events, such as growth or decline or birth, marriage or death)
(iv) location decision of the firms, workers and households
(v) transport decisions
(vi) environmental impacts which can be very rapid, but for some of them, can have long-term irreversible consequences.

		...causes change of...																				
		Net-work		Buildings				Agents			Location					Trans-port			Environ-ment			
Change of...		Road network	Public transport	Industrial buildings	Retail buildings	Office buildings	Housing	Firm lifecycles	Household lifecycles	Person lifecycles	Industrial location	Retail location	Office location	Labour mobility	Housing mobility	Vehicles	Freight transport	Travel	Energy, CO2	Air quality	Noise	Land
Net-work	Road network										Medium	Medium	Medium			Fast	Fast	Fast	Fast	Fast	Fast	Fast
	Public transport															Fast		Fast	Fast	Fast	Fast	
Buildings	Industrial buildings										Medium					Fast	Fast	Fast	Fast	Fast	Fast	Fast
	Retail buildings											Medium				Fast	Fast	Fast	Fast	Fast		Fast
	Office buildings												Medium			Fast	Fast	Fast	Fast	Fast		Fast
	Housing											Medium	Medium	Medium	Medium	Fast	Fast	Fast	Fast	Fast		Fast
Agents	Firm lifecycles								Medium	Medium	Medium	Medium	Medium	Medium		Fast	Fast					
	Household lifecycles						Slow			Medium					Medium	Fast		Fast				
	Person lifecycles						Slow		Medium						Medium	Fast		Fast				
Location	Industrial location			Slow									Medium	Medium	Medium							
	Retail location				Slow								Medium	Medium	Medium							
	Office location					Slow								Medium	Medium							
	Labour mobility															Fast		Fast				
	Housing mobility						Slow					Medium	Medium	Medium		Fast		Fast				
Trans-port	Vehicles	Slow															Fast	Fast				
	Freight transport	Slow									Medium	Medium				Fast		Fast	Fast	Fast	Fast	
	Travel	Slow	Slow										Medium	Medium	Medium	Fast			Fast	Fast	Fast	
Environ-ment	Energy, CO2										Medium	Medium	Medium	Medium	Medium							
	Air quality											Medium	Medium		Medium							
	Noise											Medium	Medium		Medium							
	Land														Medium							

● *Fast impact* ● *Medium-speed impact* ● *Slow impact*

Tab. 1: Interactions between urban change processes (source: Wegener, 2007)

Let's take another example: the improvement of the accessibility of a given area, thanks to a new important transport infrastructure, may lead to a change in household and firm location trends (increase of the demand), which in turn induces an increase of the land floor and real-estate prices in that area, which in turn may induce a process of social segregation (example: the "gentrification" process in previously popular districts).

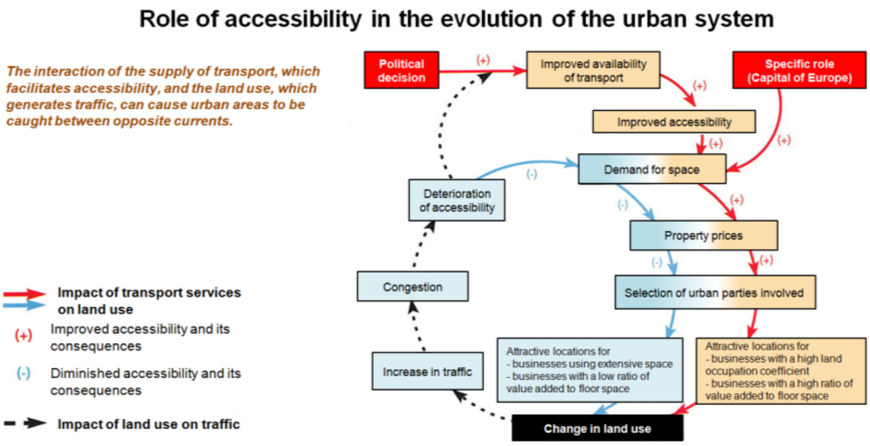


Fig. 3 : Interactions between transport system, land/floor rents, choice locations and segregation of households and firms – Scheme drawn from the 1st Transport Master Plan of the Brussels-Capital Region (1993)

Land-use/transport models attempts to take into account as many as possible of these interactions and processes (with the right speed of change) and some of the particular objectives of the SustainCity project is precisely to integrate some further interactions and processes in UrbanSim, such as the demographic processes, the creation and disappearing of firms (further to the creation and disappearing of jobs, which is classically already taken into account in these models) and the decision-making processes within households with two active members, with regard to the household location choice.

Eventually, simply listening to what people (planners, authorities, experts) say provides another illustration of the many interactions in play in urban systems: it is quite impossible to describe an urban phenomenon with restricting to only one or two sectors. The figure below is drawn from the SCATTER research project (2002-2004) funded by the European Commission and dedicated to urban sprawl and transport. The figure is a “concept map” drawn from the interviews of 24 local authorities and experts on the subject “urban sprawl”. The map was set up on the basis of a textual analysis of their interviews and highlights all the interactions and the many various concepts which are in play in their perception, understanding, diagnosis of the phenomenon of urban sprawl, and its positive and negative aspects.

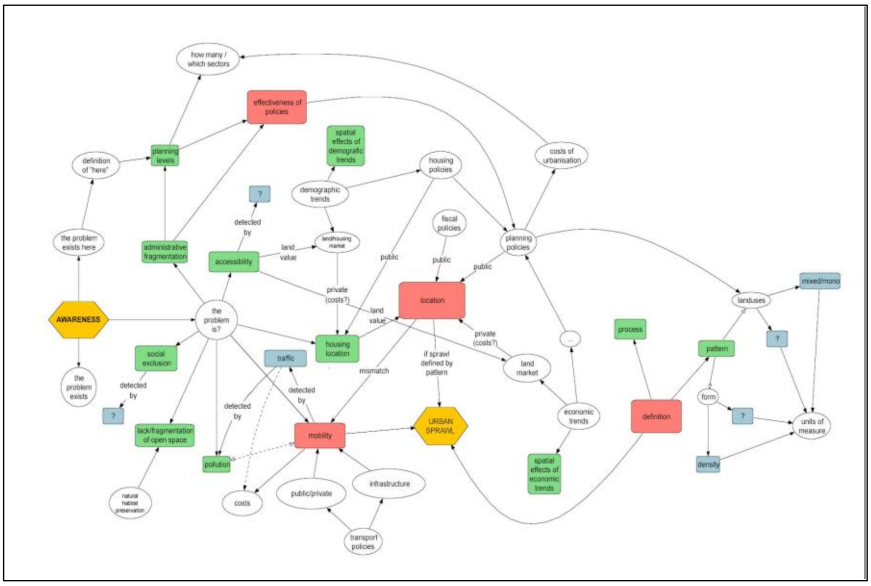


Fig. 4 : "Concept map" of the urban sprawl, set up on basis of the interviews of 24 local authorities and experts on urban sprawl and a text-analysis of their interviews (source: SCATTER project, 2002-2004)

3. Policies

The use of integrated land-use/transport models allows to study the impacts of policy measures and to better evaluate the trade-offs between objectives. The table below is an attempt to set up relationships between urban policies and urban problems to be solved. It was set up by M. Wegener (2007) and roughly summarises which policies are relevant for each urban problem. It is based on the results of a set of European research projects all dealing with urban modelling and planning (the Land Use and Transport Research (LUTI) cluster, 2006-2007).

In this table, the points indicate that there is a strong or weak impact of a policy on a problem. The impacts indicated may be positive or negative (sometimes it depends on the fact that one considers short-term or long-term impacts: for example, increasing traffic capacity reduces congestion in the short run but also induces more traffic in the long run). However, for most of the policies of the table, the impact is generally positive with respect to urban sustainability.

Wegener stresses that only direct impacts are shown in this table: "If a policy impacts on one problem in this table, it can be expected that it will produce indirect desirable or undesirable side effects" as indicated in the Table 1 above.

Policies/measures...		...have impacts on problems																		
		Environmental							Social					Economic						
		Air pollution	Noise	Land	GHG	Visual impact	Cultrual heritage	Health	Access	Social exclusion	Mobility handicaps	Equity	Health impacts	Congestion	Accidents	Financial barriers	Economic activity	External costs	Equity	Health impacts
Land use planning	Settlement planning	W	S	S	W	W	W		W	W		S		W				S	S	
	Settlement size/containment	W	S	S	W	S	W		W	W		S		W				S	S	
	Concentration/densification	W	S	S	W	W			W					W				S	S	
	Urban structure	W	S	S	W	W	W		S	W				W			W	S	S	
	Location by accessibility	W	S	W	W				W	W		W		W			W	W	W	
	PT-oriented development	W	S	W	W			W	W	S		W	W	S			W	W	W	W
	Car-free development	W	S	W	W	W	W	W	S					W	W			S	W	
	Urban design	W	W	W	W	S	S				S			W	S					
Infrastructure provision	Motorways	S	S	S	S	W		S	S				W	S	W			S		W
	Local roads	S	S	S	S			S	S				W	S	W			S		
	Walkways	W	W		W	W	W	W	W	W	W	W	W	W	W					
	Cycling lanes	W	W		W			W	W	W			W	W	W					
	Public transport	S	W	S	S				S	W	W	W		W	W			W	W	
	Freight infrastructure	S	S	S	S				W					S	W		W			
	Parking	W	W	W					W					W						
Infrastructure management	Better public transport	S	W		S	W	W	W	S	S	W	W	W	S	W		W	S	W	W
	Park and ride	S	W		S		W	W	W	W	W	W	W	W	W			W	W	W
	Parking management	W	W		W		W	W		W	W	W	W	W	W			W	W	W
	Road space management					S	S	W	S	W	W	S	W	S	S			W	S	W
	Traffic control systems	W	W		W				W					S	W					
Public transport	New infrastructure	W	W	S	W	S		W	S	W	W	W	W	W	S	W		W	W	W
	Better service	W	W	S	W	S		W	S	W	W	W	W	W	S	W		W	W	W
	Fares								S			W				W			W	
	Travel information								W											
	Mixed-mode travel				W				W					W						
Travel demand management	Marketing	W	W		W				W		W	W			W					
	Company travel plans	W	W		W									W	W					
	Ride sharing	W	W		W									W	W					
	Car sharing	W	W			W														
	Flexible work hours	W	W		W									W	W					
	Teleworking	W	W		W									W	W					
	Teleshopping	W	W		W									W	W					
Information	Radio/TV-based services													W						
	Internet-based services													W						
	PT passenger information								S	W										
	Navigation systems								W					W	W					
	Mobility centres								S	W	W	W			S	W	W			
Pricing	Fuel taxes	S	S	S	S			W	W	W		W	W	S	S	S		S		W
	Car taxes	S	S	S	S			W	W	W		W	W	S	S	S		S		W
	Road pricing, motorways	W	W	W	W									W	W			S		
	Road pricing, all roads	S	S	S	S			W	W	W		W	W	S	S			S		W
	Parking charges	W	W	W	W	W	W		S	W				W	W			S		
	Rail network charges				W									W				W		
	Public transport fares				W				W	W				W				S		

S • *Strong impact*   W • *Weak impact*

(to be continued)

Policies/measures…		…have impacts on problems																		
		Environmental							Social					Economic						
		Air pollution	Noise	Land	GHG	Visual impact	Cultrual heritage	Health	Access	Social exclusion	Mobility handicaps	Equity	Health impacts	Congestion	Accidents	Financial barriers	Economic activity	External costs	Equity	Health impacts
Walking Cycling	Walkways	W	W		W	W	W	W	W	W	W	W	W	W	W					W
	Pedestrianisation					W			W	W	W				W		W			
	Safe crossings										W				W					
	Cycling lanes	W	W		W			W	W	W			W	W	W					W
	Bicycle service stations								W											
Urban freight transport	Access constraints	W	W			W	W		W					W	W			W		
	Loading zones								W					S				W		
	Freight terminals	W	W		W	W			S					W				W		
	City logistics	W	W		W	W	W		W					W				W		
	Parcel delivery points								W					W						
Vehicle technology	Cleaner cars	S			S			W					W					S		W
	More energy-efficient cars	S			S			W					W					S		W
	Safer cars														S					
	Hybrid cars	S			S			W					W					W		W
	Natural gas vehicles	W						W					W					W		W
	Alternative fuels																	W		
Innovative modes	Personal rapid transit	W	W		W	W	W		S	W	W	W		S	S			W	W	
	Ultra-light rapid transit	W	W		W	W	W		S	W	W	W		S	S			W	W	
	Cybercars	W	W		W					W	S			S	S			W		
	Co-operative highway	W	W	S	W					W	S			S	S			W		
Integrated strategies	Infrastructure	S	S	W	S	W	W	W	S	W	W	W	W	S	W		W	W	W	W
	Infrastructure and pricing	S	S	W	S	W	W	W	S	W	W	W	W	S	W		W	S	W	W
	Infrastructure and land use	S	S	S	S	W	W	W	S	W	W	W	W	S	W		W	W	W	W
	Pricing and land use	S	S	S	S	W	W	W	S	W	W	W	W	S	W					
	Infrastructure and TDM	S	S	W	S	W	W	W	S	S	S	S	W	S	W					
	TDM and information	W	W	W	W	W	W	W	S	S	S	S	W	S	S					
	Integrated programmes	S	S	W	S	W	W	W	S	W	W	W	W	S	W		W	W	W	W

• *Strong impact* • *Weak impact*

Tab. 2 : Impacts of policies on problems – table set up from a meta-analysis of European research projects dedicated to land-use and transport planning (source: Wegener, 2007)

To sum up, there is a wide range of land use and transport policies that can be applied to achieve sustainable urban development. At first glance on the table, it can be seen that playing on pricing, land use planning, infrastructure provision and management, vehicle technology and eventually integrated strategies, stand out as the most effective measures to improve urban sustainability, as they have strong impacts on problems. In general, research projects showed that transport policies are more effective in the short to medium term; however, land use policies that act on the long run are essential for achieving a settlement structure that is not too dispersed as a prerequisite for less car-dependent cities.

Most of the policies mentioned above can be simulated by land-use/transport models and, once again, these relatively complex models are needed to catch all the complexity of these processes and interactions.

4. Topical urban issues

In this section, we present a few topical issues for the future of European cities for which land-use/transport models can help designing sensible and efficient policies.

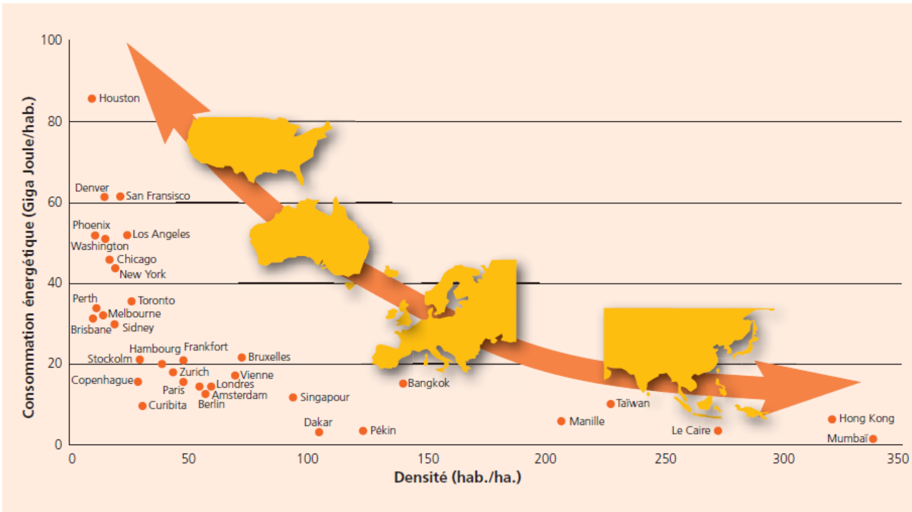
4.1 More or less sustainable spatial patterns: urban sprawl, densification, polycentrism, etc

A first topical issue is the question of the urban sprawl versus the densification of the urban/suburban areas. There is some consensus on the fact that a very scattered spatial pattern has more disadvantages than advantages and roughly is not a sustainable development pattern, but the consensus is not complete, what shows that research is still needed on this topic[2]. Among the positive effects of urban sprawl, one can mention: access to cheaper private residential developments: middle-class households have the possibility to become owners of single family housing, with enhanced personal and public open space ; access to cheaper private non-residential developments : young and/or small companies have more pleasant work environment than what they could have afforded in the urban centre. The usually admitted negative effects of urban sprawl are: consumption of land, loss of high quality agricultural land and open space ; destruction of biotopes and fragmentation of eco-systems ; higher costs of the new neighbourhood infrastructures ; higher costs of public services and especially transport services ; land use patterns which are unfavourable to the development of collective and other sustainable transport modes ; hence, increase of the level of use of private car ; increased trip lengths ; congestion on the radial roads giving access to the urban centres ; increase in fuel consumption ; increase in air pollution ; sometimes, contribution to the decay of downtown areas ; poor access to services for those with limited mobility such as the young and elderly.

There also exists a well known relation between energy consumption and density. This relation has been often illustrated in graphs like the one below; this one focuses on cities.

[2] On the costs and benefits of urban sprawl, see “Transport, urban form and economic growth”, Round Table 137, OECD, European Conference of Ministers of Transport, 2007.

Consommation énergétique et densité urbaine



Source : SYSTRA d'après UITP Millenium Cities Database. 2001

Fig. 5 : Energy consumption in cities (in Gigajoule/hab.) as a function of the urban density (in hab./hectare) (source: CERTU – Note de synthèse "Mobilités et transports", Fiche n°1, January 2008)

On the other side, some experts argue that densification of (already dense) agglomerations, cities even more compact than today, may raise more new problems than solve existing ones, for example in terms of road congestion and time losses.

Somewhere in-between these two extreme spatial patterns, there are intermediate approaches, such as polycentric regional systems and "concentrated de-centralisation (i.e decentralisation towards a few secondary centres instead of scattered uncoordinated extension of the city). Several European cities, for example, currently test the concept of "rail-oriented urban planning", as it is promoted by the French-German projects Bahn-ville and Bahn-ville2. The objectives of Bahn-ville (2001-2005) and Bahn-ville2 (2007-2010) were to study, experiment and promote urban planning practices aimed to "rail-oriented urban planning" and also to promote a better integration of urban planning and regional rail transport policy. The Bahn-ville approach involves residential location (housing) and economic activities (firms). Twenty years ago already, this concept existed, under a slightly different form invented by the Dutch urban planners. It is called the "ABC policy" and focuses on economic activities: the idea was to locate the "right activity" at the "right place", i.e. to match the mobility profile of the economic activities (what are their mobility needs?) with the accessibility profile of the locations (which accessibility do they offer?): activities type A should locate in locations type A, etc ... In this classification, type A activities are large offices, with many employees (tertiary sector, administrations), and type A locations are districts with a regional-scale or even national-scale railway station (with high level of service). This approach has been applied in The Netherlands and in the Regional Master Plan of the Brussels-Capital Region.

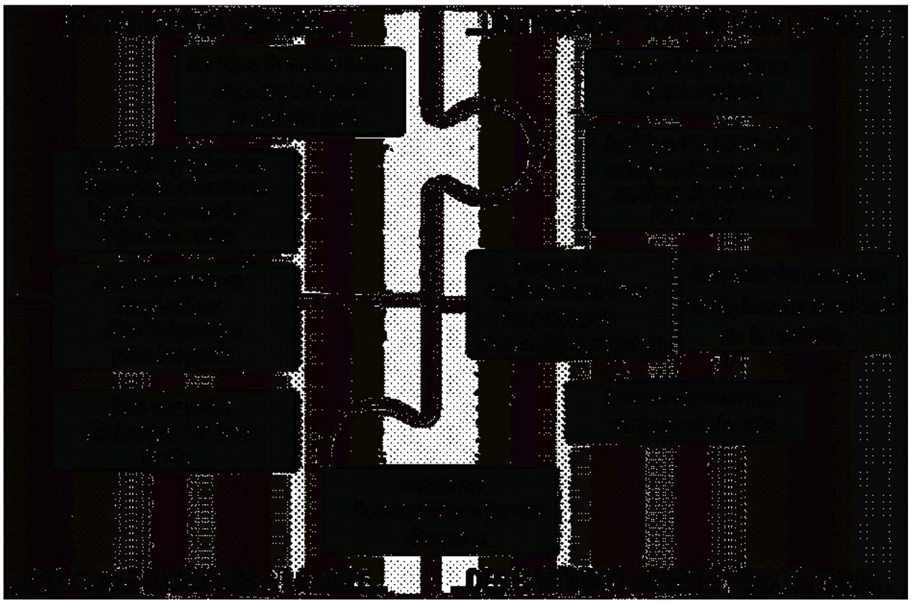


Fig. 6: Main principles of a "rail-oriented" urban planning, as it is promoted by the Bahn-ville project (source: www.bahn-ville2.fr, 2007-2010)

The socio-economic costs of a scattered pattern versus a more concentrated pattern are significant. For example, in the socio-economic evaluation study of the Grand Paris project (public transport project: orbital automatic metro in and around Paris, to be implemented progressively from 2018 to 2030), two scenarios were compared: (i) a reference scenario with implementation of the PT project, *without* accompanying land use measure (population and employment tend to sprawl in the periphery of Paris), (ii) a scenario with implementation of the PT project *combined* with land-use measures which would limit the urban sprawl and on the contrary would concentrate the population growth around the new Grand Paris PT stations. The supplementary socio-economic costs in scenario (i) compared to the scenario (ii) were estimated to 1,43 billion € (value of the development of building sites, on currently un-built space – one shot cost), plus 156 million €/year (value of the rural open space and public services exploitation costs) (source : Etude d'évaluation socio-économique dans le cadre de la préparation du débat public sur le Grand Paris, Société du Grand Paris, STRATEC/SETEC, 2010)[3].

It is therefore very important to properly assess the impacts of policies in this field and the socio-economic cost of alternative scenarios. Land-use/transport models can bring a fundamental contribution in this matter.

[3] These values were obtained from classical socio-economic calculations, without the help of a land-use/transport model. There are therefore estimates not taking into account the interactions between land-use, transport, housing systems, employer location decision, real-estate prices, etc.

Indeed, these different options in terms of spatial patterns (more or less scattered structure, densification, polycentrism) can be tested with a land-use/transport model, for example by simulating regulations, land taxes or development projects. And the performances of the various options may be compared, on many different aspects (land consumption, car mileage, greenhouse gas and pollutant emissions, relocation of firms and access to jobs, social segregation, etc), hence covering as much as possible the three dimensions of sustainability: social, economic, environmental.

4.2 Investments in public transport systems, road pricing

In many European large cities, the public transport system is near to saturation, because of an increase of the PT market share in the last decade. This increase of the PT market share is conjointly due to the measures reducing the road capacity in the cities, the car use pricing by means of the parking fares, the increase of the fuel cost, the decrease of the average income consequently to the successive economic crises, and the increase of the sensitiveness to ecological concerns among the population. In certain cases, this is also due to an accentuated social segregation between large cities and the rest of the country: in these cities, the part of low-income people increase, which contributes to the increase of the PT market share.

In these large cities, investments in the public transport systems are therefore needed.

Investments are also needed around the large cities, to meet the need of the so-called "tangential" mobility, i.e. the trips from suburban areas to suburban areas. This tangential demand has significantly increased in the last decade, due to the growth of the suburban areas, both in terms of population and of economic activities.

Faced to these investment needs, PT infrastructure managers, regional and national authorities in charge of the transport systems generally lack financial resources.

On the road side, many cities are envisaging urban road pricing, to reduce congestion and, more generally, to internalise the external costs (including the environmental cost and the cost of time lost in congestion) of the car users. Whatever it is designed to reduce congestion or, more comprehensively, to apply the "polluter-pays" principle (internalisation of the external costs), urban road pricing offers better travel times to car users with high value of time (who will afford the pricing) and in the same time bring revenues, resources which can be used in PT investments (mutualisation of the revenues and costs of public transport and road).

Eventually, all these types of transport policies (large new public transport investments, urban road pricing) will definitively have impacts on the spatial pattern, which on turn will influence the location of the transport demand (where people are and where they want to go). These policies need therefore to be tested with a land-use/transport model taking into account all the main effects and side-effects in their assessment. Again, the tests may provide all kind of indicators: transport indicators (mode market shares, car mileage), environmental indicators (emissions, noise), social indicators (travel time losses), land use indicators (relocation of households and firms due to the new pattern of accessibilities).

5. Land-use/transport models

To summarise the advantages of land-use/transport models:

- they allow to simulate the complex socio-economic system of a city ;
- they allow to take into account a series of interactions and feedback loops that cannot be taken into account by simpler models ;
- as they take into account the location changes, the indicators and elasticities they provide are long-term indicators/elasticities ; the estimated impacts are long-term impacts (while classical four-steps models for example provide short-term or medium-term impacts) ;
- they provide indicators related to all the three dimensions of sustainability (social, economic, environmental) and hence allow a comprehensive assessment of the policies ;
- as a simulation tool, they allow to assess not only one single policy but also to assess and compare packages of policies (e.g. packages where the impacts of each single policy compensate each off or reinforce each other) ;
- to go one step further than the simple calculation of a set of indicators: land-use/transport models can be coupled with socio-economic assessment methods, like a multi-criteria analysis, a cost-benefit analysis or a social welfare function (as it will be the case in SustainCity). Multi-criteria analysis and cost-benefit analysis allow to take into account the cost of implementation of each tested policy, together with its positive and negative impacts. The social welfare function is also an unifying evaluation framework and, as method chosen in SustainCity, is further developed in another section below.

Several integrated land use/transport models, with significant variations among them with respect to overall structure, theoretical foundations, modelling techniques, data requirements, model calibration according to the interest of the project, are used today (Hunt et al., 2005, Lausto & Wegener, 2007). Furthermore these models benefit from constant improvement through research projects.

In the SustainCity project, we start from the integrated model "UrbanSim" developed by a research team led by Paul Waddell at the centre for urban Simulation and Policy Analysis of University of Washington. This model will be improved and developed for three European towns becoming "UrbanSimE".

UrbanSimE simulates the behaviour of each of the agents of an urban system (Brussels, Paris and Zurich) through a series of submodels with feedback mechanisms between them. The overall process modelled by UrbanSimE is summarised in the diagram below; the most important components intervening in this process are the following:

- Demographic and Economic Transition models: predict new households and jobs migrating into the region, or the loss of households or jobs emigrating from the region. This includes the formation of new households and jobs.
- Household and Employment Relocation models: predict households and jobs leaving their current location and looking for a new location within the city.
- Household and Employment Location Choice models: predict the location choices of new and relocating households and jobs.
- Land Price model: predicts land prices for each location in the city as a function of its attributes.
- Real Estate Development model predicts new development projects needed to satisfy market demand.
- Real Estate Development Location Choice model: predicts the location of the new real estate developments within the parcels or zones of a city.
- Accessibility model: links the land use model with the transport model by calculating the accessibility conditions for each location in the city. UrbanSim does not include an integrated transport model, but is able to interact with any external transport model.

In each simulation period (usually a year), new and relocating households and jobs look for new locations within the vacant housing units or buildings. Simultaneously, land prices are adjusted and new developments are built in different locations.

In a parallel process, the transport model takes the output of UrbanSim (located households and firms) and simulates traffic conditions. The output of the transport model (travel times, congestion levels, etc) re-enters UrbanSim as variables that affect location choice. The interaction between UrbanSim and the transport model is done in an iterative fashion, usually running a simulation of each model for each simulation period.

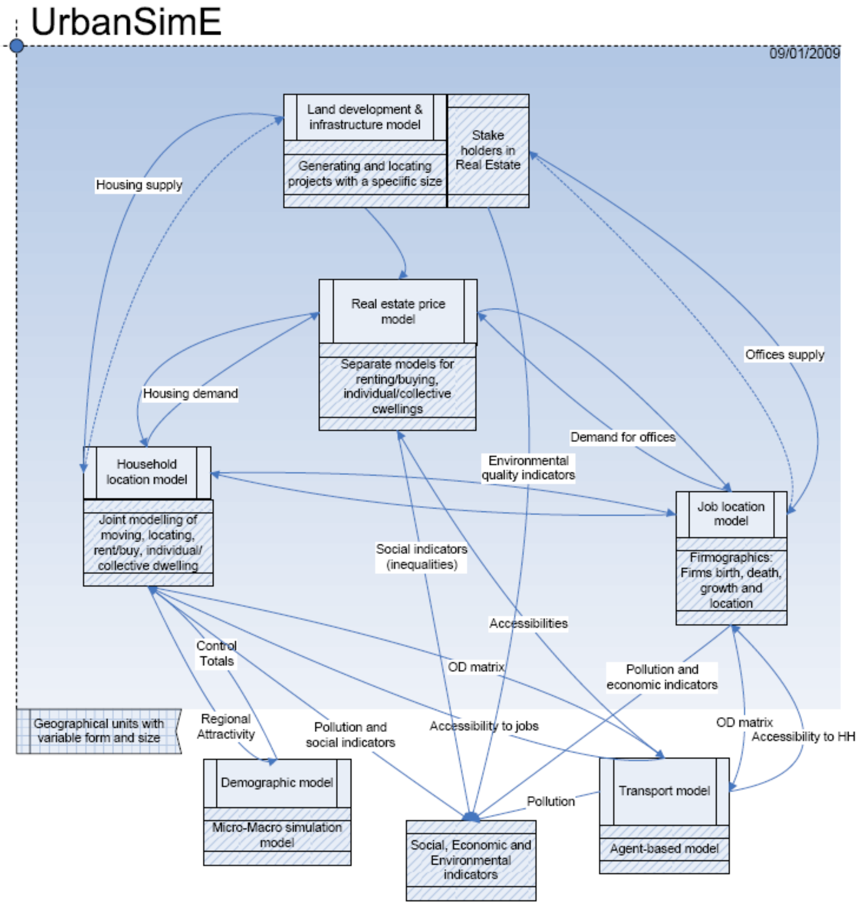


Fig. 7: Scheme of the UrbanSim-E model (source : SustainCity)

The multiple submodels of UrbanSim will allow to evaluate the impacts of policies in various fields.

The policies tested will belong to two policy families: urban road pricing and land use regulations aiming to a densification.

6. A key contribution of SustainCity: coupling a land-use/transport model with a social welfare function

For anyone who has the ambition to design a sustainable city, the first step is to define what is meant by urban sustainability and what could be the appropriate way to measure sustainability.

It is well known that, by definition, sustainability covers three dimensions: social, environmental, and economic, but just producing a long set of indicators to assess policies is not sufficient. Assessing policies also involves trade-offs among social ecological and economic objectives. For a proper assessment it is useful to include all relevant aspects and indicators in a single unified framework (including the cost of implementation of the policies, which is sometimes neglected in the policy assessment). These issues (definition of sustainability and unified evaluation framework) will be dealt with in depth in SustainCity. The evaluation framework is not embedded in the land-use/transport model but we mention it here, because it is closely related with the object of this note.

Starting from the definition of urban sustainability (in practice: “A sustainable city is a city where I like to live, and where I know my grandchildren would like to live, and that does not decrease quality of life on the rest of the planet”, (Proost & Van der Loo, 2011), SustainCity will propose, as an approach to provide an unifying and integrated evaluation framework, to couple the outcomes of the land-use/transport model with a Social Welfare function. Such a social welfare function allows for trade-offs between different kinds of stocks and equity can be taken into account by weighting income classes differently.

The social welfare function is a (discounted) weighted sum of various components, representing the impacts of the policies on various groups, for example: the residents of the study area, the commuters, the rest of the world, the future generations. The welfare (or “utility”) of each group can be weighted differently, according to the objectives and criteria of the policy evaluator.

Further to the social welfare function, other sustainability indicators will also be computed. The ambition is to put more consistency in the evaluation of “policy sustainability”. The computations will be applied to the three case cities, Paris, Zürich and Brussels (Proost & Van der Loo, 2010).

7. Examples of outcomes of LUTI models

Preliminary remarks
The examples from the Paris, Zürich and Brussels case studies of the SustainCity project are only short examples illustrating how LUTI models can help in planning and decision-making. The full results are described in technical reports and in the final project report.
Beside examples from the Paris, Zürich and Brussels case studies, we also shortly describe examples of results from two older research projects, to more broadly illustrate the types of outcomes of LUTI models.

7.1. Application of UrbanSim on Greater Paris region

The studies applying UrbanSim on Greater Paris region began in 2004 by SimAURIF project (dePalma et al., 2004 and de Palma et al., 2007b), performed bythe University of Cergy-Pontoiseand the Institute of Development and Urbanism of Ile-de-France region. This project provided the opportunity to explore available data, and to estimate different models under the double constraint to use only these data and tools already available in UrbanSim at that time (see de Palma et al, 2007a). The first simulation experimentswere focused on a small improvement in the Public Transport Network, namely the Northern Ring Rail Link of Paris area. This project made it clear that it is necessaryto adapt the model to European context, because of important differences between European and American cities from various points of view, like Urban form (complexity and history), real-estate market structure and data availability, and induced improvements in UrbanSim.

A new version of UrbanSim, better adapted to the European context, has been recently applied in socio-economic evaluations of Grand Paris project. This large project includes 200 km of new automatic metro lines and more than 100 new stations connecting several radial lines in the city suburbs and connecting several cities to the already existing rail network. This represents a 30 billion Euros investment over a period of 20 years. It is associated to some urban policies to boosta dozen of specialized activities poles all over the region. The objective is to make these poles secondary centers, and to improve the competitiveness of the region with respect to other important metropolis like London or Singapore.

Several scenarios were simulated: a reference scenario and two scenarios corresponding, respectively, to the upper and lower assumptions for the regional attractiveness. The simulations are mainly performed for the period of 1999 to 2035. Extensions up to 2050, focused on long run relocation effects,assume constant population and employment after 2035. The simulation results confirm most of the project objectives, and show that there will be an important gain of attractiveness for the central area of the region. The secondary centers will prevent urban sprawl without worsening market tensions in land use and real-estate markets in central Paris.

Additional results on agglomeration effects, social mix, welfare and equity,computed from UrbanSim results, add to the benefit of the Grand Paris project.

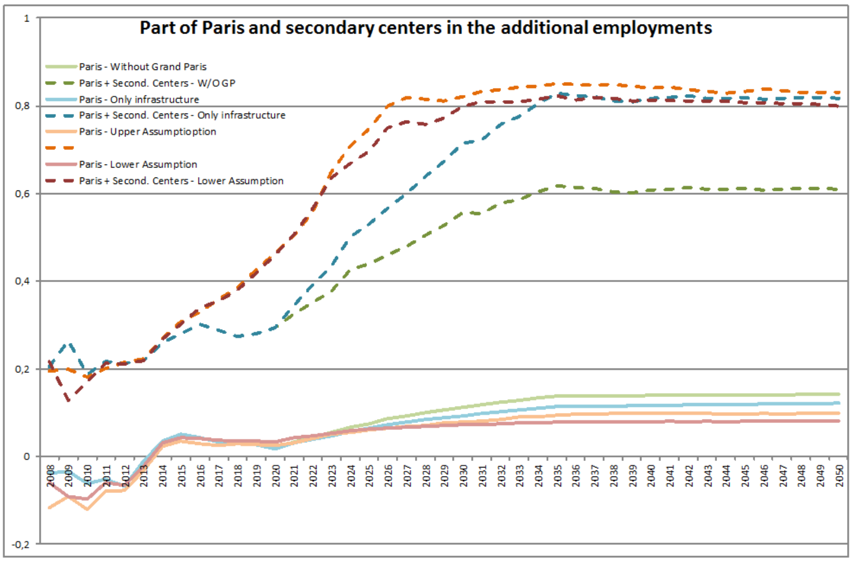


Figure 8. Part of Paris and secondary centers in the additional employments (Picard and Motamedi, 2012)

7.2. Application of UrbanSim on Zürich

This case study implements a micro-simulation land use transport interaction (LUTI) model in the Canton of Zurich, Switzerland. The study area is 1'729 square kilometres large and has 1.4 million inhabitants. The two major cities are Zurich and Winterthur. Zurich is the main economic centre and is home to global financial and insurance service providers.

A previous study in the same perimeter tested the feasibility of implementing a land use simulation for the purpose of spatial planning (Löchl et al., 2007). A gird cell version of UrbanSim (Waddell, 2002) was implemented in combination with the cantonal transport model. The study demonstrated the potential of a LUTI model and that the necessary data is available for the perimeter.

Continuing political debates on spatial development show the need for planning support tools. Motivated by the successful application of the national transport model, the Federal Office for Spatial Development confirmed its interest in a tool for quantitative assessments of spatial planning regulations and infrastructure investments. (Lezzi, 2013; Zöllig et al., 2011). Main challenges stated to which LUTI models shall be applied are the assessment of spatial planning regulation and infrastructure projects. The goal is to achieve sustainable development under expected population growth by containing urban sprawl, maintaining descent transport services and land prices.

The SustainCity project was the opportunity to develop a more consistent and detailed implementation. The main achievements in terms of model development are described in the following.
The degree of detail is increased in three important aspects. Firstly, we use the more advanced version of UrbanSim which allows to use parcels as primary spatial units. This allows to use the highly accurate data of the castrate to which spatial planning regulations apply. Secondly, we detailed the data structure of UrbanSim by introducing living units as separate entities which are chosen by households in the location choice model. An addition survey researches location choice behaviour of households (Schirmer et al., 2011). This novel degree of detail improves the household location choice model substantially. The raised requirements for data preparation where tackled by using geo-database and GIS techniques. Thirdly, we use MATSim (Balmer et al., 2008) as transport model which is an activity based micro-simulation. This allows to calculate accessibilities on the level of parcels.

The evolution of the population is micro-simulated as well. We apply the simulation software provided by INED (Turci et al., 2012) which results in persons and households for each year of the land use transport simulation. These persons and households are fed directly to the land use and transport simulations. The consistent usage of the same persons required further models in UrbanSim to update car ownership and income.

To analyse the results various indicators are calculated. Most indicators are specified and calculated in UrbanSim. A few were calculated in SQL to make use of GIS functionalities. Scripts have been written to visualise the indicators as maps and plots.
Four scenarios were simulated after having set up all necessary

models. The simulations start in 2000 and end in 2030. The first scenario is the reference scenario assuming business as usual. The second scenario assumes a cordon road pricing regime for the city of Zurich. Each agent travelling on the road to the city centre has to pay 5 Euros. The measure is introduced in 2015. The third scenario assumes higher allowed densities for real estate construction in central areas (densification zones). This scenario shows the effects of densification policies to contain urban sprawl. The fourth scenario combines the road pricing policy with the densification policy. It demonstrates the capability of the simulation system to assess policy packages.

Illustration shows the main effect of the road pricing assumption. Since car travel gets more expensive, the agents switch to public transport which we see in the decreasing car share. Note that the transport simulation is executed every five years. There is no stronger decrease before 2015. The line is misleading in this respect. The effect is highest for cordon crossing traffic which is depicted in Figure 9. Consequently, we see as well a reduction in car travel time and distance travelled by car. The trend towards public transport in the baseline and densification scenario can be explained by increasing congestion on the road network due to population growth.

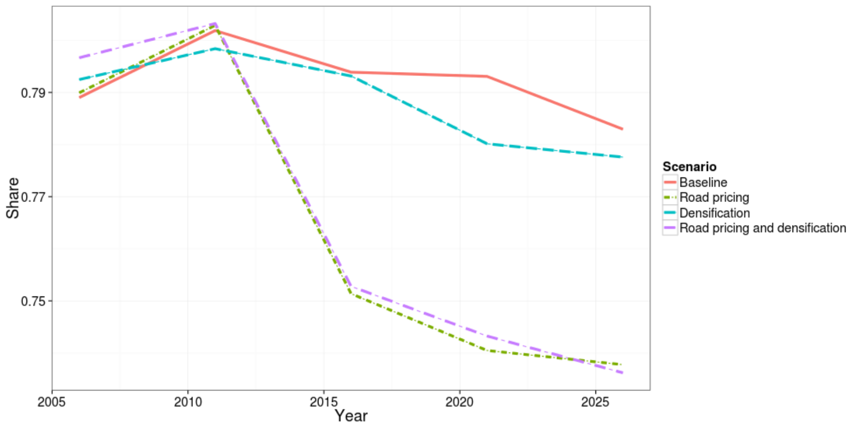


Figure 9. Effect of road pricing on car share in cordon crossing traffic

The increased capacity for additional construction of buildings introduced in 2015 leads to more buildings built in densification zones (Figure 10). Households follow this new opportunities and locate increasingly in the designated zones.

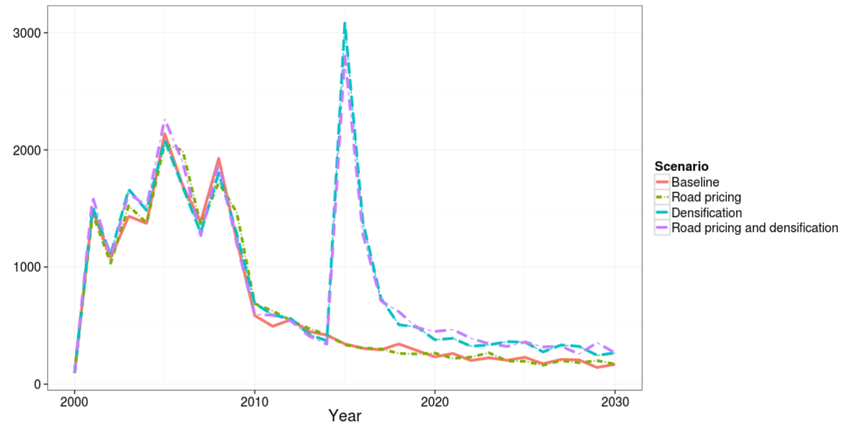


Figure 10. Number of newly created buildings in densification zones

In Table 3 the main indicators are listed to show the effects of the scenario assumptions in 2030 of the simulation. The upper part contains the effects on the transport side whereas the lower part contains the effects on the land use side.

Main indicators regarding transport are travel time, travelled distance and mode share. For the whole perimeter we see an increase of travel time compared to the baseline in all scenarios. In case of road pricing travel time increase is highest. One reason is that public transport generally has longer travel times for a given relation. In the densification scenario travel time increases only marginally. Travelled distance by car is reduced in all scenarios while the effect is strongest with the combination of road pricing and densification. Some of the reduction is due to mode choice but it cannot be clearly distinguished from the effect of relocating households and jobs with the current analysis. Car share decreases stronger than distance travelled by car in scenarios with road pricing which implies that short trips are given up disproportionally. As well travel time by car is reduced in all scenarios, partly due to mode share shift and partly due to closer relations.

Tailoring the analysis to the scenarios, we also list the main indicators for traffic related to directly affected areas, here namely the city of Zurich and the densification zones. The numbers specific to cordon crossing traffic show higher sensitivity towards the road pricing assumption. This is reasonable. The deviations in the road pricing scenario are the result of relocation processes and randomness.

The increasing travel times of inhabitants to densification zones are striking in all scenarios. The numbers of the road pricing scenario show that the increase is not due to more inhabitants. The increase is due to adapted mode choice and more congestion. In case of scenarios with densification the effect originates largely in the concentration of households and jobs in densification zone which leads to more congestion.

In respect of land use we are only looking at the spatial

distribution of households and jobs because the total number of persons and households is given by the demographic model which is calibrated such that the trend of population growth is extended. Household avoid residing inside the cordon area (-0.7%) which is also a consequence of fewer living units provided (-0.6%). Jobs on the other hand are attracted to Zurich (+4.9%).
Allowing for higher densities of built space offers more opportunities for households to locate in these zones. An example is the increase of 0.9% in living units in Zurich which is also a densification zone. The households are using these opportunities. In Zurich the number of households is 1% higher than in the baseline. An even stronger increase can be noted for all densification zones (+18.3%).

Applying road pricing and densification leads to an almost balanced effect in respect of households and living units (-0.1% each) in Zurich where both measures are effective. The attraction of jobs to Zurich by road pricing is diminished by the densification measure.

Variable	Road pricing	Densification	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

Tab. 3: Deviation from baseline of main indicators

Despite the considerable achievements there are still a lot of challenges remaining. In terms of usability it is a drawback that three simulation software packages are used. A unified platform would lower the efforts to familiarise with the system. The individual sub-models as well as the calibration of the composite model can be improved. The segmentation of the real estate market is not satisfying yet. Separate price models would have to be estimated. Job distribution in space is simulated as location choice of single jobs. A more similar implantation like in case of households is desirable. Rather than jobs we should model firms which get created, relocate (with all associated jobs) and disappear again. The transportation model simulates only commuting trips. Including further trip purposes such as leisure activities or shopping would make the simulation more realistic. The decision on making a trip at all should be included as well. Also public transport simulation can be improved.

Behavioural models estimated on survey data are often difficult to integrate fully into the simulation system because the necessary data is not available for the whole population. A solution is to enrich the available data with synthetic data created with intelligent imputation algorithms. In any case, it is beneficial to simulation systems if data sources are harmonised and easily available via data warehouses.

The baseline definition should include all projects of which is known that they are realised in future. This study could not cope with the additional effort of data collection required.

The integration of demography simulation can be improved by linking demographic events such as the birth of a child, to location choice. For instance, we would assume that households growing in size are more likely to relocate. This is currently not modelled.
Given the long time horizons which are simulated we can also expect changes in the behaviour. Such changes are not taken care of up to know. Considerable research efforts are needed to reveal trends in behaviour because longitudinal observations are required. An example of trends in travel behaviour which could be included is given in Feige and Kuhnimhof (2013).

7.3. Application of UrbanSim on Brussels

At the beginning of the SustainCity project, there was an existing UrbanSim model for Brussels, but it was a pure prototype model developed with very aggregate data and unable to provide meaningful results.

In the framework of the project, a comprehensive UrbanSim model was developed for an area covering the Brussels urban agglomeration and the suburban area, i.e. an area including about 3 million inhabitants. Three partners were involved in the study: STRATEC, EPFL (École Polytechnique Fédérale de Lausanne) and UCL (Université Catholique de Louvain). The land-use model was coupled with a road traffic model, MATSim, developed by TUB (Technische Universität Berlin).

The UrbanSim-MATSim model was used to simulate a set of policies that are relevant in the context of Brussels. Brussels as many other European cities undergoes an out-migration of middle class families to the suburban areas, yet for several decades, which causes urbanization of previously open spaces, commuting by car and traffic congestion. Some topical issues that the city is currently facing are the following ones: 1) the housing supply to be developed to meet the needs of the demographic growth foreseen for the next decades, 2) the densification of office districts and namely of the European institutions district, 3) the possible implementation of an urban congestion pricing scheme, 4) the funding of the development of the public transport network and services (including the funding of the Regional Express Railway Network to be fully implemented by 2025). Consequently, the policy scenarios that were chosen to be simulated were: a densification scenario and a cordon pricing scenario.

Each scenario was simulated from 2001 to 2020 and compared with the business-as-usual scenario.The table below illustrates the type of results provided for the 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.. 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 (Fontaine, 2010). The hypotheses regarding the increase of housing supply and the increase of office floor space are described in detail in the technical reports of the project (Deliverable D7.2); roughly, the growth assumed is significant but still realistic.

Indicator	Unit	BAU 2020	Densification 2020
Number of households in Brussels-Capital Region	number of households	459 214	498 123
Absolute variation		*48 167*	*38 909*
Relative variation	%	*11.7%*	*8.5%*
Number of households in the target area of densification	number of households	644 214	707 180
Absolute variation		*80 803*	*62 966*
Relative variation	%	*14.3%*	*9.8%*
Number of jobs in Brussels-Capital Region	number of jobs	871 142	865 326
Absolute variation		*192 891*	*-5 816*
Relative variation	%	*28.4%*	*-0.7%*
Number of jobs in the target area of densification	number of jobs	1 138 070	1 133 418
Absolute variation		*232 528*	*-4 652*
Relative variation	%	*25.7%*	*-0.4%*

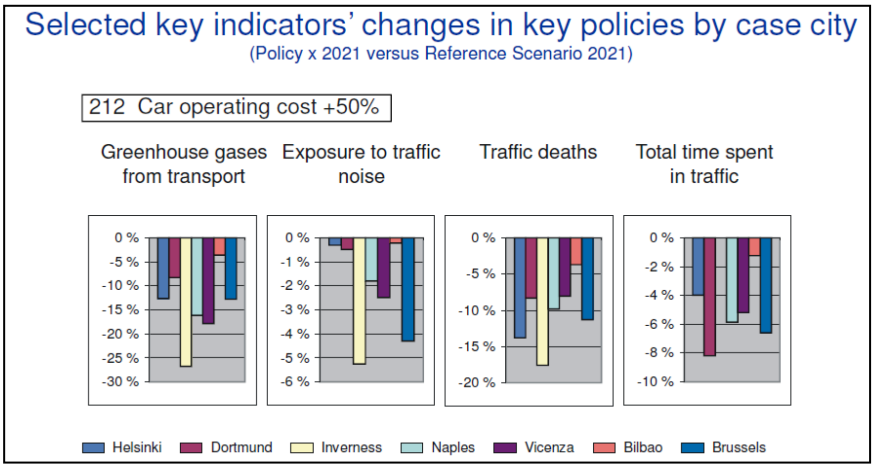
Tab. 4: Impacts of the densification scenario on the number of households and jobs in Brussels-Capital Region and in the target area of densification, horizon = 2020 (source: SustainCity, Deliverable D7.2)

Table 4 shows that increasing housing supply in "highly accessible" locations leads to a relocation of households in Brussels-Capital Region (+ 8.5%) and in the target zones of densification (+9,8%). On the other hand, increasing office floor space in "highly accessible" locations does not have a significant effect on the relocation of jobs in Brussels-Capital or in the target zones of densification. This means that the implemented policy is not enough incentive to induce a change in the choice location of jobs. Note that the imposed variation of the office floor space was less important than the imposed variation of the housing supply because the densification scenarios were defined with a concern for realism.

Although the elasticities of the Brussels model are not completely validated, this example illustrates how land-use/transport models can help in policy planning, by providing an estimation of the relocation effects of a realistic floor space concentration programme ; furthermore, not only the final result is of interest to planners, but also the underlying mechanisms (changes in accessibilities, changes in the housing prices, reactions of the real-estate developers, all elements that are represented in UrbanSim).

7.4. PROPOLIS

The PROPOLIS project (2002-2003) co-funded by the European Commission and national entities was dedicated to the simulation and the assessment of urban policies in 7 European cities (Inverness, Bilbao, Brussels, Dortmund, Helsinki, Vicenza, Naples), in order to draw general conclusions on the LUTI models and on the efficiency of policies with regard to sustainability. Various policies were tested in the 7 cities. The indicators calculated for these policies were integrated into three single indexes (social, economical and environmental) by means of a multi-criteria analysis and a cost-benefit analysis. The figures below illustrate the type of result provided by the project and the type of comparison which was made, across policies and across cities.



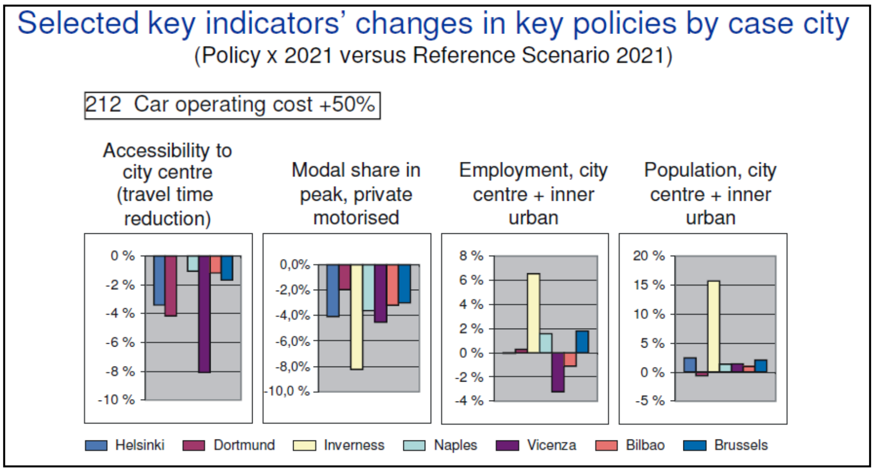


Fig. 11: Indicator values in the 7 case cities for the policy "car operating cost + 50%" (source: PROPOLIS final presentation)

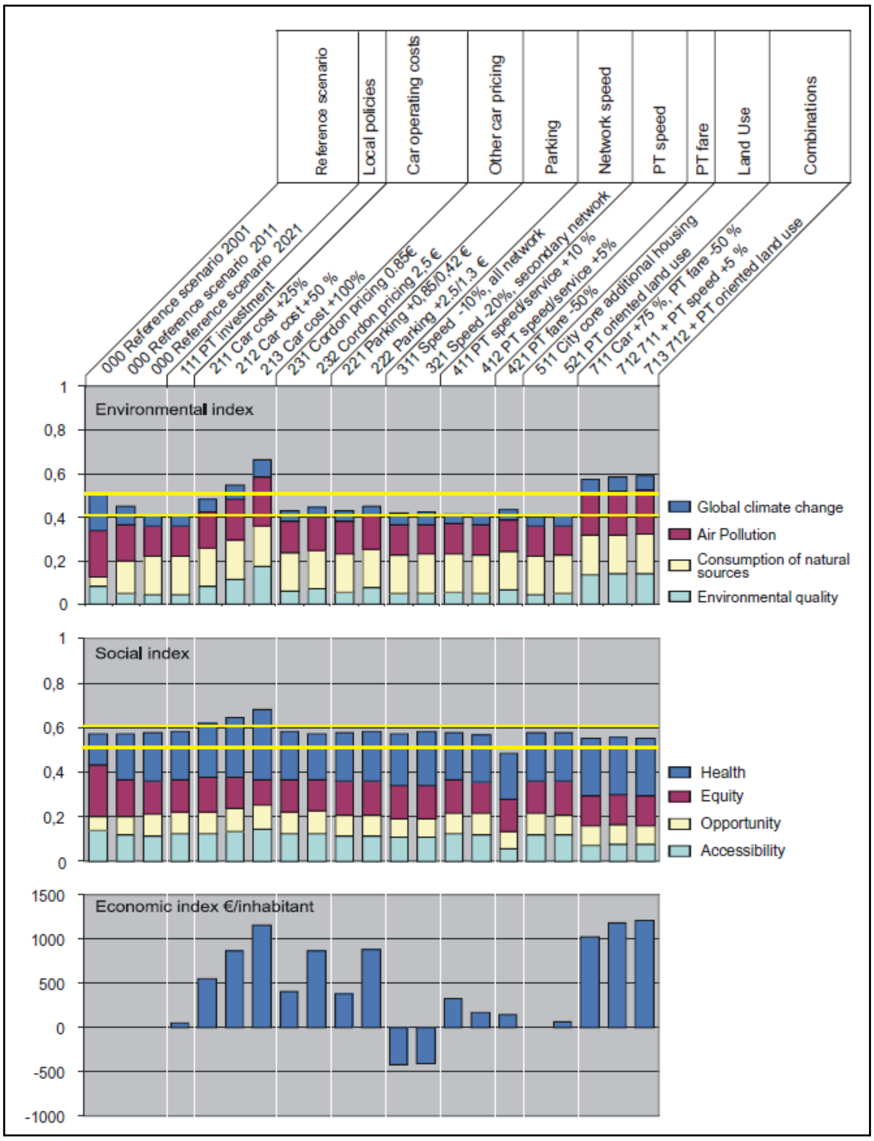


Fig. 12: Policy comparison in the Naples case city (source: PROPOLIS final report)

Fig. 13: Intercity comparison of key policies (source: PROPOLIS final presentation)

7.5. SCATTER – The Brussels case city

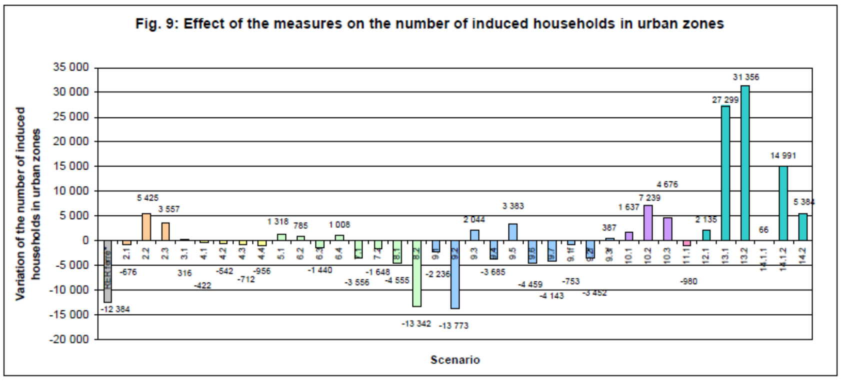
The SCATTER project (2002-2005) was dedicated to urban sprawl and transport. Within SCATTER, the Brussels case city was co-funded by the European Commission (DG Research), the Administration of Equipment and Mobility (Administration de l'Equipement et des Déplacements) of the Brussels-Capital Region and the Belgian federal administration of Mobility and Transport (Service Public Fédéral Mobilité et Transport). This section presents a few results from the Brussels case city.

In the Brussels case city, a LUTI model was developed to measure the long-term effects of the implementation of a large-scale public transport project (Regional Express Railway services around and in the Brussels agglomeration – *Réseau Express Régional* or RER), and to highlight that thanks to the improvement in accessibility (between centre and suburban areas) households would tend to migrate towards the suburban areas. The objective was also to build an integrated strategy (a package of land use, fiscal, pricing, transport policies) to accompany the implementation of this project, i.e. to reinforce its positive impact (modal shift) and to reduce the migration towards the suburban areas. The integrated land-use/transport model covers the central agglomeration and the suburban areas, i.e. a regional system including about 3 million inhabitants.

The simulation tool allowed to simulate a whole set of scenarios referring to various types of policy: parking restrictions, improvements in the public transport services, changes in the public transport fares, road pricing, land use taxes to orientate household or firm location choices, land use regulations.

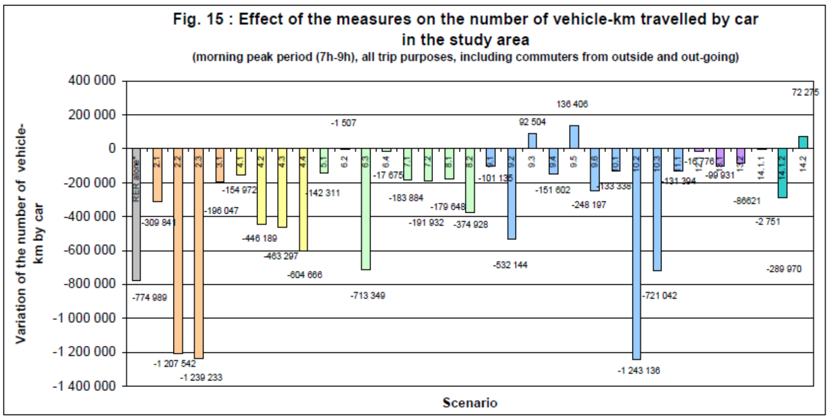
The model provided transport and land use indicators and allowed to classify the policies with regard to efficiency to tackle urban sprawl and/or to reinforce the modal shift towards PT.

As examples, the figures below show the variations in the number of households in the urban areas (compared to the suburban/rural areas), due to the various policies tested, and the variation in the car mileage travelled in the morning peak-period (7h-9h), in the study area. In these diagrams, each bar expresses the impact of one single scenario.



* The effect of the RER is calculated by comparison with the 2021 reference scenario without RER.
The effect of the other scenarios is calculated by comparison with the scenario 2021 with RER.

Fig. 14: Impacts on the number of households in urban zones (source: SCATTER report - Deliverable D5-D6)



* The effect of the RER is calculated by comparison with the 2021 reference scenario without RER.
The effect of the other scenarios is calculated by comparison with the scenario 2021 with RER.

Fig. 15: Impacts on the vehicle-travelled by car in the study area (source: SCATTER report - Deliverable D5-D6)

Conclusion - Key messages for policy-makers, businesses,

Cities are complex systems. Improving the sustainability of European cities requires a good understanding of the interactions between the components of the system, notably

trade unions and civil society actors

between land use, housing, amenities, economic activities, local environmental conditions and transportation conditions. Only when these different interactions are understood and quantified will a policy maker be able to assess the impacts of envisaged policies and will he be able to classify these policies by order of efficiency, in relation with pre-defined objectives.

Because they take into account and simulate these complex interactions, integrated land-use/transport models are the appropriate tool for city level assessment of policies. They provide long-term indicators and long-term elasticities, taking into account the location changes ; they provide indicators related to all the three dimensions of sustainability (social, economic, environmental) and hence allow a comprehensive assessment of the policies ; they allow to assess single policies as well as packages of policies, and hence to build a whole strategy (i.e. a consistent package of policies where the impacts of each single policy compensate each off or reinforce each other). Eventually, to go one step further than the simple calculation of a set of indicators, land-use/transport models can be coupled with socio-economic assessment methods. In the case of SustainCity, the model outcomes will be further processed in a social welfare function, which constitutes a further innovation of the project.

Due to its flexibility and open source features, the UrbanSim software is a convenient starting point for an integrated land use and transportation model. Although originally developed for cities in the United States, it can be adapted to account for particular characteristics of European cities and to include the latest methodological developments in land use modelling.

The European version, UrbanSim-E, will be a useful tool to evaluate development policies in European cities, by providing quantitative measures of the trade-off between urban development and economic, environmental or social objectives. Moreover, the coupling with a social welfare function will allow to assess the policy in an unified and theoretically robust framework.

	PROJECT IDENTITY

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Website	www.sustaincity.eu
Further readings	Bahn-ville project: www.bahn-ville.net Bahn-ville2 project : www.bahn-ville2.fr / www.bahn-ville2.de Balmer, M., K. Meister, M. Rieser, K. Nagel and K.W. Axhausen (2008) Agent-based simulation of travel demand: Structure and computational performance of MATSim-T, paper presented at 2nd TRB Conference on Innovations in Travel Modeling, Portland, June 2008. de Palma, A., D. Nguyen-Luong, K. Motamedi, and J. Moyano (2004): "Simaurif, Modèle Dynamique De Simulation De L'interaction Urbanisation-Transports De Région Ile-De-France, Application À La Tangentielle Nord; Rapport Final De La 1ère Année," Paris: Institut d'aménagement et d'urbanisme de la région d'Ile-de-France (IAU-IdF). de Palma, A., K. Motamedi, N. Picard, and P. Waddell (2005): "A Model of Residential Location Choice with Endogenous Housing Prices and Traffic for the Paris Region," *European Transport*, 31, 67-82. de Palma, A., K. Motamedi, N. Picard, and P. Waddell (2007a): "Accessibility and Environmental Quality: Inequality in the Paris Housing Market," *European Transport*, 36, 47-74. de Palma, A., D. Nguyen-Luong, K. Motamedi, N. Picard, H. Ouaras, and M. Fernandes (2007b): "Simaurif, Modèle Dynamique De Simulation De L'interaction Urbanisation-Transports De Région Ile-De-France, Application À La Tangentielle Nord; Rapport Intermédiaire De La 2ème Phase," Paris: Institut d'aménagement et d'urbanisme de la région d'Ile-de-France (IAU-IdF). Feige, I. and T. Kuhnimhof (2013) Mobility Y – The Emerging Travel Patterns of Generation Y, Final Report, Institute for Mobility Research, Munich. Fontaine N., 2010, « ABC, un outil d'aide à la décision territoriale ». Gayda, S.and Lautso, K. (2007) Urban sprawl and Transport, in Land Use and Transport, S. Marshall and D. Banister (editors), Elsevier, Oxford, United Kingdom. Gayda, S., Lautso, K., Schaillee, N;, Lehto, H., Moilanen, P., Haag, G. and Binder, J. (2004), Simulations with integrated land-use/transport models in 3 case cities: Brussels, Helsinski and Stuttgart, and Assessment of the impacts of the simulated measures , SCATTER Deliverables 5-6, Brussels, Belgium. Hunt, J. D., Kriger, D. S. and Miller, E. J., Current operational urban land-use-transport modelling frameworks: a review, *Transport Reviews*, vol. 25, n°3, 329-376, May 2005. Lautso, K. and Wegener, M. (2007) Integrated Strategies for Sustainable Urban Development, in Land Use and Transport, S. Marshall and D. Banister (editors), Elsevier, Oxford, United Kingdom. Lezzi, M. (2013) Integrated Land-Use and Transport Simulation in Politics, presentation, SustainCity Conference on Integrated Land-Use and Transport Simulation, Zurich, April 2013. Löchl, M., M. Bürgle and K.W. Axhausen (2007) Implementierung des integrierten Flächennutzungsmodells UrbanSim für den Grossraum Zürich – ein Erfahrungsbericht, disP, 168 13–25.

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