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SCATTER

Sprawling Cities And TransporT: from Evaluation to Recommendations

Deliverables 5 and 6

Simulations with integrated land-use/transport models in 3 case cities:

Brussels, Helsinki and Stuttgart

and

Assessment of the Impacts of the simulated Measures

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Authors :	Sylvie Gayda and Nathalie Schaillée (STRATEC) (chapters 1, 2, 4, 7), Kari Lautso and Hannu Lehto (LT) (chapters 3 and 5), Paavo Moilanen (STRAFICA) (chapter 5), Guenter Haag and Jan Binder (STASA) (chapter 6)
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FOREWORD

This report represents two Deliverables: Deliverable 5 and Deliverable 6. The object of Deliverable 5 is to present the results of the simulations of policies aiming to reduce or control sprawl in three case cities: Brussels, Helsinki and Stuttgart (work package 5). The object of Deliverable 6 is to set up an evaluation framework harmonised for the three case cities and to assess the policy impacts by means of that framework (work package 6). The evaluation framework had to address the three inter-related themes under study in SCATTER: location of activities, transport and environment. The objective of both D5 and D6 is to lead to conclusions on the effectiveness of the tested measures against urban sprawl.

When preparing these Deliverables, it appeared that they were closely intertwined (as presenting simulation results evidently requires presenting indicators). That is why D5 and D6 have been brought together into a single document. The structure of the report is given in Section 1.

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EXECUTIVE SUMMARY

This report represents two Deliverables D5 and D6. It present the results of simulations of policies aiming to reduce urban sprawl in three case cities: Brussels, Helsinki and Stuttgart, and the assessment of the policy impacts. The simulations were achieved using integrated land-use/transport models.

In the 3 case cities, new regional-level public transport infrastructures or services will be implemented (in Brussels and Helsinki) or were implemented these last years (in Stuttgart): the question is first to assess to what extent these investments could launch (or launched) an urban sprawl process, by providing faster (and/or cheaper) access to the city centre from the suburban areas. Then, the next question is which accompanying measures implement to go against, or simply reduce, the expected relocation of activities and population, if it is shown that it would have negative effects.

The land-use/transport models which have been used are most appropriate tools for evaluating the effectiveness of policies against urban sprawl, as they simulate the interactions between the transport subsystem and the land use subsystem. They make it possible to assess long term impacts of (transport or land use) policies on the spatial structure of activities and population and on the mobility pattern (travel times, distances, etc.).

The structure of the report is as follows: Section 2 presents and gives the detailed definition of the measures which were simulated (the *common* measures which were tested in all 3 cities, or at least 2 of them, as well as the *local* measures, which were only tested in one of the 3 cities). Section 3 sets up the harmonised evaluation framework and lists the indicators used to assess the impacts. Sections 4, 5 and 6 presents each the simulation results and indicator values for one city: respectively Brussels, Helsinki and Stuttgart. These sections also provide a description of the overall local context and a brief description of the modelling tool used in each city. Finally, section 7 presents the results of the comparative analysis performed on the 3 cities and the final conclusions.

To the question “to what extent do public transport investments generate sprawl”, the simulations provide the answer that they actually generate sprawl if they extend to the suburban or rural areas, if they provide a significant improvement in the accessibility, and whether the network is radial or radial *and* orbital.

The second question was “which policies are most effective to control sprawl and reduce its negative effects” or “do some policies appear as more effective in all 3 cities ?”.

With regard to *urban concentration* and *land consumption*, the most effective policies in the 3 cities are:

- road pricing
- impact fee on new suburban residential developments
- in some cases: fiscal measure to incite services (offices) to locate in zones served by high quality public transport (e.g. around rail stations), or constraining regulatory measure with the same purpose. For this last type of measure, the potential effectiveness depends of the percentage of jobs already located in that kind of zones, in the reference scenario.

Cordon pricing and parking policies are effective too. However, they were not kept in the final selection because they produce a repulsive effect on employment.

With regard to *climate change* and *air pollution*, the most effective policies are road pricing and parking policies. In this respect, land use policies seem to have only little impact, except a drastic regulatory measure on office location in Brussels.

On the basis of the simulations, the final recommendation of SCATTER is to combine 4 approaches:

- congestion pricing: i.e. car use cost increase in congested areas, at peak hours
- reduction of the public transport fare territorially limited to the central agglomeration (indeed a reduction of fare at regional level encourages sprawl, whereas a reduction of fare inside the central area should increase its attractiveness – both measures have of course a positive effect on the modal share)
- impact fee on new suburban housing developments
- fiscal measure to incite offices to locate in areas well served by public transport at regional level (e.g. rail stations).

The policies selected to be combined in the final package 813 are pricing policies or fiscal measures. Three of them appeal to the general principle “polluter pays” which is considered by the economists as the most adequate means to distribute among users the external costs of transport. Besides, pricing policies (either pricing land use or transport) can generally be more easily adjusted to the observed problems (congestion, land consumption, spatial competition, etc) than regulatory actions, and hence can be more effective. But on the counter-side, their acceptability is generally lower.

Pricing polices also provide the governments with revenue which enable them to make public transport investments or to make investments to increase the attractiveness of the cities (embellishment, open spaces, etc).

1. INTRODUCTION

This report present the results of simulations of policies aiming to reduce urban sprawl in three case cities: Brussels, Helsinki and Stuttgart, and the assessment of the policy impacts. The simulations were achieved using integrated land-use/transport models.

In the 3 case cities, new regional-level public transport infrastructures or services will be implemented (in Brussels and Helsinki) or were implemented these last years (in Stuttgart): the question is first to assess to what extent these investments could launch (or launched) an urban sprawl process, by providing faster (and/or cheaper) access to the city centre from the suburban areas. Then, the next question is which accompanying measures implement to go against, or simply reduce, the expected relocation of activities and population, if it is shown that it would have negative effects.

The land-use/transport models which have been used are most appropriate tools for evaluating the effectiveness of policies against urban sprawl, as they simulate the interactions between the transport subsystem and the land use subsystem. They make it possible to assess long term impacts of (transport or land use) policies on the spatial structure of activities and population and on the mobility pattern (travel times, distances, etc.).

The structure of this report is as follows: Section 2 presents and gives the detailed definition of the measures which were simulated (the *common* measures which were tested in all 3 cities, or at least 2 of them, as well as the *local* measures, which were only tested in one of the 3 cities). Section 3 sets up the harmonised evaluation framework and lists the indicators used to assess the impacts. Sections 4, 5 and 6 presents each the simulation results and indicator values for one city: respectively Brussels, Helsinki and Stuttgart. These sections also provide a description of the overall local context and a brief description of the modelling tool used in each city. Finally, section 7 presents the results of the comparative analysis performed on the 3 cities and the final conclusions.

2. DEFINITION OF THE SIMULATED MEASURES

In the 3 case cities, the first scenarios simulated are scenarios of implementation of a new radial transport infrastructure (or service) which decreases the travel times between the centre and the periphery.

Further to these infrastructure scenarios, scenarios of policy measures have been defined and simulated.

The selection of the simulated measures was based on the elements highlighted in the previous work packages of the project, as well as on the particular interests of the regional or national administrations supporting the project, in the field of control of sprawl. Roughly, urban sprawl is essentially due to:

- a decrease of the travel costs;
- a decrease of the travel times;
- an increase of household's income;
- unsuitability between the real estate and the demand for housings;
- an aspiration to a better quality of life or a new way of life.

Therefore, to reduce, control or avoid urban sprawl, the measures should consist in:

- increasing travel time and costs, specially regarding private car transport, as it is more polluting compared to the public transport mode;

- regulatory measures; for example: “containment policies” corresponding for example to apply urban growth boundaries (UGB): it consists in imposing (by regulations) ground assignment (the distribution between residential, open space, offices and other assignments) and controlling on a statutory way the urban growth of the city;
- fiscal measures on the location of residential developments or on offices, leading to a control of their location.

All types of measures were simulated in SCATTER (however in the regulatory type, no “containment policy” was simulated, but other type of land use regulation).

2.1. The common policies

Roughly, the common policies, i.e. the policies which were tested in all the 3 cities (or at least 2 of them) can be grouped in 2 categories:

- public transport investments (supposed to generate sprawl), radial or orbital:
- policies to control sprawl or reduce its negative effects.

The transport investments simulated are as follows:

- in Brussels:
  - the future Regional Express Railway Network (REN)
  - an alternative operating scheme of the REN with more orbital connections (“called “goose-foot type” scheme)
- in Helsinki:
  - the full Helsinki Metropolitan Area investment plan, with the distinction between the road components and the public transport components
  - the development of orbital connections by public transport
- in Stuttgart:
  - the extension of a light-rail line S1 (S-bahn), parallel to the motorway A81 (in 1992)
  - the completion of a missing link of the motorway A81 (in 1978).

The common policies are as follows:

- *land use policies*:
  - impact fee on suburban residential developments, combined with land tax reduction in urban areas
  - regulatory measure on office location: …
  - fiscal measure applied to offices: …
- *transport pricing*:
  - road pricing (increase of the car use cost per km)
  - cordon pricing
  - reduction of the fare of public transport.

One of the objectives of the simulations was therefore to compare the effects and global effectiveness of land-related fiscal measures and transport pricing measures.

It has to be noted that in each case city, different reference scenarios were defined for the following reason:

- the effects of the new transport supply were assessed against a reference scenario *without* that new supply
- the effects of the accompanying measures were assessed against a scenario *with* the new supply.

The common policies are listed and defined in detail in the table below.

Table 2.1 Common policies tested in the 3 case cities

Policy code	Description of the common policy		
	Brussels	**Stuttgart**	**Helsinki**
0	***Reference scenarios***[1]	***Reference scenarios***	***Reference scenarios***[2]
001	**001B**: Horizon 2021 without the REN (Regional Express Railway Network)	**001S**: Situation 1995 without motorway A81 / without extension of S1 light rail / without road tunnel Kappelberg	**001H**: Horizon 2021 without any transport investment
002	**002B**: Horizon 2021 with the REN (=111B)	**002S**: Horizon 2015 with motorway A81 / with extension of S1 light rail / without road tunnel Kappelberg	**002H**: Horizon 2021 with the Helsinki metropolitan area (HMA) general transport plan-Car I transport investments
003	**003B**: Horizon 2021 with the REN and the local investment plan (=711B)	**003S**: Horizon 2020 with motorway A81 / with extension of S1 light rail / with road tunnel Kappelberg	**003H**: Horizon 2021 with PLJ-public transport investments from HMA plan
004			**004H**: Horizon 2021 with the full HMA plan investments (=111H)
1	***Transport infrastructures / services, decreasing travel times between centre and periphery: railway, motorway, buses, HOV***		
11	***Radial transport infrastructure***		
111	**111B**: Horizon 2021 with the REN (=002B)	**111S:** Extension of the light rail (S bahn) line S1 **112S**: Completion of a missing link of the motorway A81, without S1 **113S**: 111S + 112S **114S**: 111S + 112S + park & ride facilities **115S**: 114S + building of a new road tunnel (Kappelberg)	**111H**: Horizon 2021 with the full HMA plan investments (=004H)
12	***Radial transport infrastructure with tangential components***		
121	**121B**: "Goose foot" alternative scheme for the REN railway (with more orbital connections)		**121H**:Devlopment of orbital connections of public transport
3	***Land use measures having an influence on urban sprawl***		
31	***Fiscal measures applied to residential developments***		
311	**311B**: Development impact	**311S**: Development impact	**311H**: Development impact

[1] Only one scenario (002B) was tested on 001B. Most of the other scenarios have been simulated on 002B, while some of them have been tested on 003B (local investment plan), which is indicated in the tables. The simulations on reference 003B were made to be able to select the final combinations of measures.

[2] Most of the scenarios are compared to the 004H scenario, equal to the 111H scenario.

	fee in non urban areas + fiscal incentive in urban areas *311B has been tested on reference 003B*	fee in non urban areas + fiscal incentive in the urban areas	fee in non urban areas + fiscal incentive in urban areas
32	***Regulatory measures applied to offices***		
321	**321B:** ABC-type policy applied to the "business services"	**321S:** ABC-type policy applied to a part of the tertiary sector	**321H:** ABC-type policy applied to a part of the tertiary sector
33	***Fiscal measures applied to offices***		
331	**331B**: ABC-type policy applied to the "business services" *331B has been tested on reference 003B*	**331S**: ABC-type policy applied to a part of the tertiary sector	**331H**:ABC-type policy applied to a part of the tertiary sector
4	***Increase of travel costs or time by private car***		
41	***Increase of car use cost***		
411	**411B**: Increase by 50% of the cost per km	**411S**: Increase by 50% of the cost per km	**411H**: Increase by 50% of the cost per km
412	**412B**: Cordon pricing with a tariff of 7.5 euro/day	**412S**: Cordon pricing with a tariff of 2.1 euro/day	**412H**: Cordon pricing with a tariff of 2.5 euro in orbital cordons and 1.3 euro in radial cordons (per day)
5	***Decrease of travel costs or time by public transport or by Park&ride facilities***		
51	***Decrease of public transport travel costs***		
511	**511B**: Decrease by 20% of the public transport fare for the home-work trips		
512	**512B**: Decrease by 20% of the public transport fare for all users	**512S**: Decrease by 20% of the public transport fare for all users	**512H**: Decrease of public transport fare for all users by 20%
8	***Combinations of measures***		
811	811B = 411+511+311	811S = 411+511+311	811H = 411+512+311
812	812B = 411+511+331	812S = 411+511+331	812H = 411+512+331
813	813B = 411+511+311+331	812S = 411+511+311+331	813B = 411+512+311+331

2.2. The local policies

Table 2 presents the entire programmes of measures which have been tested in each case city, made of common scenarios and city-specific scenarios (local policies).

Policy code	Description of the policy		
	Brussels	**Stuttgart**	**Helsinki**
0	***Reference scenarios***		
001, 002, 003	*Horizon : 2021 - different reference scenarios* : • **001B** = without REN • **002B** = REN railway only • **003B** = REN railway + local investment plan (= scenario 711 B) Only one scenario (002B) was tested on 001B. Among the other scenarios, some have been simulated on 002B, others on 003B.	*Different reference scenarios :* • **001S** = without motorway A81, without S1 extension, without road tunnel Kappelberg • **002S** = with motorway A81, with S1 extension, without road tunnel Kappelberg • **003S** = with motorway A81, with S1 extension, with road tunnel Kappelberg The reference scenarios (001S) are used for all policy codes 111S – 114S, reference scenario (002S) is used for policy code 115S, all other policy codes refer to the reference scenario (003S). The time horizons are: horizon (001S): 1995 horizon (002S): 2015 horizon (003S): 2020	*Horizon : 2021 - different reference scenarios* • **Scenario 001 H –** Without any transport investments • **Scenario 002 H :** Helsinki metropolitan area (HMA) general transport plan-Car i transport investments • **Scenario 003 H :** PLJ-public transport investments from HMA plan • **Scenario 004 H –** Reference scenario with the full HMA Plan investments
1	**Transport infrastructures / services : radial infrastructures decreasing travel times between centre and periphery**		
11	**Implementation of a radial transport infrastructure linking centre and periphery : rail infrastructure, motorway, buses, HOV**		
111 – *Common policy*	**111B:** REN rail only (Regional Express Network): • 8 express railway lines – radial operating scheme • frequency: 4 trains/hour This is the scenario 002B, to which most of the following measures in the Brussels case city are compared (the exceptions are mentioned)	**111S**: Extension of the light rail (S-Bahn) S1 (parallel to the corridor of the motorway A81) without motorway (length 16 km) This is tested on the 001S reference scenario, to which also the following measures (policy codes 112S, 113S, 114S) in the Stuttgart case city are compared.	**111 H :** PLJ-public transport rail investments This is the Reference 004 H scenario, to which most of the following measures are compared (the exceptions are mentioned). The effects of this is compared to 002H. Another comparison is between 001H and 003H.
112 – *Local policy*	**112B:** REN rail + express buses: – 19 bus lines – several bus-lanes on radial highways leading to Brussels, where: average bus commercial speed : 24 km/h inside the Brussels agglomeration, 30 km/h outside – frequency : 4 buses/hour	**112S:** Completion of the missing link of the motorway A81 in 1978 (length 23.9 km) , without S1 (light rail) parallel to the corridor of the A81	
113 – *Local policy*	**113B**: Implementation of the REN rail + buses, together with HOV lanes	**113S**: Completion of the missing link of the motorway A81 in 1978 (length 23.9 km), and extension of the S1 (light rail) parallel to the	

		corridor of the A81 in 1992 (length 16 km)	
114 – *Local policy*	**114B**: Implementation of the REN rail + buses, together with HOV lanes and with parking facilities	**114S**: Completion of the missing link of the motorway A81 in 1978 (length 23.9 km), and extension of the S1 (light rail) parallel to the corridor of the A81 in 1992 (length 16 km), with park&ride facilities (6 park&ride facilities, 7.500 new Parking spaces (about 19%))	
115 – *Local policy*	**115B**: HOV dedicated lanes only	**115S**: 114S and building of a new road tunnel (tunnel Kappelberg) of the Bundesstrasse B29 in east-direction (Schwäbisch Gmünd)	
12	**Implementation of a transport infrastructure with radial and tangential components (the latter one thus provides improved services for trips from periphery to periphery)**		
121 – *Common policy*	**121B**: Alternative for the REN railway scheme: "goose foot" type operating scheme instead of a purely radial-type operating scheme		**121H:** Develop orbital connections of public transport
2	**External factor : relocation of work places**		
211 – *Local policy*		**211S**: Relocation of 10.000 workplaces from Esslingen and Stuttgart-Untertürkheim to Sindelfingen (due to a shift of a production plant of DaimlerChrysler) tested on reference 003S	**211 H:** New Centre in East (Vuosaari) **212 H:** New Centre in North (Marja-Vantaa**)** **213 H:** New Centre next to City (Keski-Pasila) **214 H:** New Centre in North-West (Espoon keskus) **215 H:** New Centre in West (Matinkylä) In Helsinki various new urban structures will be tested by "creating" a new city to various places next to good railway connections. This will be accomplished by assigning the location attractors for each employments type of the City which (hopefully) attracts the associated extra employees and its side effects to the planned zone.
3	**Land use measures having an influence on urban sprawl**		
30	**Increase of the attractiveness of the city**		
301 – *Local policy*	**301B**: Implementation of a hierarchy in the road network of the Brussels-Capital Region, together with a reduction of the network capacity (measure recommended by the Regional Mobility Master Plan).		

302 – *Local policy*	**302B**: Improvement of the quality of life in the residential neighbourhoods in the inner city within the Brussels-Capital Region (5 communes), through diversion of the transit traffic, traffic calming, greening, improving the safety for children.		
31	**Fiscal measures applied to residential developments**		
311 – *Common policy*	**311B** : • annual tax (development impact fee) applied on households locating in non-urban zones and who moved to those zones between 2001 and 2021 with REN (=scenario 111B) ; the tax amounts to 670€/housing/year (which corresponds to a one-shot tax of 13400€/housing distributed on 20 years) • fiscal incentive (tax reduction) applied to all households located in urban zones (60 communes) : it is calculated to redistribute the impact fee, which leads to 37€/housing/year for all households *tested on reference 003B*	**311S** : • annual tax (development impact fee) applied on households locating in non-urban zones (about 670€ / household / year) and redistribution of the revenue of impact fee to the urban areas, as fiscal incentive to all households located in urban zones (Stuttgart, Ludwigsburg, Sindelfingen, Böblingen, Esslingen and Göppingen) *tested on reference 003S*	**311H:** annual tax (development impact fee) : Same as in Brussels. Level fixed to 670€/year/housing.
312 – *Local policy*	**312B:** ▪ fiscal incentive (tax reduction) for households locating in the inner city within the Brussels-Capital Region (in 5 communes): annual tax of 1985 €/housing/year (which corresponds to a one shot tax of 39700€/housing distributed on 20 years) ▪ annual tax applied on households locating in all the other zones (similar to a development impact fee), calculated so that the net cost of the measure for the government is zero, i.e. 215 €/housing/year		**312H:** Same as in 311H but level fixed to 340€/year/housing.
313 – *Local policy*	**313B:** Same measure as 312B but the fiscal incentive is applied to a total of 12 zones including central zones of Brussels and central zones of the main secondary cities of the study area.		**313H:** Same as in 311H but level fixed to 1000€/year/housing
32	**Regulatory measures applied to offices, inspired form the ABC theory**		
321 – *Common policy*	**321B** : ABC-type policy applied to a part of the tertiary sector: • obligation (regulatory measure) for all jobs of the employment sector “business services”, to locate in A-type zone	**321S** : ABC-type policy applied to a part of the tertiary sector: • obligation (regulatory measure) for all jobs of the employment sector “business services”, to locate in A-type zone	**321H:** ABC-type policy applied to a part of the tertiary sector.

	• an A zone is a zone served by high quality public transport at regional scale; in Brussels, they are defined as zones served by an Inter-City-Inter-Region railway station; in this scenario, there are 14 A-zones in the Brussels-Capital Region + in the periphery.	• an A zone is a zone of the capital of a district (NUTS3). In general those zones are also served by high quality public transport at regional scale. In these scenario, there are 7 A-zones in the Stuttgart Region *tested on reference 003S*	
322 – *Local policy*	**322B:** same policy as 321B except the obligation is put only on the <u>new jobs</u> of the concerned sector, since the implementation of scenario 002B		
33	**Fiscal measures applied to offices, inspired form the ABC theory**		
331 – *Common policy*	**331B**: ABC-type policy applied to a part of the tertiary sector: • tax on jobs of the employment sector "business services" locating in non-A-type zone; the tax amounts to 1983€/job • an A zone is a zone served by high quality public transport at regional scale; in Brussels, they are defined as zones served by an Inter-City-Inter-Region railway station; in these scenario, there are 19 A-zones in the Brussels-Capital Region + in the periphery. *tested on reference 003B*	**331S:** ABC-type policy applied to a part of the tertiary sector: • tax on new jobs of the employment sector "business services" locating in non-A-type zone; the tax amounts to 976 €/job • an A zone is a zone of the capital of a district (NUTS3). In general those zones are also served by high quality public transport at regional scale. In these scenario, there are 7 A-zones in the Stuttgart Region *tested on reference 003S*	**331H :** ABC-type policy applied to a part of the tertiary sector. Same as in Brussels. Level fixed to the yearly season ticket for public transport ticket (a cross metropolitan ticket for all, 710.8€), as in Brussels. Implemented as percentage decrease.
4	**Measures aiming at a modal shift towards public transport by increasing travel costs or time by private car**		
41	**Increase of car use cost**		
411 – *Common policy*	**411B**: increase by 50 % of the cost per km for all drivers.	**411S**: increase by 50 % of the cost per km for all drivers *tested on reference 003S*	**411H:** car operating costs +50% (increase by 50 % of the cost per km for all drivers)
412 – *Common policy*	**412B**: cordon pricing (the cordon is located just inside the Ring road which surrounds the Brussels-Capital Region and some adjacent communes) ; tariff : 7.5 €/day applied to all drivers	**412S:** cordon pricing (the cordon is located just inside the city of Stuttgart and the adjacent communes Ludwigsburg, Sindelfingen, Böblingen and Esslingen); tariff: 2,1 €/day applied to all drivers *tested on reference 003S*	**412H:** Cordon (peak) pricing, corresponding to 60 of minutes time value (2,5€) in orbital cordons or 30 minutes of time value (1,3€) in radial cordons
413 – *Local policy*	**413B** : increase by 100 % of the cost per km for all drivers having a company car		
42	***Parking policies***		
421 – *Local policy*	**421B**: Strong capacity restriction in the inner city; no increase in the parking tariff. The study area is divided in 2 area types : ▪ type 1 : inner city (8 communes) :		

	- parking capacity restriction : 1 place for 8 jobs - parking tariff : base price (2001) ▪ type 2 : rest of the study area : - parking capacity restriction : 1 place for 2 jobs - parking tariff : base price (2001)		
422 – *Local policy*	**422B**: Strong capacity restriction in the inner city + increase in the parking tariff. The study area is divided in 2 area types : ▪ type 1 : inner city (8 communes): - parking capacity restriction: 1 place for 8 jobs - parking tariff: long term (home-work trips): 12.5 €/day; short term: 6.25 €/day ▪ type 2 : rest of the study area: - parking capacity restriction: 1 place for 2 jobs - parking tariff: long term (home-work trips): 6.25 €/day; short term: charge free		
423 – *Local policy*	**423B**: Strong capacity restriction + increase in the parking tariff, both in the inner city and in the urban centres of the periphery. The study area is divided in 2 area types : ▪ type 1: inner city (8 communes) + urban centres of the periphery (15 communes): - parking capacity restriction: 1 place for 8 jobs - parking tariff: long term (home-work trips): 12.5 €/day; short term: 6.25 €/day ▪ type 2 : rest of the study area: - parking capacity restriction: 1 place for 2 jobs - parking tariff: long term (home-work trips): 6.25 €/day; short term: charge free		
424 – *Local policy*	**424B**: Strong capacity restriction + increase in the parking tariff, both in the inner city and in the urban centres of the periphery. The study area is divided in 2 area types: ▪ type 1: urban centre (Brussels Capital Region, 19 communes) + urban centres of the periphery (15 communes) : - parking capacity restriction: 1 place for 5		

	jobs - parking tariff: long term (home-work trips): 12.5 €/day; short term: 6.25 €/day ▪ type 2 : rest of the study area: - parking capacity restriction: 1 place for 2 jobs - parking tariff: long term (home-work trips): 6.25 €/day; short term: charge free ▪ *tested on reference 003B*		
425 – *Local policy*	**425B**: New regulation regarding parking facilities in the new office buildings. The study area is divided in 2 area types : ▪ type 1 inner city (8 communes) + urban centres of the periphery (15 communes): suppression of the capacity corresponding to the off-street parking facilities (only the on-street capacity remains available) ▪ type 2: rest of the study area: no change compared to the 2021 reference situation		
5	**Measures aiming at a modal shift towards public transport by decreasing travel costs or times by public transport, or by providing P&R facilities**		
51	**Change in the fare of public transport**		
511 – *Local policy*	**511B**: decrease of fare by 20 %, for home-work trips only		.
512 – *Common policy*	**512B**: decrease of fare by 20%, applied to all public transport users	**512S**: decrease of fare by 20%, applied to all public transport users *tested on reference 003S*	**512H:** decrease public transport price by 20 %
513 – *Local policy*	**513B:** decrease of fare by 20%, applied to low income households, for home-work trips		
514 – *Local policy*	**514B:** decrease of fare by 100%, applied to low income households, for home-work trips		
515 – *Local policy*	**515B:** increase of fare by 20%, applied to low income households, for home-work trips		
516 – *Local policy*	**516B:** increase of fare by 20%, applied to all users making home-work trips		
517 – *Local policy*	**517B:** Increase of the speed of surface PT (bus and tramways) in the Brussels-Capital Region to 18 km/h (the speed improvement could be e.g. obtained through rules giving priority to PT at the crossroads with traffic lights)		
518 – *Local policy*	**518B:** Decrease of the access time to rail stations located in the periphery by 5 minutes, whatever		

	the access mode		
519 – *Local policy*	**519B:** Increase of the commercial speed of the local buses driving the users towards the REN stations by 20 %		
52	**Park&ride facilities**		
521 – *Local policy*	**521B:** Park and ride facilities: ▪ parking facilities located at the REN stations ▪ at the stations located at the ends of the branches: no capacity restriction; at the other stations: capacity limited to the level of demand in the 2021 reference scenario ▪ charge free parking at the ends of the branches ; 6.25 €/day at the other stations	**521S:** Park and ride facilities see scenario 114S *tested on reference scenario 113S*	
7	**Local investment plan**		
711 – *Local policy*	**711B:** The local investment plan (=**003B**) for 2021 comprises: ▪ 111B: the REN - railway: – 8 express railway lines – radial operating scheme – frequency: 4 trains/hour ▪ 112B: the REN - express buses: – 19 bus lines – several bus-lanes on radial highways leading to Brussels, where: average bus commercial speed : 18 km/h inside the Brussels agglomeration, 30 km/h outside – frequency : 4 buses/hour ▪ 517B: increase of the speed of surface PT (bus and tramways) in the Brussels-Capital Region to 18 km/h ▪ 519B: increase of the commercial speed of the local buses driving the users towards the REN stations by 20 % ▪ 301B: implementation of a hierarchy in the road network of the Brussels-Capital Region (reduction of the network capacity) ▪ 302B: improvement of the quality of life in the residential neighbourhoods in the inner city within the Brussels-Capital Region (5 communes).		
8	**Combinations of selected measures**		
811 – *Common*	Combination **811B** = 411 + 511 + 311 :	**811S** = 411 + 512 + 311	Combination **811H** = 411 + 512 + 311

policy	▪ increase by 50% of the private car cost/km applied to all drivers ▪ decrease of PT fare by 20% for home-work trips ▪ fiscal measure on residential developments: see scenario 311 *tested on reference 003B*		
812 – *Common policy*	Combination **812B** = 411 + 511 + 331 : ▪ increase by 50% of the private car cost/km applied to all drivers ▪ decrease of PT fare by 20% for home-work trips ▪ ABC-type policy applied to a part of the tertiary sector: see scenario 331 *tested on reference 003B*	**812S** = 411 + 512 + 331	Combination **812 H** = 411 + 512 + 331
813 – *Common policy*	Combination **813B** = 411 + 511 + 311 + 331: ▪ increase by 50% of the private car cost/km applied to all drivers ▪ decrease of PT fare by 20% for home-work trips ▪ fiscal measure on residential developments: see scenario 311 ▪ ABC-type policy applied to a part of the tertiary sector: see scenario 331 *tested on reference 003B*	**813S** = 411 + 512 + 311 + 331	Combination **813 H** = 411 + 512 + 311 + 331

3. THE EVALUATION FRAMEWORK

3.1. The approach to evaluation

The evaluation framework has to address 2 questions, when assessing a scenario:

- does the scenario generate sprawl or concentration ?
- what are the positive and negative effects of this sprawl or concentration (on environment, quality of life, economy, etc) ?

Two distinct sets of indicators were used, both tackling the 2 above mentioned issues, but the second set addressed them in a more comprehensive approach.

First, in order to be able to make intercity comparisons a set of *urban sprawl indicators* has been defined. These indicators are common for all the three cities and defined and calculated in a uniform way. The aim of these indicators is to describe and illustrate the effects of city sprawl. In addition to these indicators city sprawl is also illustrated using maps and graphs. All this information helps understanding the phenomenon of city sprawl.

However, the city sprawl indicators, although they include environmental, social and economic aspects, do not provide a global and comprehensive assessment of a policy. They do not completely answer the question if the development is sustainable. It is also not easy to say if one of the alternative policies is better than some of the other ones. The answers to the above questions are sought using the *PROPOLIS approach*. This includes analysing the results using *indicator sets* developed in the PROPOLIS project for the environmental, social and economic dimensions of sustainability. An *environmental, social and economic index* is calculated based on the weights of the individual indicators. The results are interpreted as being desirable at least in the case where the policy is able of simultaneously improving all the three dimensions of sustainability. The complete approach was used for the Helsinki case only in the SCATTER project. However, some indicators developed in PROPOLIS were also calculated for Brussels and Stuttgart, among the city sprawl indicators.

Both the city sprawl indicators and the sustainability indicators are calculated for the current situation, for the base scenario and for the individual policies tested. This makes it possible to make comparisons between the policies, between a policy and base scenario, and between the policies and the current situation.

The city sprawl indicators together with the environmental, social and economic indicators are defined in the next sections. A complete description of the PROPOLIS approach and methodologies of calculating the indicator values is described in the PROPOLIS Final Report, see www.ltcon.fi/propolis

3.2. The city sprawl indicators

The city sprawl indicators common for each of the three case cities are presented in the table below. The indicators are self-explaining except for “productivity gain for land use”. This is also an accessibility indicator, which measures how well the active people have access to the work places, the labour market. This accessibility has a link to the productivity of firms: the better the accessibility is the more productive can the firms become[3].

[3] The precise definition of the Productivity Gain indicator is given in annex (source: PROPOLIS Final Report). The definition is based on two threshold times, which are defined as t_1 = 30 min and t_2 = 40 min. However in the case of Stuttgart, these thresholds were not appropriate to the general level of accessibilities and led to exaggerated boundary effects. The values for Stuttgart were therefore calculated with the more appropriate thresholds t_1 = 20 min and t_2 = 30 min.

It is worth noting that the land use indicators are calculated both for the core metropolitan area and for all the urbanised zones together (i.e. including secondary urban centres). This illustrates that two approaches can be considered when tackling the issue of sprawl: either a mono-centric approach in which the city sprawl is strengthened if the number (or share) of households or employees in the core metropolitan area is decreasing (centre-periphery competition), and a polycentric approach which also considers the benefits of a "decentralised concentration", i.e. a concentration in secondary urban centres.

Table 3.1 The city sprawl indicators

City sprawl indicators	**Unit**
Land use	
Households in core metropolitan area	#
Households in urban zones	#
Jobs in core metropolitan area	#
Jobs in urban zones	#
$H_{relative}$ measure of population	km²
$H_{relative}$ measure of employment	km²
Mobility pattern	
Average home-work travel distance	km
Average travel time (all modes)	minutes
Public transport	
Modal share of public transport	%
Passenger-km by public modes	passenger-km per year
Road traffic	
Private vehicle-km	vehicle-km per year
Average road traffic speed	km/h
Greenhouse gases from transport	tons/peak hours
Accessibilities	
Accessibility to city centre	minutes/trip
Accessibility to services	minutes/trip
Productivity gain from land use	%

The $H_{relative}$ measure is an indicator of de-concentration developed in the work package 3 of SCATTER (statistical analysis). The higher the value of $H_{relative}$ is the more the spatial structure is de-concentrated.

The indicator H was inspired by physics and is defined as :

$$H = \int \boldsymbol{r}(\vec{r})\,\vec{r}^{\,2}\; dA(\vec{r})$$

where the density (e.g. population density) $\boldsymbol{r}(\vec{r})$ at distance $\vec{r}$ from city centre is weighted with the square of distance from the city centre. The integration $dA(\vec{r})$ has to be performed over the whole case study area (*A* being the urban area). This formulation translated in discrete terms leads to :

$$H = \sum_i X_i \boldsymbol{r}_i^2$$

with :

i = 1,2, … n being the zones of the study area

X_i being the value of the stock variable X in i (e.g. population, employment)

r_i being the distance between the centre of gravity of each zone i and the centre of gravity of the whole study area.

The indicator $H_{relative}$ is then defined on the same way than H, but considering relative values $X_i/X_{average}$ instead of X_i .

3.3. The urban sustainability indicators

The list of sustainability indicators is presented in the table below. A detailed description together with the calculation methods for each of the indicators is presented in the PROPOLIS final report and is not repeated here.

The table also shows the weights given to each of the indicator themes and each of the indicators. Weights are used in order to arrive at the *social and environmental index* that describes the social and environmental qualities of the policy. Thus, the index value takes into account the values of each individual indicator.

Table 3.2 The urban sustainability indicators

THEME	INDICATOR	UNIT	WEIGHT %
ENVIRONMENTAL DIMENSION			
Global climate change			[21.6]
	Greenhouse gases from transport	CO2 eq./1000 inh. /	21.6
Air pollution			[22,5]
	Acidifying gases from transport	acid eq./1000 inh. / year.	13.2
	Volatile organic compounds from transport	tons /1000 inh. / year.	9.3
Consumption of natural sources			[34,3]
	Consumption of mineral oil products,	tons /1000 inh. / year.	14.7
	Land coverage	percent of area	11.1
	Need for new construction	annual growth in %	8.5
Environmental quality			[21,6]
	Fragmentation of open space	index	13.4
	Quality of open space	index	8.2
SOCIAL DIMENSION			
Health			[37.6]
	Exposure to particulate matter from transport in the living environment	percentage of population	7.5
	Exposure to nitrogen dioxide from transport in the living environment	percentage of population	5.9
	Exposure to traffic noise	percentage of population	6.7
	Traffic deaths	deaths/1000000	10.6
	Traffic injuries	injured/1000000 inh/year	7.0
Equity			[23,0]
	Justice of distribution of economic benefits	justice index	5.1
	Justice to exposure to particulates	justice index	4.4
	Justice of exposure to nitrogen dioxides	justice index	4.3
	Justice of exposure to noise	justice index	4.2
	Segregation	GINI-index	5.0
Opportunities			[16.4]
	Housing standard	% of overcrowded	4.8
	Vitality of city centre	index	3.1
	Vitality of surrounding region	index	3.1
	Productivity gain from land use	percent / year	5.4
Accessibility and traffic			[23.0]
	Total time spent in traffic	hours/inhabitants/year	4.6
	Level of service of PT and slow modes	minutes/trip	5.8
	Accessibility to city centre	minutes/trip	4.0
	Accessibility to services	minutes/trip	4.6
	Accessibility to open space	minutes/trip	4.1
ECONOMIC DIMENSION			
Total net benefit from transport			
	Investment costs	Euro/capita	
	Transport user benefits	Euro/capita	
	Transport operator benefits	Euro/capita	
	Government benefits from transport	Euro/capita	
	Transport external accident costs	Euro/capita	
	Transport external emissions cost	Euro/capita	
	Transport external greenhouse gases	Euro/capita	
	Transport external noise costs	Euro/capita	

3.4. General features of the modelling tools used in the three case cities

The modelling tools used in the 3 cities belong to 2 different types of integrated land-use/transport models. The Brussels and Helsinki models use commercial softwares (TRANUS and MEPLAN), whereas the Stuttgart model uses a specific software specifically developed for the case of Stuttgart by STASA (Weidlich and Haag).

The TRANUS and MEPLAN models have the same structure: input-output matrix, location choices, mode choices and path choices determined by choice models based on the random utility theory, interactions between the transport sub-model and the land use sub-model with delays in some cases.

However, the Brussels and Helsinki models are not quite similar in the way they run. In Brussels, the model was calibrated against the observed situation 2001. The reference scenario at horizon 2021 was then built up exogeneously (outside the model) and the new transport infrastructure (the future Regional Express Railway Network – REN) and the other measures were simulated starting from that 2021 reference situation. Some measures were simulated starting from the local investment scenario.

The Helsinki's model, starting from the base year 2001, runs in a five-year time thresholds up to 2021. For each intermediate year (2006, 2011 and 2016) and for the horizon year, the model produces the travel demand resulting from the socio-economic forecasts and the accessibility provided by the transport network and services.

The STASA model is based on a master equation framework. The simulation of decision processes is based on a stochastic and dynamical decision model within the master equation approach. The Stuttgart model was calibrated on data sets of the years 1997-1999. It was used to calculate long-term socio-economic changes in the location of population, workplaces, traffic flows and accompanied emissions.

Of course, as the starting points (the references scenarios) are clearly different in the 3 cities, only the net impacts of the measures can be compared (the absolute or relative variations caused by the measures) between the cities.

The following table gives some general features of the 3 study areas and of the 3 models.

Table 3.4 General features of the 3 modelling tools and study areas

Characteristic	Brussels	Stuttgart	Helsinki
Key statistics			
Area covered by the modelled study area (km²)	4 332	3 654	743 (HMA[4]) 11 500 (whole study area)
Number of inhabitants	2 944 716 (in 2001)	2 634 161 (in 2001)	946 000 (HMA in 2000)
Main city population	964 405 (in 2001)	589 161 (in 2001)	546 000 (in 2000)
Population density (inh./km²)	680 (in 2001)	721 (in 2001)	1 273 (HMA in 2000)
Number of jobs	1 353 426 (in 2001)	1 075 368 (in 2002)	560 000 (HMA in 2000)
Job density (job/km²)	312 (in 2001)	294 (in 2002)	753 (HMA in 2000)
City-specific features of the model			
Nature of zones	Commune (administrative entity)	Commune (administrative entity)	In HMA : statistical district of the

[4] HMA: Helsinki Metropolitan Area.

			municipalities; in hinterland: commune (administrative entity)
Number of zones: • urban centre • outer urban ring • hinterland TOTAL	 23 39 90 152	 1 36 142 179	 9 18 54 81
Socio-economic groups	7	2	8
Employment sectors	13	2	8
Land and floor space types	3	3	3
Trip types	8	4	6
Transport modes	7	2	5
Link types	85	15	18
Value of time (€/hour): • journey to work • journey to school • shopping • other journeys	 • 6.12 • 4.07 • 4.38 • 5.89	(source: BVWP 2003) • 3.83 €/pers-h • 3.83 €/pers-h • 3.83 €/pers-h • 3.83 €/pers-h	 • 4.07 • 4.07 • 4.07 • 5.88

4. THE BRUSSELS CASE CITY

4.1. Description of the Brussels case city

Brussels is a metropolitan area of about 2.9 million inhabitants (2001). Its central part, the so-called "Brussels-Capital Region", is an important administrative capital, grouping a little less than 1 million inhabitants. The Region has lost population for 30 years (about 120 000 inhabitants), while economic activities – with a rather stable total number of jobs (about 650 000) - were undergoing an important mutation: strong decline of industrial and heavy tertiary activities and strong growth of administrative functions. The result of this evolution is an increase in the number of daily commuters and traffic congestion.

The spatial structure of Brussels is quite typical. An old industrial axis along a canal surrounded by poor neighbourhoods of different ethnic communities with very few green spaces makes its way through the whole city, cutting it in two parts. Neglected during decades this area slowly begins to be renovated. On the other hand, the strong increase of administrative functions introduced a speculative pressure on higher status neighbourhoods making the cost of living increase. Emigration of middle class families to the suburbs encouraged urban sprawl, commuting by car and congestion. The decline of the population of the Brussels-Capital Region and the lowering of its average income increases the scarcity of the resources, essentially based on income taxes of residents, while a lot of public works must be done to adapt the Region to its new important administrative functions. One of the major goals of the local Development Plan is to reinforce the residential attractiveness of the capital by all means. On the other hand, since the efficiency of the public transport networks is too low, especially between the periphery and the urban centre, the authorities decided to implement what could be called a “regional metro” on the existing railway tracks: this is the REN or “Regional Express Railway Network” (“Réseau Express Régional”), linking the suburbs to the central part of the metropolitan area.

The effect expected from the implementation of the REN is a strong modal shift from private car towards public transport, shorter road travel times and a reduction of fuel consumption and of emissions of greenhouse gases and pollutants. However, the long-run effect could be an acceleration of the out-migration of households towards the periphery. Therefore the authorities are interested in testing and evaluating policies to counterbalance the accelerating effect of REN on urban sprawl, as well as to reinforce the positive effect of REN on modal shares. The Belgian authorities co-funding the research (the federal Transport Administration (*Service Public Fédéral Transport et Mobilité*) and the Equipment and Transport Administration (*Administration de l’Equipement et des Déplacements*) of the Brussels-Capital Region) are expecting the demonstration of the adequacy of policies in a long-term strategy to reach the goals of a sustainable development.

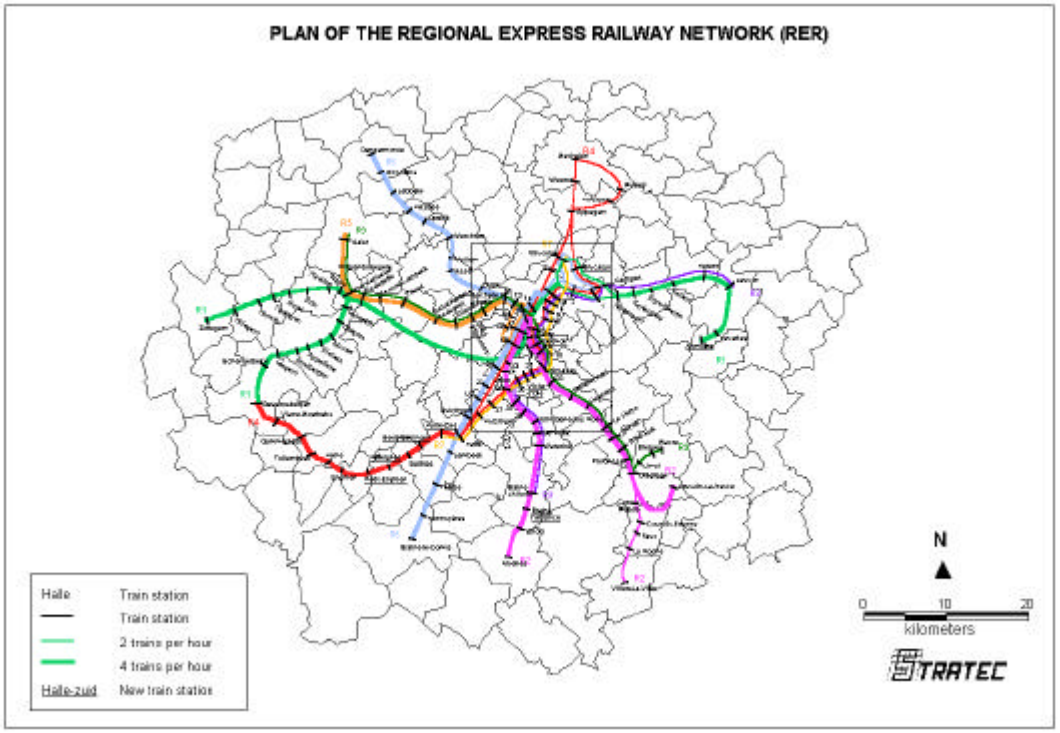


Figure 4.1 Plan of the Regional Express Railway Network (REN)

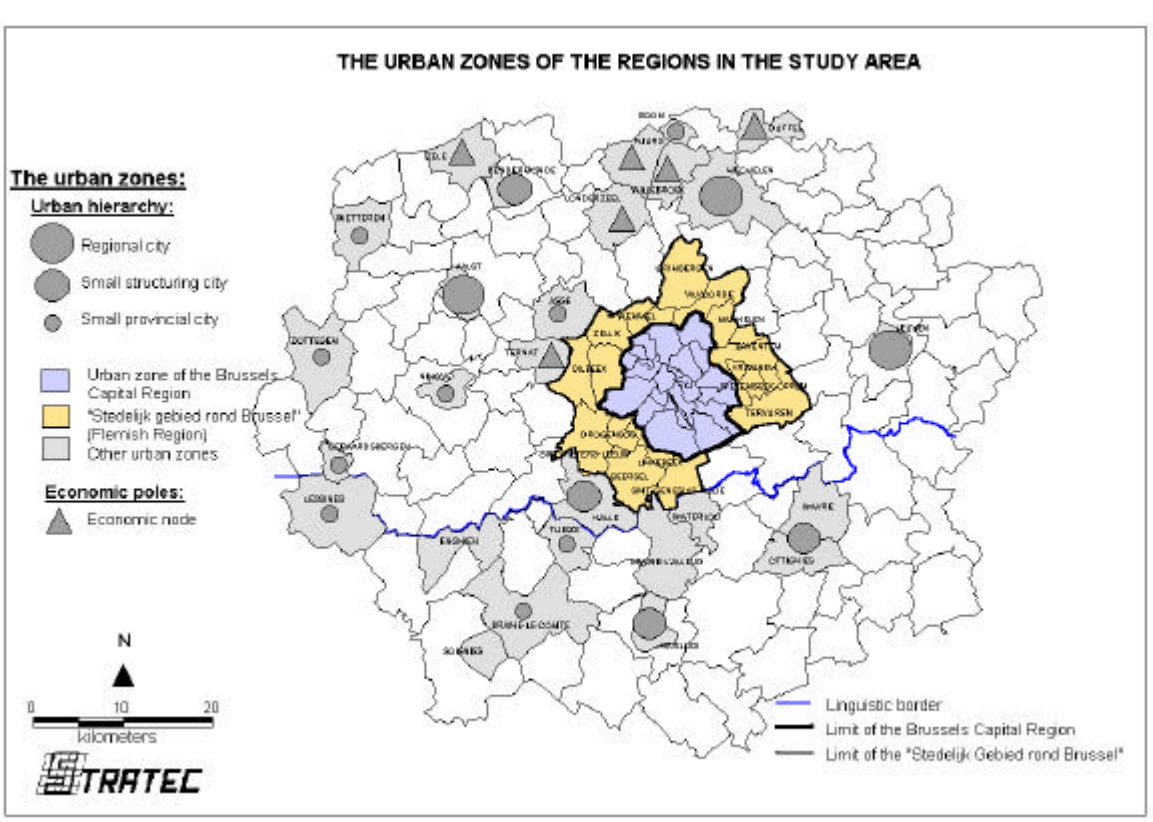


Figure 4.2 : The urban zones of the Brussels study area

4.2. The Brussels land use/transport model: the TRANUS framework[5]

The Brussels case city uses the TRANUS software. TRANUS is an integrated land-use transport model developed by Modelistica based in Caracas, Venezuela. It can be applied at an urban or at a regional scale. The software has a double purpose: firstly, the simulation of the probable effects of applying particular land use and transport policies and projects, and secondly the evaluation of these effects from social, economic, financial and energy points of view. The advantages of integrating the modelling of land-use and transportation are well known and have been documented extensively in the literature. For the transport planner, land-use and transport integration provides a means of making medium and long-term demand estimates, which are impossible with transport-only models (where demand is a given input).

TRANUS has its roots in the tradition of spatial interaction theories, building on Wilson (1970) who first showed how land use and transport could be represented in a common theoretical framework. It also draws heavily on the work of Domencich and McFadden (1975) in discrete choice analysis and random utility theory. Although these authors proposed a general model, most of their work and that which followed is centred on the problem of modal choice in transport, and no specific models were proposed and developed for other elements of the urban or regional system. In TRANUS, this theoretical backbone has been extended to all decision levels, from modal split to assignment, trip generation, the location of activities, and the behaviour of property developers.

In general terms, decision theory describes social processes as sets of decisions made by individuals. The main assumption is that individuals choose rationally between the options available to them. Each individual, faced with a number of options, will rank them according to the degree of satisfaction or *utility* perceived in each case, and will choose the one that provides the greatest utility. On the other hand, utility is a subjective phenomenon - its perception will vary from one individual to another and from one choice to another.

Mathematically, utility can be represented as a *utility function* for a particular individual, which contains variables describing measured attributes of each option. Faced with a particular set of options, an individual may be assumed to evaluate each one with the same utility function, and will choose the option that yields the greatest utility. This concept provides the basis of microeconomic theory.

Aggregation introduces sources of variability, because individuals within a group are different and perceive utility in different ways. The same can be said about aggregated options and zones. Naturally, if groups are small, variability will be small also. In order to represent variability, *random utility* adds a random element to the utility function.

In the individual case, the utility function is deterministic and produces a unique result: the selection of a specific option (i.e. the one with greatest utility). In the aggregate case, since there are random elements, utility functions are probabilistic, producing a distribution of individual choices among the available groups of options. Mathematically, the probabilistic model is obtained by integrating the joint distribution. Hence, several models may be derived from the general one, according to the particular shape of the distribution. Domencich and McFadden (1975) explored several possible shapes, showing that the most appropriate was the Gumbel distribution, which after integration yields a multinomial logit model. If logit is the chosen model, then there is one and only one way of measuring the average utility of the population, the logarithmic average of the distribution, also called composite cost or *log-sum*. Furthermore, if such a model is applied in the context of two different scenarios of future conditions, the difference in utility will be equivalent to the consumers' surplus in traditional

[5] This section is broadly inspired from the User Guide of TRANUS.

economic theory. In TRANUS, this general formulation has been improved in several ways, introducing scaled utilities and an improved formulation of the log-sum.

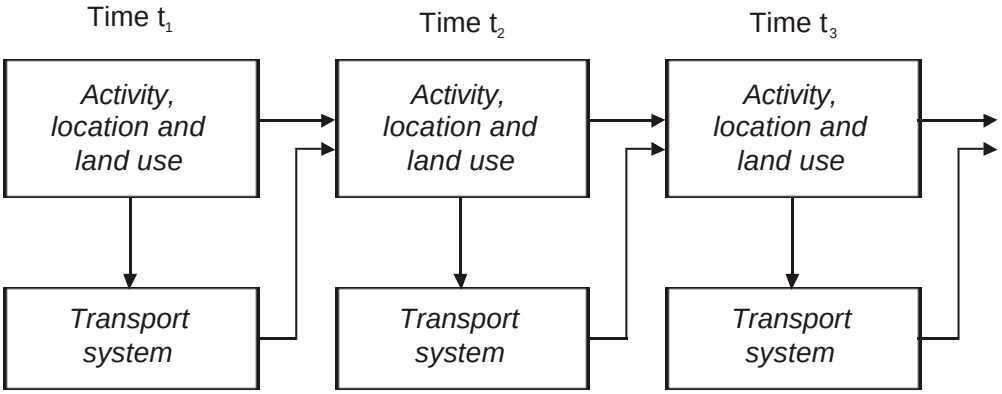
So far we have discussed one particular choice situation. In an urban or regional system however, long and complex *chains of decisions* may be established. An example of a typical chain would be:

place of work → residence → shopping → transport mode

Each link along the chain is conditioned by the preceding link. Thus, where to go shopping is a decision conditioned by the place of residence; the choice of place of residence is in turn conditioned by the place of work. In order to represent such a decision chain in a set of sub-models, the components must follow each other in the correct order. The problem is however complicated by the fact that each link in the chain may influence the preceding one. Thus in the example, it could well be that people decide to go shopping precisely because there is a good bus service: the choice of transport mode affects the choice of shopping place. All this means that the estimation process must work along the decision chain in both directions, backward and forward, calculating and multiplying the probabilities, until a state of equilibrium is reached. Demand elasticities also influence the process

An explicit *dynamic structure* relates the two main components of TRANUS, land use and transport. The way in which the land use relates to transport through time is shown in Figure 2, where discrete time intervals are represented as t_1, t_2, t_3, and so on. The land use and transport systems influence each other through time. Economic activities in space interact with each other, generating flows. These flows determine transport demand within the same time period, and are assigned to the supply of transport. In turn, the demand-supply equilibrium at the transport level determines accessibility, which is fed back to the land use system, influencing the location of activities and their interaction. This feedback does not, however, occur instantaneously in the same time period, but is lagged. Hence, transport accessibility in period t_1 affects the distribution of flows in the following period t_2. Since there are also elements of inertia in land use from one period to the next, the effects of transport might well take several periods to consolidate.

A change in the transport system, such as a new road, a public transport system, or changes in fares, will have an immediate effect on travel demand, but will only affect activity location, interaction, and the property market in the following time period. Changes in land use, on the other hand, such as growth in the production of particular economic sectors, a new supply of land, buildings, or investment, will result in modified interactions and change transport demand within the same time period.



Dynamic relations in the land use/ transport system

4.3. The design of the Brussels land use/transport model

The initial integrated land-use/transport model for the Brussels metropolitan area has been developed in 1996 as part of the ESTEEM project, and has been used in several studies for federal, regional and local transport authorities, for the purpose of policy testing. The model has been designed to assess the major impacts of the future REN on the migrations of households and induced activities, and on the modal choice of people.

In the current version of the model, the study area covers the region that would be served by the future Regional Express Railway (about 30 km around Brussels) The area includes 19 administrative entities in Brussels-Capital Region and 116 municipalities in the suburban area.

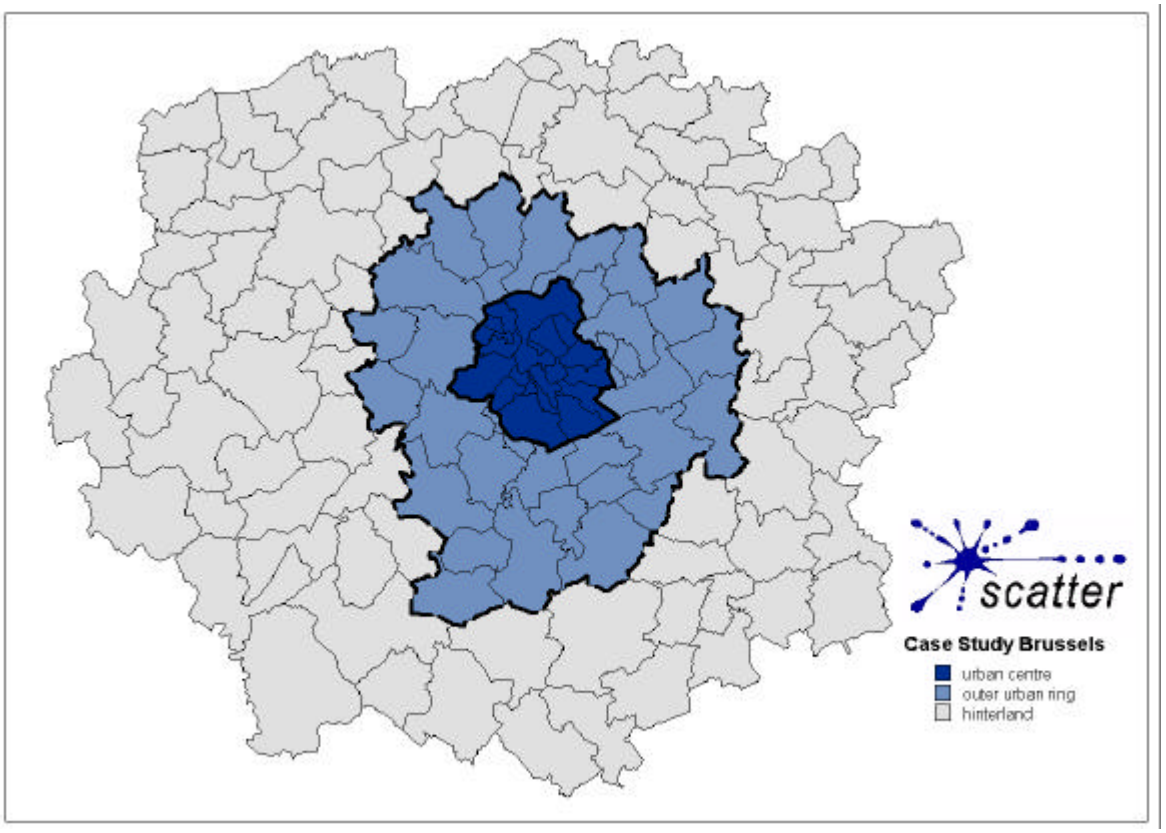


Figure 4.3 The Brussels model zoning system

The Brussels land-use model is based on a spatial input-output model, where economic production sectors include private local services, retail trade and business services (not allowed to locate on industrial land), as endogenous sectors, and agriculture, industry, heavy tertiary, Belgian public administration, international public administration (EC, NATO), public local services, business services (allowed to locate on industrial land), and teaching sector (primary, secondary and high education), as exogenous sectors.

Household categories (classified according to the characteristics of the household's head) consist of white collars (families or one person households), blue collars (families or one person households), non-active people, people over 65 and students living in a campus (for some of these, further distinctions are made according to the number of persons in the household). Land categories consist of 3 types: low and high density residential land, and mixed economic activities land.

The interrelations between the different factors are characterised by the coefficients of an input - output matrix that were derived from the national census and national surveys on

labour force and on household expenses. These coefficients are elastic for land consumed by economic sectors and households .

Transport supply is represented by a single integrated multimodal network, whose details are adjusted to the scale of the zones under consideration. The modelled transport network consists of the primary road network (ca. 1300 links), the railway network serving the study area (ca. 500 links), the metro and pre-metro (i.e. tramway in tunnels) networks (ca. 100 links), representing 85 different link types. Buses are not modelled explicitly: they are represented by links gathering zone centroïds to railways or metro stations. However, separate bus links have been designed for the express buses running mainly in segregated lanes, modelled in several scenarios.

The Brussels model considers passenger transport only. The multi-path search is based on a multimodal shortest path search procedure (i.e. a path between a given O-D pair may include several modes), and the assignment of demand on the paths is based on a conventional multinomial logit procedure based on the path *generalised cost*, considering travel time and cost. Available modes in the reference scenario are car (with a distinction between single-occupancy car and high-occupancy car), metro and pre-metro (i.e. tramways in tunnels), train, REN and express buses.

The demand for travel is represented by a set of O-D matrices of flow volumes in the morning peak hour (7h00 - 9h00): high/medium income home-to-work trips, low income home-to-work trips, non-regular trips (i.e. other than home-to-work or home-to-school), as endogenous matrices, and home-to-school trips, commuting from outside the study area and transit trips, as exogenous matrices.

4.4. Calibration of the Brussels model

In the Brussels case, the model has been calibrated on situation 2001 and the reference scenario at horizon 2021 (without the REN) was built exogeneously (outside the model). The 2001 situation has been calibrated with observed data whose sources were:

- for transport data: the Regional Mobility Plan of Brussels (IRIS1 1990-1996 – STRATEC), road countings carried out in 1997 by STRATEC (on a cordon around the city) and the National Survey on the mobility of the households (1998-1999 –Facultés universitaires Notre-Dame de la Paix de Namur);
- for land-use data: the national census of the population and the residences (1991, INS, National Institute of Statistics), the register of the population (2001), a specific analysis of the ONSS (national office of social security) statistics, the Survey on labour force (INS, 1993 and 1999), statistics of the Ministry of National Education and of University foundation, the survey on the household's budget (INS 1995), the register statistics on buildings giving data on the land surfaces (1991 and 2000), and finally the housing prices of the STADIM data (1991 and 2000).

The 2021 reference scenario was also built up exogenously[6], on the basis of various sources and data mentioned previously. These included the recent socio-economic tendencies observed in the study area between 1991 and 2001, demographic forecasts set up by the National Institute of Statistics, macro-economic forecasts set up by the National Planning Office, and the strategic planning objectives expressed in the Master Plans of the 3 Regions

[6] The model doesn't provide the situation at horizon 2021 starting from the base year 2001. This results partly from the fact that the model is rather complex (7 household segments, 13 activity sectors) and that the part of endogenous actors is high (in the Brussels model, 72 % of the total number of households and 45 % of the total employment are endogenous, i.e. their location is determined by the model).

(Brussels-Capital Region, Flemish Region, Walloon Region), especially with regard to the spatial structure.

The Brussels model reference scenario 2021 (002B) includes the project of Regional Express Railway Network (REN), which will provide high quality, rapid and frequent train services between the periphery and the central area. Other transport investments, such as 19 new lines of express buses on radial highways giving access to the central area, are not included in the reference scenario but are tested in some of the accompanying measures, such as the so-called "local investment plans" (711B) policy.

Most of the policies were tested on this 2021 reference scenario (002B, without population/employment growth). Some policies were tested on the third reference scenario (003B) constituting the local investment plan (711B). Results are provided for the 2021 horizon, in comparison with the adequate reference.

4.5. Definition of the simulated scenarios

The following table specifies the measures which were simulated in the Brussels case city.

Table 4.1 Measures simulated in the Brussels case city

Policy code	Description of the policy
	Brussels
0	***Reference scenarios***
001, 002, 003	*Horizon : 2021 - different reference scenarios* : • **001B** = without REN • **002B** = REN railway only • **003B** = REN railway + local investment plan (= scenario 711 B) Only one scenario (002B) was tested on 001B. Among the other scenarios, some have been simulated on 002B, others on 003B.
1	**Transport infrastructures / services : radial infrastructures decreasing travel times between centre and periphery**
11	**Implementation of a radial transport infrastructure linking centre and periphery : rail infrastructure, motorway, buses, HOV**
111 *Common policy*	**111B:** REN rail only (Regional Express Network): • 8 express railway lines – radial operating scheme • frequency: 4 trains/hour This is the 002B scenario, to which most of the following measures in the Brussels case city are compared (the exceptions are mentioned)
112 Local policy	**112B:** REN rail + express buses: – 19 bus lines – several bus-lanes on radial highways leading to Brussels, where: average bus commercial speed : 24 km/h inside the Brussels agglomeration, 30 km/h outside – frequency : 4 buses/hour
113 Local policy	**113B**: Implementation of the REN rail + buses, together with HOV lanes
114 Local policy	**114B**: Implementation of the REN rail + buses, together with HOV lanes and with parking facilities
115 Local policy	**115B**: HOV dedicated lanes only
12	**Implementation of a transport infrastructure with radial and tangential components (the latter one thus provides improved services for trips from periphery to periphery)**
121 *Common policy*	**121B**: Alternative for the REN railway scheme: "goose foot" type operating scheme instead of a purely radial-type operating scheme
3	**Land use measures having an influence on urban sprawl**
30	**Increase of the attractiveness of the city**
301 *Local policy*	**301B**: Implementation of a hierarchy in the road network of the Brussels-Capital Region, together with a reduction of the network capacity (measure recommended by the Regional Mobility Master Plan).
302 *Local policy*	**302B**: Improvement of the quality of life in the residential neighbourhoods in the inner city within the Brussels-Capital Region (5 communes), through diversion of the transit traffic, traffic calming, greening, improving the safety for children.
31	**Fiscal measures applied to residential developments**

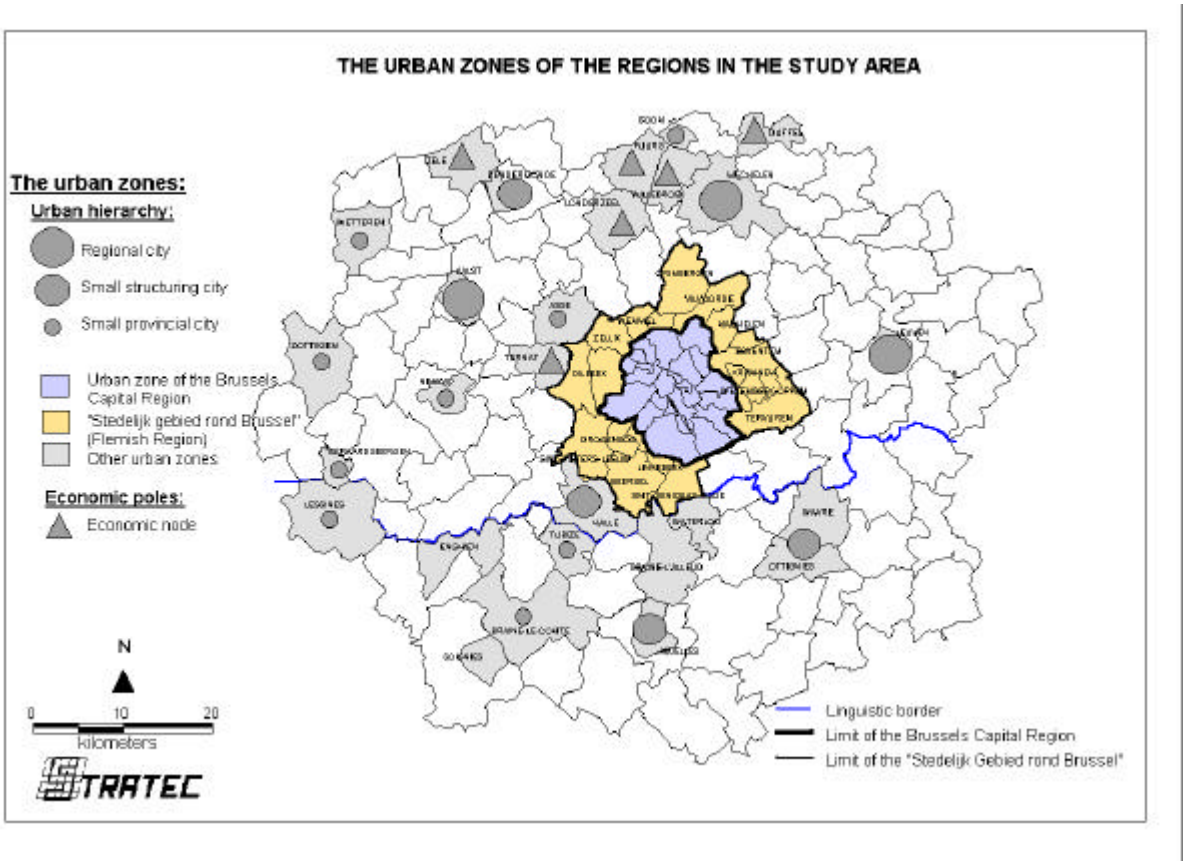
311 *Common policy*	**311B** : • annual tax (development impact fee) applied on households locating in non-urban zones and who moved to those zones between 2001 and 2021 with REN (=scenario 111B) ; the tax amounts to 670€/housing/year (which corresponds to a one-shot tax of 13400€/housing distributed on 20 years) • fiscal incentive (tax reduction) applied to all households located in urban zones (60 communes) : it is calculated to redistribute the impact fee, which leads to 37€/housing/year for all households *tested on reference 003B*
312 *Local policy*	**312B:** ▪ fiscal incentive (tax reduction) for households locating in the inner city within the Brussels-Capital Region (in 5 communes): annual tax of 1985 €/housing/year (which corresponds to a one shot tax of 39700€/housing distributed on 20 years) ▪ annual tax applied on households locating in all the other zones (similar to a development impact fee), calculated so that the net cost of the measure for the government is zero, i.e. 215 €/housing/year
313 *Local policy*	**313B:** Same measure as 312B but the fiscal incentive is applied to a total of 12 zones including central zones of Brussels and central zones of the main secondary cities of the study area.
32	**Regulatory measures applied to offices, inspired form the ABC theory**
321 *Common policy*	**321B** : ABC-type policy applied to a part of the tertiary sector: • obligation (regulatory measure) for all jobs of the employment sector “business services”, to locate in A-type zone • an A zone is a zone served by high quality public transport at regional scale; in the Brussels case, these zones are defined as zones served by an Inter-City-Inter-Region railway station; in this scenario, there are 14 A-zones in the Brussels-Capital Region + in the periphery.
322 *Local policy*	**322B:** same policy as 321B except the obligation is put only on the new jobs of the concerned sector, since the implementation of scenario 002B
33	**Fiscal measures applied to offices, inspired form the ABC theory**
331 *Common policy*	**331B**: ABC-type policy applied to a part of the tertiary sector: • tax on jobs of the employment sector “business services” locating in non-A-type zone; the tax amounts to 1983€/job • an A zone is a zone served by high quality public transport at regional scale; in the Brussels case, these zones are defined as zones served by an Inter-City-Inter-Region railway station; in these scenario, there are 19 A-zones in the Brussels-Capital Region + in the periphery. *tested on reference 003B*
4	**Measures aiming at a modal shift towards public transport by increasing travel costs or time by private car**
41	**Increase of car use cost**
411 *Common policy*	**411B**: increase by 50 % of the cost per km for all drivers
412 *Common policy*	**412B**: cordon pricing (the cordon is located just inside the Ring oad which surrounds the Brussels-Capital Region and some adjacent communes) ; tariff : 7.5 €/day applied to all drivers
413 Local policy	**413B** : increase by 100 % of the cost per km for all drivers having a company car
42	***Parking policies***
421 *Local policy*	**421B**: Strong capacity restriction in the inner city; no increase in the parking tariff. The study area is divided in 2 area types : ▪ type 1 : inner city (8 communes) : - parking capacity restriction : 1 place for 8 jobs - parking tariff : base price (2001) ▪ type 2 : rest of the study area : - parking capacity restriction : 1 place for 2 jobs - parking tariff : base price (2001)
422 *Local policy*	**422B**: Strong capacity restriction in the inner city + increase in the parking tariff. The study area is divided in 2 area types : ▪ type 1 : inner city (8 communes): - parking capacity restriction: 1 place for 8 jobs - parking tariff: long term (home-work trips): 12.5 €/day; short term: 6.25 €/day ▪ type 2 : rest of the study area: - parking capacity restriction: 1 place for 2 jobs - parking tariff: long term (home-work trips): 6.25 €/day; short term: charge free
423 *Local policy*	**423B**: Strong capacity restriction + increase in the parking tariff, both in the inner city and in the urban centres of the periphery. The study area is divided in 2 area types : ▪ type 1: inner city (8 communes) + urban centres of the periphery (15 communes): - parking capacity restriction: 1 place for 8 jobs

	- parking tariff: long term (home-work trips): 12.5 €/day; short term: 6.25 €/day ▪ type 2 : rest of the study area: - parking capacity restriction: 1 place for 2 jobs - parking tariff: long term (home-work trips): 6.25 €/day; short term: charge free
424 *Local policy*	**424B**: Strong capacity restriction + increase in the parking tariff, both in the inner city and in the urban centres of the periphery. The study area is divided in 2 area types: ▪ type 1: urban centre (Brussels Capital Region, 19 communes) + urban centres of the periphery (15 communes) : - parking capacity restriction: 1 place for 5 jobs - parking tariff: long term (home-work trips): 12.5 €/day; short term: 6.25 €/day ▪ type 2 : rest of the study area: - parking capacity restriction: 1 place for 2 jobs - parking tariff: long term (home-work trips): 6.25 €/day; short term: charge free ▪ *tested on reference 003B*[7]
425 *Local policy*	**425B**: New regulation regarding parking facilities in the new office buildings. The study area is divided in 2 area types : ▪ type 1 inner city (8 communes) + urban centres of the periphery (15 communes): suppression of the capacity corresponding to the off-street parking facilities (only the on-street capacity remains available) ▪ type 2: rest of the study area: no change compared to the 2021 reference situation
5	**Measures aiming at a modal shift towards public transport by decreasing travel costs or times by public transport, or by providing P&R facilities**
51	**Change in the fare of public transport**
511 *Local policy*	**511B**: decrease of fare by 20 %, for home-work trips only
512 *Common policy*	**512B**: decrease of fare by 20%, applied to all public transport users
513 *Local policy*	**513B:** decrease of fare by 20%, applied to low income households, for home-work trips
514 *Local policy*	**514B:** decrease of fare by 100%, applied to low income households, for home-work trips
515 *Local policy*	**515B:** increase of fare by 20%, applied to low income households, for home-work trips
516 *Local policy*	**516B:** increase of fare by 20%, applied to all users making home-work trips
517 *Local policy*	**517B:** Increase of the speed of surface PT (bus and tramways) in the Brussels-Capital Region to 18 km/h (the speed improvement could be e.g. obtained through rules giving priority to PT at the crossroads with traffic lights)
518 *Local policy*	**518B:** Decrease of the access time to rail stations located in the periphery by 5 minutes, whatever the access mode
519 *Local policy*	**519B:** Increase of the commercial speed of the local buses driving the users towards the REN stations by 20 %
52	**Park&ride facilities**
521 *Local policy*	**521B:** Park and ride facilities: ▪ parking facilities located at the REN stations ▪ at the stations located at the ends of the branches: no capacity restriction; at the other stations: capacity limited to the level of the demand in the 2021 reference scenario ▪ charge free parking at the ends of the branches ; 6.25 €/day at the other stations
7	**Local investment plan**
711 *Local policy*	**711B:** The local investment plan (=**003B**) for 2021 comprises: ▪ 111B: the REN - railway: – 8 express railway lines – radial operating scheme – frequency: 4 trains/hour ▪ 112B: the REN - express buses: – 19 bus lines – several bus-lanes on radial highways leading to Brussels, where: average bus commercial speed : 18 km/h inside the Brussels agglomeration, 30 km/h outside – frequency : 4 buses/hour ▪ 517B: increase of the speed of surface PT (bus and tramways) in the Brussels-Capital Region to 18 km/h ▪ 519B: increase of the commercial speed of the local buses driving the users towards the REN stations by 20 % ▪ 301B: implementation of a hierarchy in the road network of the Brussels-Capital Region (reduction of the network capacity) ▪ 302B: improvement of the quality of life in the residential neighbourhoods in the inner city

[7] The reference 003B, of the Brussels case city, is the scenario of the local investment plan (711B). Some selected measures are compared with this reference 003B, in order to build the combinations of measures.

	within the Brussels -Capital Region (5 communes).
8	**Combinations of selected measures**
811 ***Common policy***	Combination **811B** = 411 + 511 + 311 : ▪ increase by 50% of the private car cost/km applied to all drivers ▪ decrease of PT fare by 20% for home-work trips ▪ fiscal measure on residential developments: see scenario 311 *tested on reference 003B*
812 ***Common policy***	Combination **812B** = 411 + 511 + 331 : ▪ increase by 50% of the private car cost/km applied to all drivers ▪ decrease of PT fare by 20% for home-work trips ▪ ABC-type policy applied to a part of the tertiary sector: see scenario 331 *tested on reference 003B*
813 ***Common policy***	Combination **813B** = 411 + 511 + 311 + 331: ▪ increase by 50% of the private car cost/km applied to all drivers ▪ decrease of PT fare by 20% for home-work trips ▪ fiscal measure on residential developments: see scenario 311 ▪ ABC-type policy applied to a part of the tertiary sector: see scenario 331 *tested on reference 003B*

Figure 4.5 : The urban zones of the Brussels study area



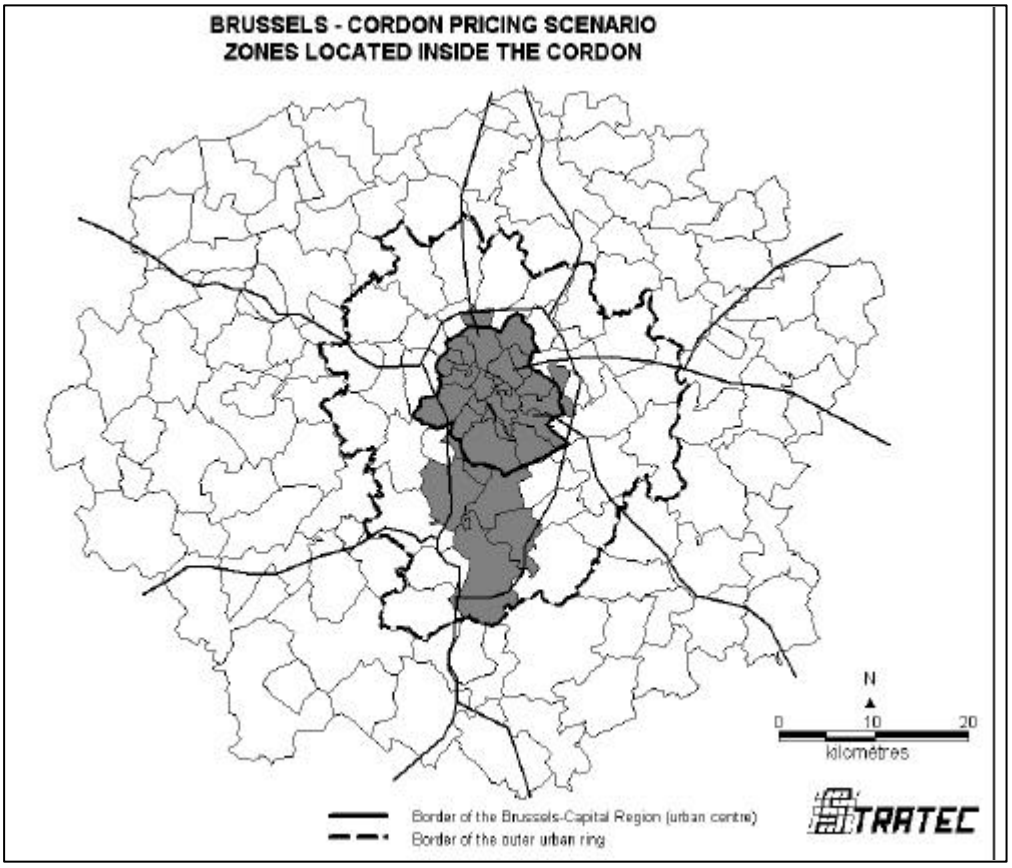


Figure 4.6 : Brussels – Cordon pricing scenario zones located inside the cordon

4.6. Simulation results in the Brussels case city

Tables with all the indicator values are given in annex for the 3 case cities. A set of key indicators is illustrated in diagrams below. In all these diagrams, the results are expressed as follows:

- the first bar expresses the effect of the scenario "2021 RER alone" (002B) compared to the scenario "2021 business-as-usual reference scenario (without RER)" (001B)
- the following bars express the effect of each scenario compared to the scenario "2021 RER alone".

The key indicators are as follows:

- number of induced (i.e. endogeneous)[8] households in the Brussels-Capital Region (urban centre)
- number of induced households in the urban zones
- number of induced jobs in the Brussels-Capital Region
- number of induced jobs in the urban zones
- average home-work travel distance
- average travel time (all purposes, all modes)
- total car mileage in the morning peak period (7h-9h), in the whole study area
- average road traffic speed in the morning peak period
- CO2 emissions
- average modal share of the public transport in the morning peak period
- total number of passenger-km travelled by public transport in the morning peak period.

It is worth noting that the effects as regards travel times mainly result from the combination of two effects:

- the changes in the average trip distances

and the modal shifts between on average faster modes (e.g. car) and on average slower modes (e.g. PT).

[8] In this modelling framework, *induced* or *endogeneous* sectors (either household categories or activity sectors) are sectors whose "production" is determined by a local demand, i.e. a demand coming from the study area; therefore their location is depending on the accessibilities (between "consumers" and "producers") within the study area. On the contrary, *basic* or *exogeneous* sectors do not respond to a local demand, but respond to an external demand; consequently their location is not depending on the accessibilities within the study area. In the case of Brussels, exogeneous categories of households are the retired people and the households of students; exogeneous activity sectors are roughly agriculture, industry, public administration, public services, teaching sector.

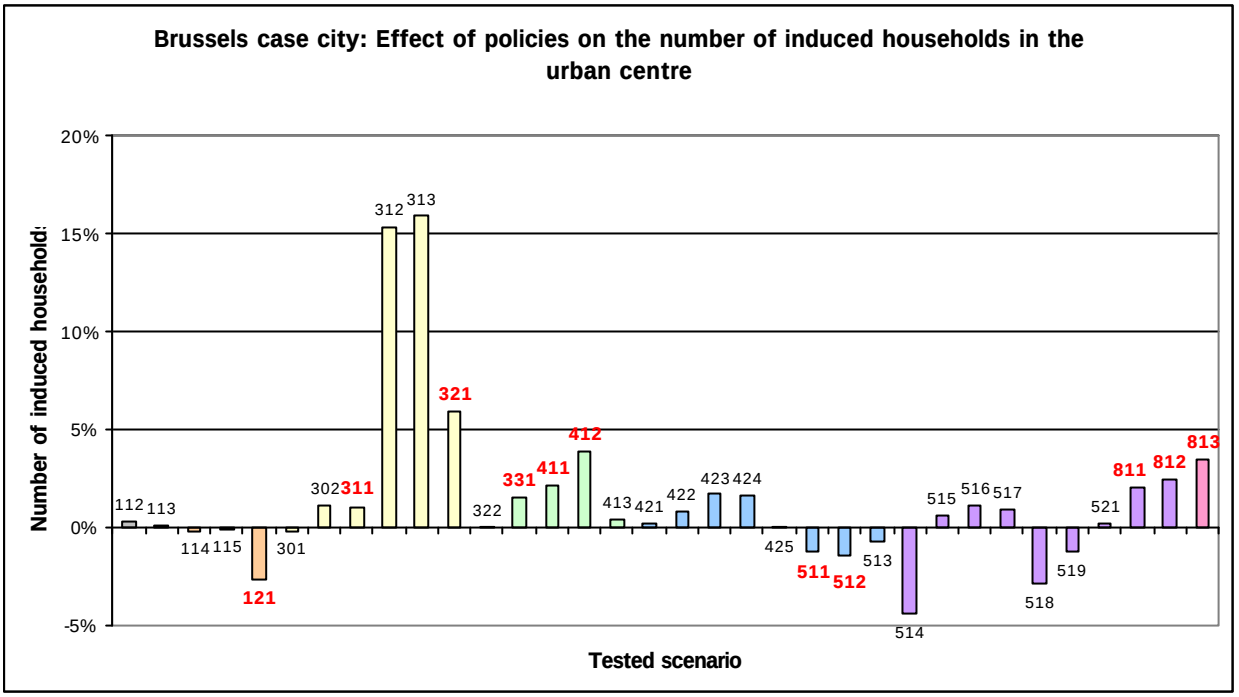


Figure 4.7 : Brussels case city : Effect of policies on the number of induced households in the urban centre

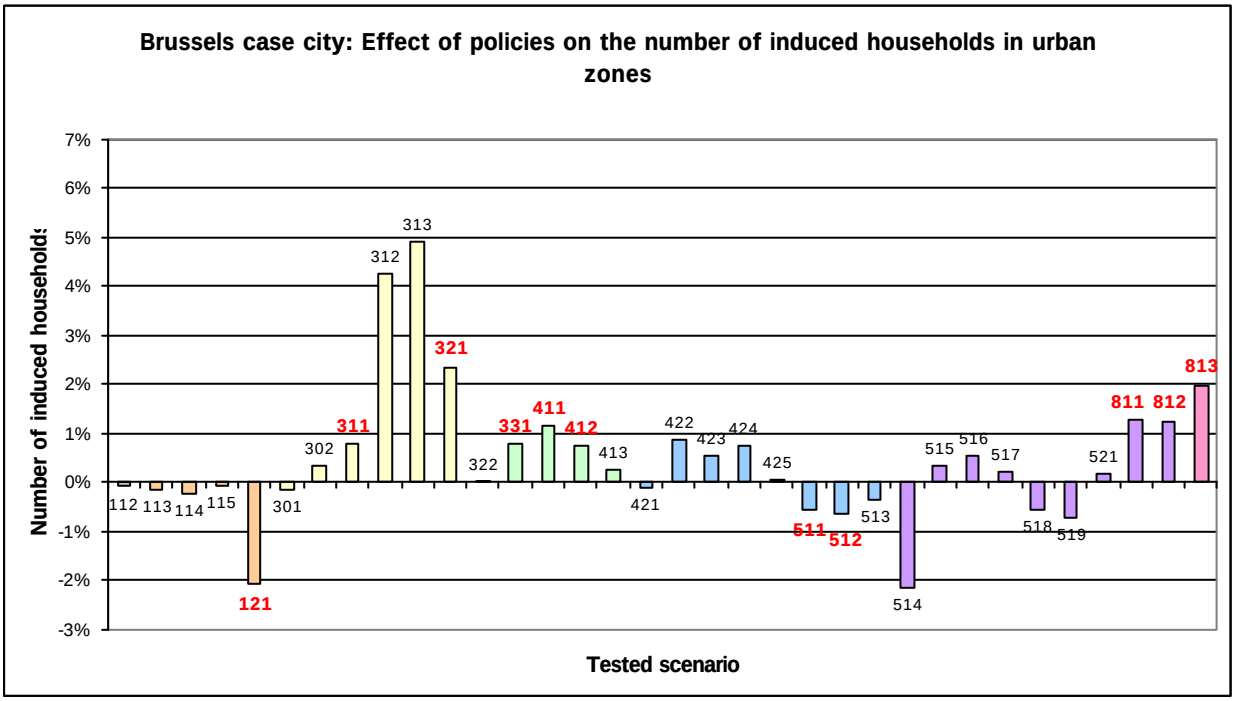


Figure 4.8 : Brussels case city : Effect of policies on the number of induced households in urban zones

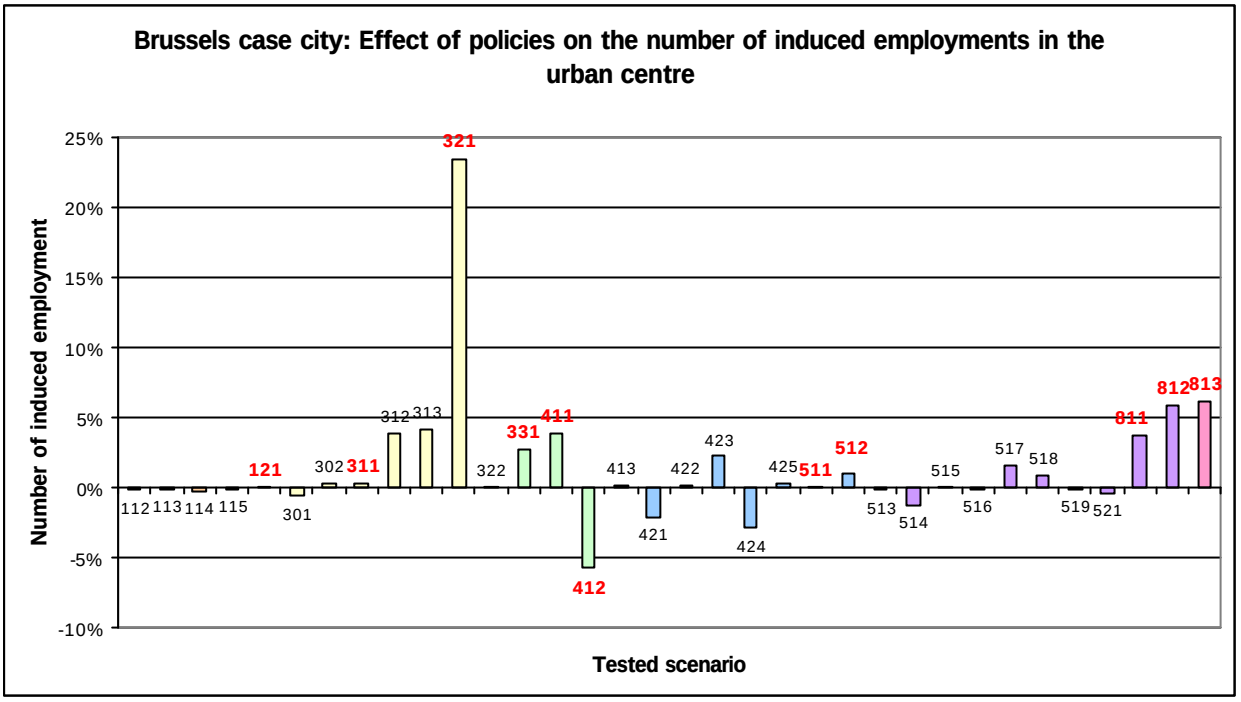


Figure 4.9 : Brussels case city : Effect of policies on the number of induced employments in the urban centre

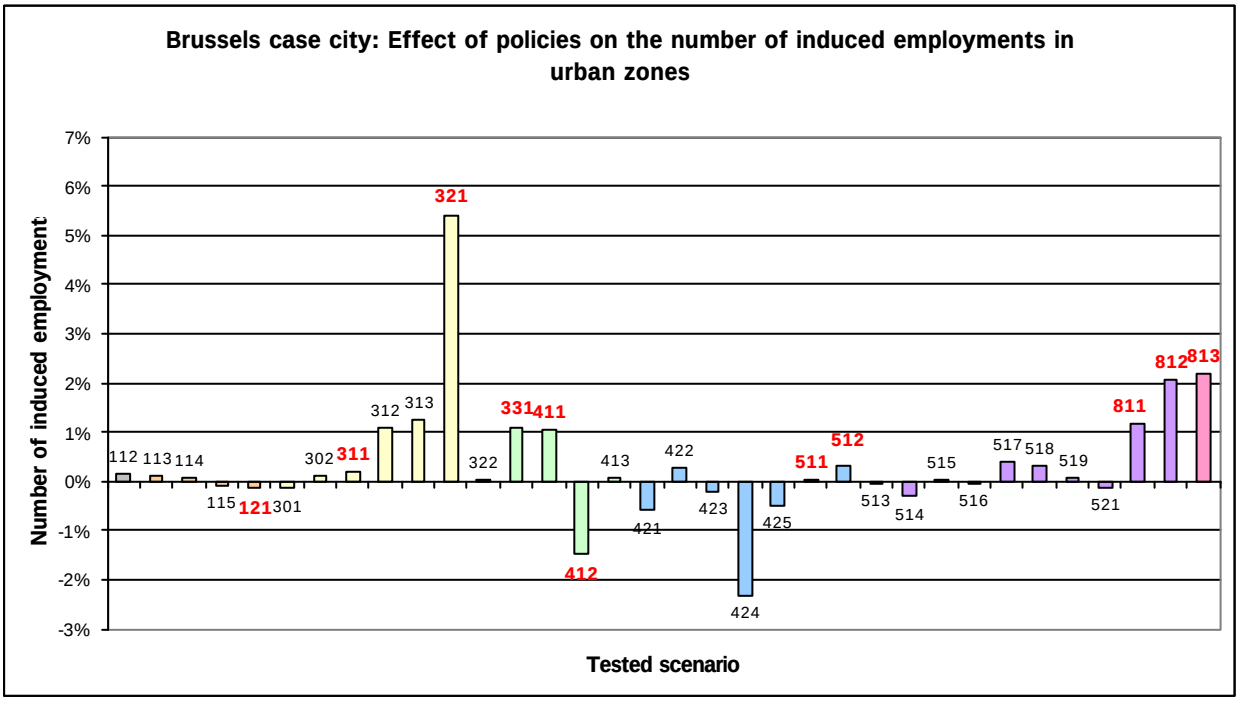


Figure 4.10 : Brussels case city : Effect of policies on the number of induced employments in urban zones

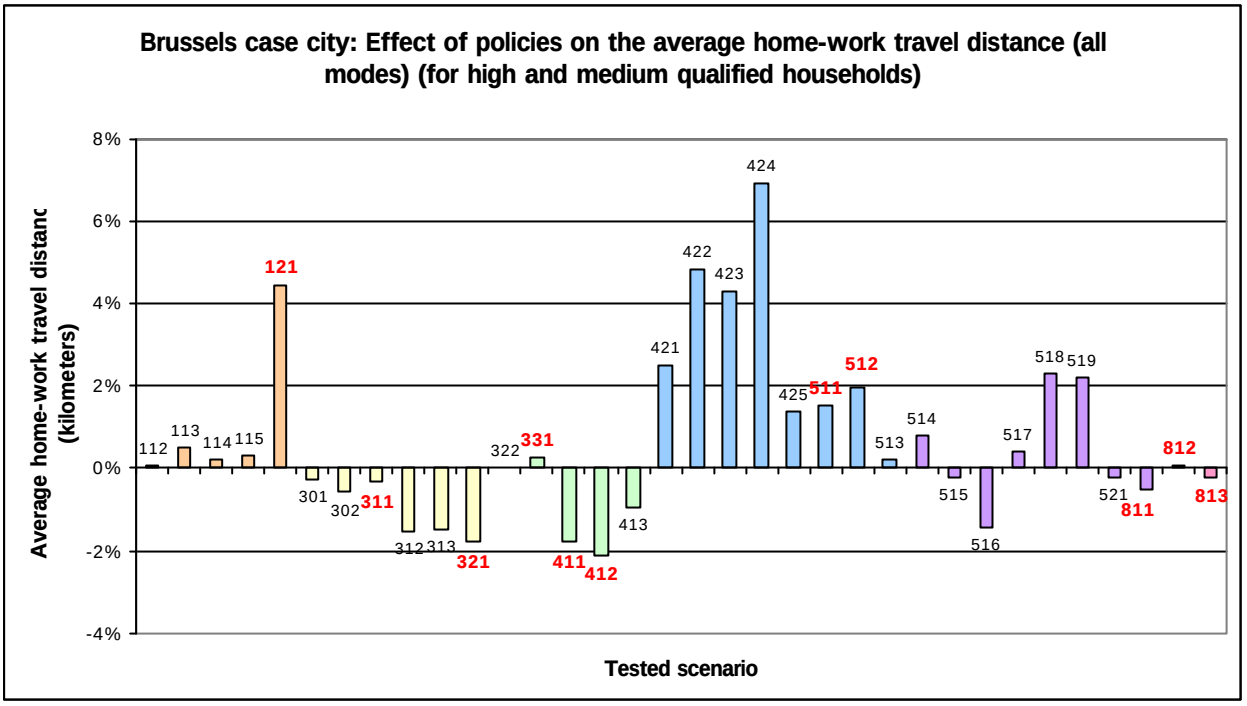


Figure 4.11 : Brussels case city : Effect of policies on the average home-work travel distance (all modes) for high and medium qualified households)

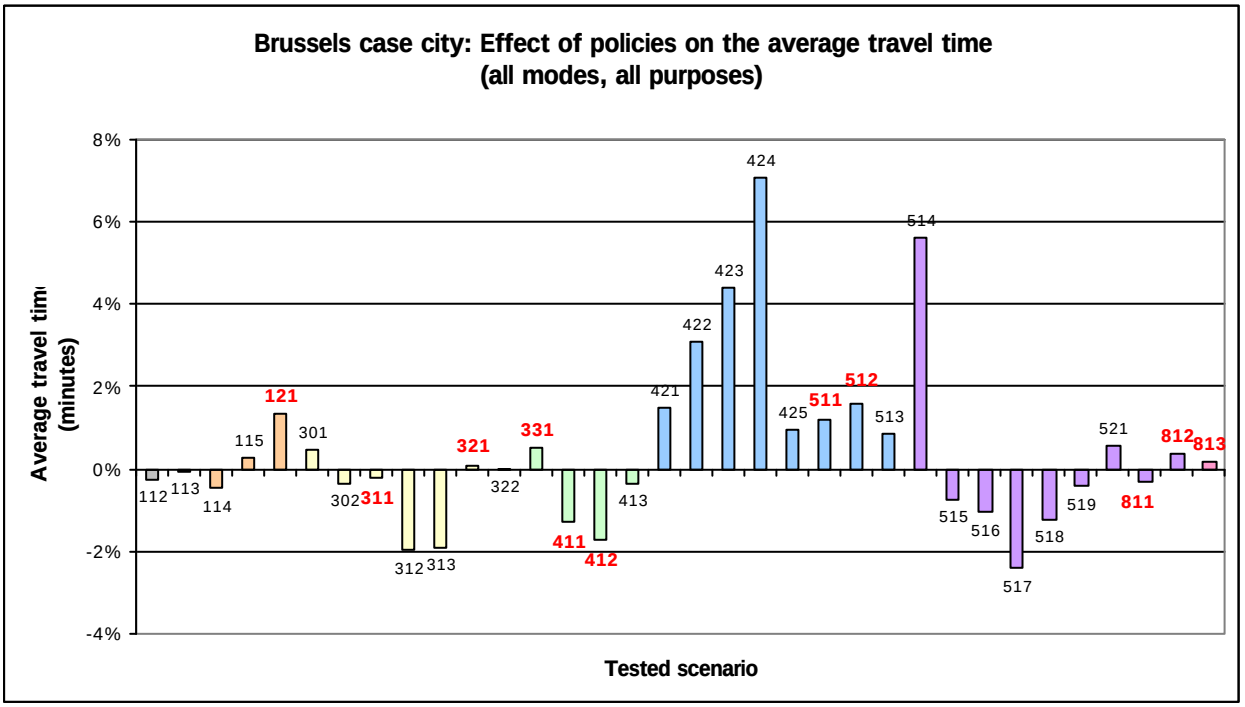


Figure 4.12 : Brussels case city : Effect of policies on the average travel time (all modes, all purposes)

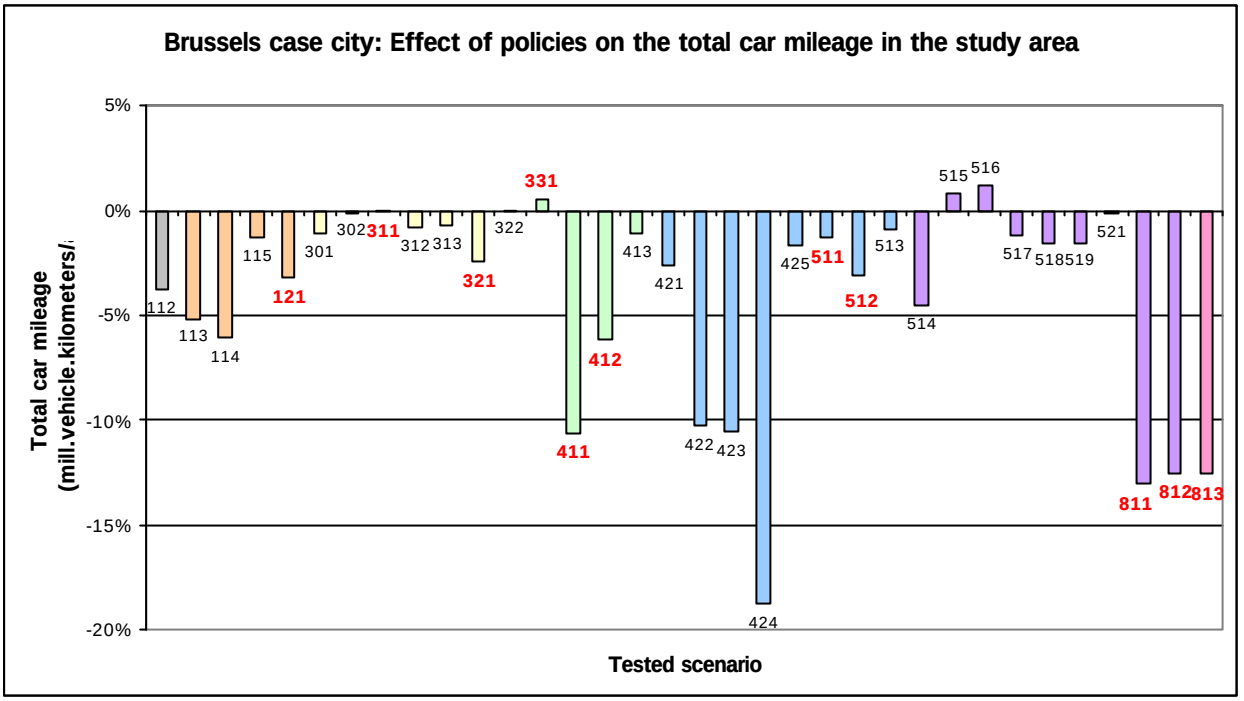


Figure 4.13 : Brussels case city : Effect of policies on the total car mileage in the study area

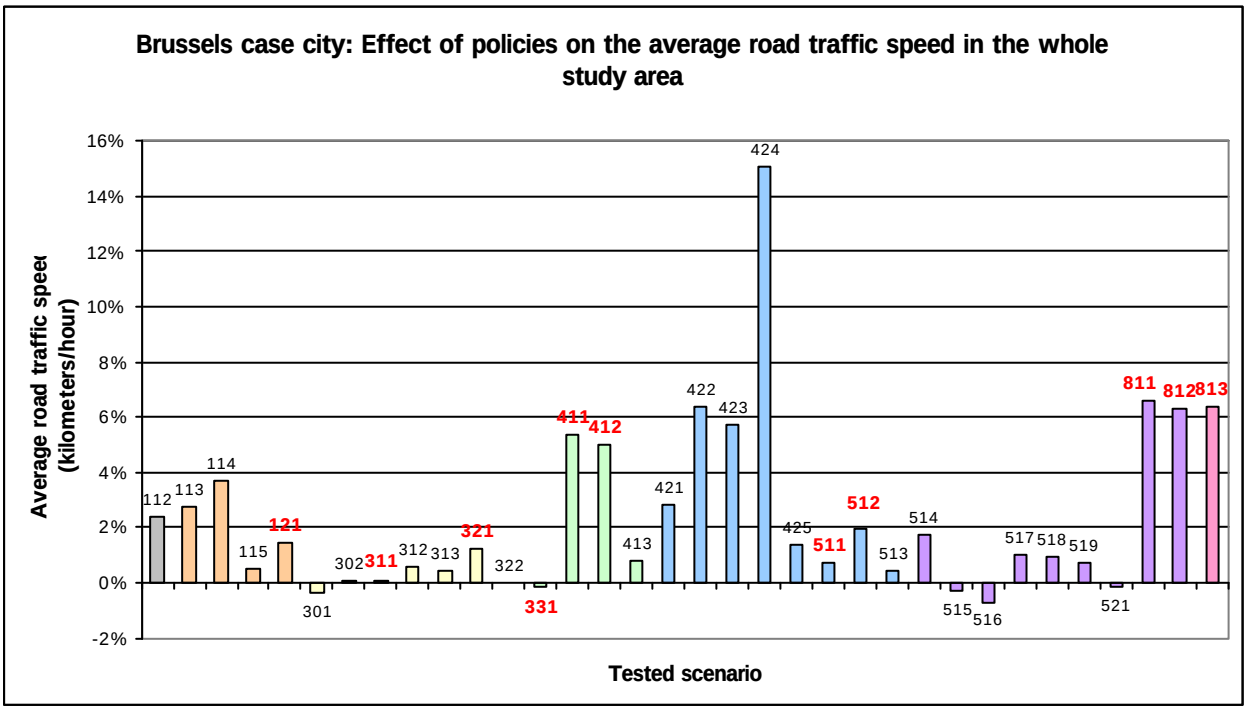


Figure 4.14 : Brussels case city : Effect of policies on the average road traffic speed in the whole study area

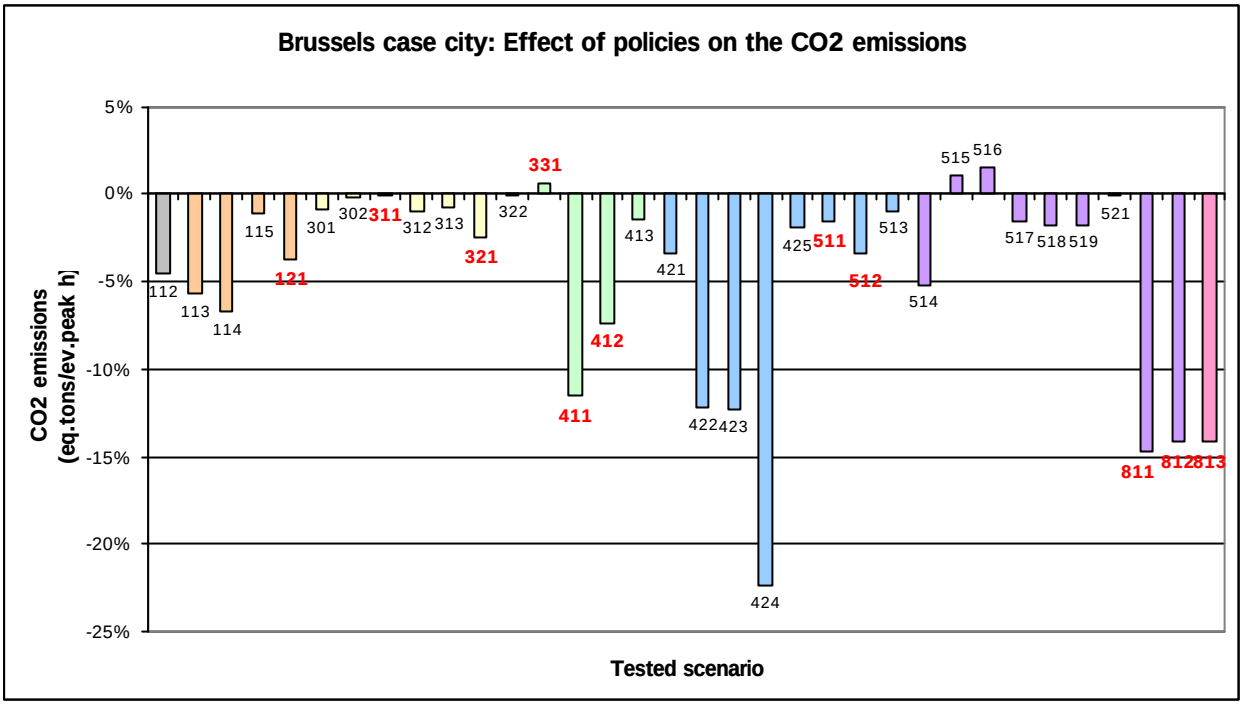


Figure 4.15 Brussels case city : Effect of policies on the CO2 emissions

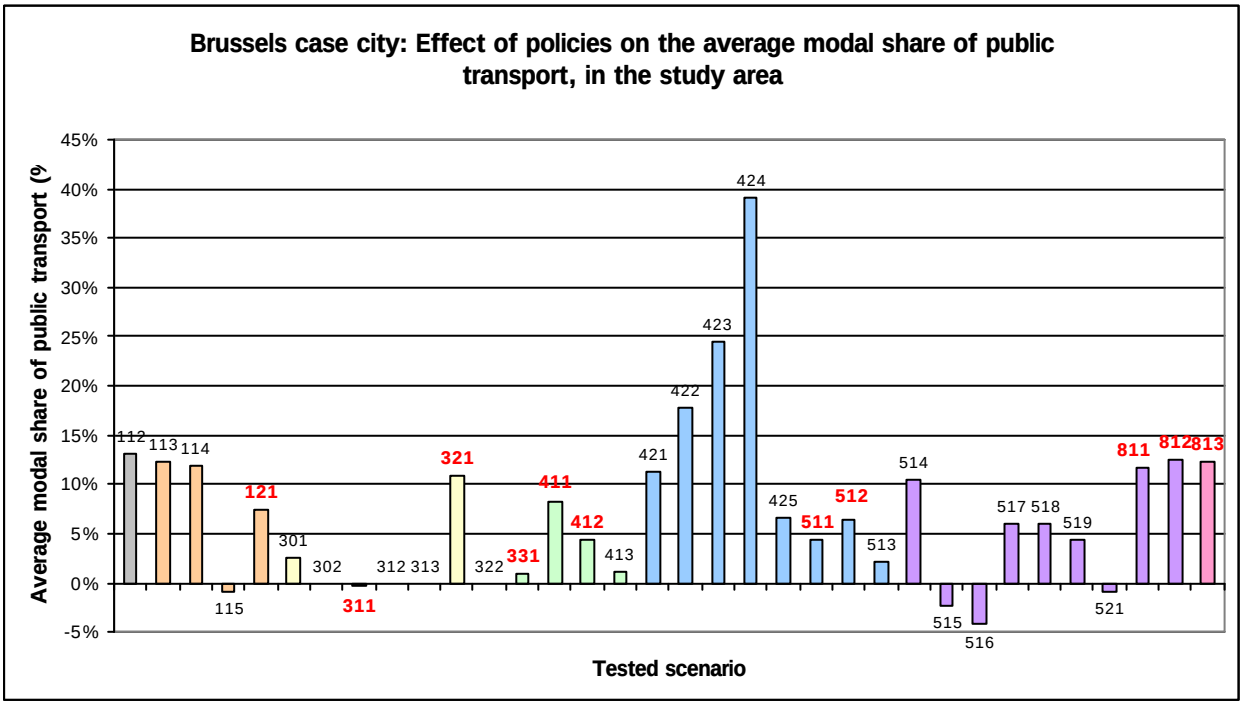


Figure 4.16 : Brussels case city : Effect of policies on the average modal share of public transport, in the study area

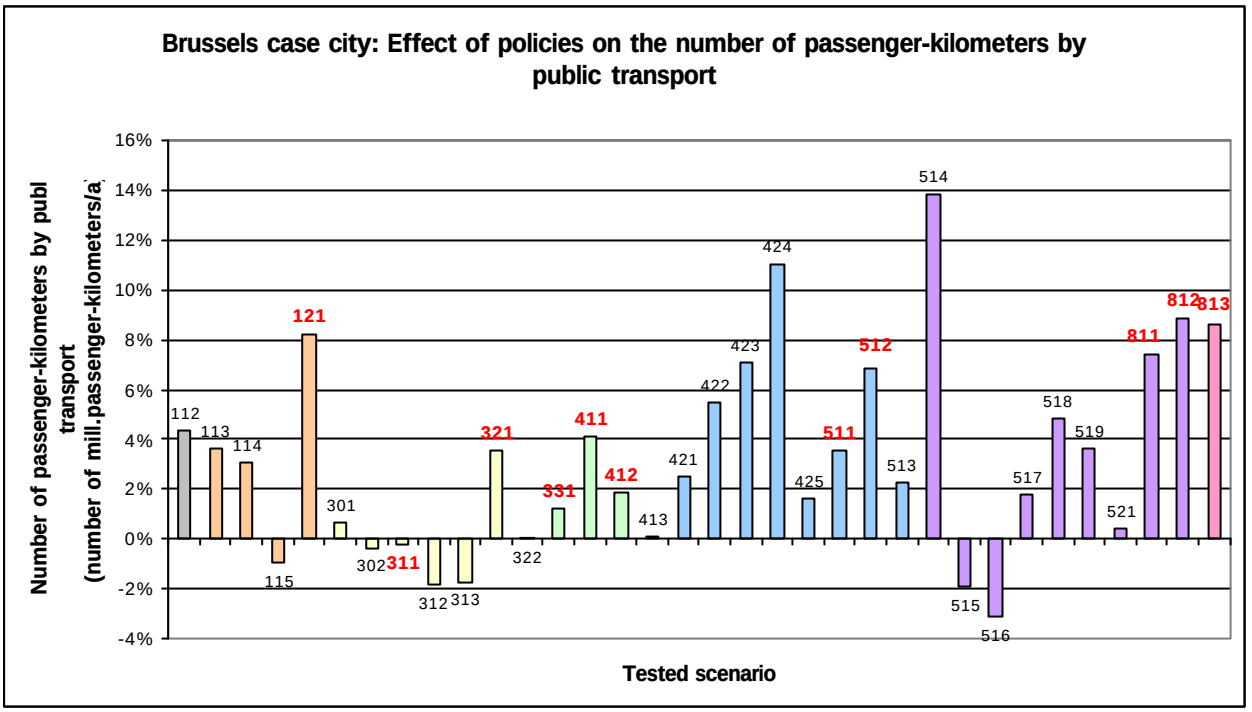


Figure 4.17 : Brussels case city : Effect of policies on the number of passenger-kilometers by public transport

4.6.1. The reference scenarios

- ***Scenario 001B – Reference scenario at horizon 2021, without new public transport services***

The reference scenario 001B includes the overall demographic and socio-economic trends to the horizon year 2021. It also assumes that the objectives of the regional Land Use Plans of the 3 Regions (Brussels-Capital Region, Flemish Region, Walloon Region) are mainly achieved; for the Flemish and Walloon Regions, the objective is to concentrate a major part of the population and employment growth in the urban areas.

The 001B scenario constitutes therefore a continuation of the 1991-2001 trends (in terms of population, jobs and mobility growth) until 2021, with an implementation of the regional land use plan objectives of the three Regions. Only the scenario 002B (with the REN) is compared to this reference scenario 001B, to assess the net effects of the implementation of the REN.

- ***Scenario 002B (=111B)- Scenario 2021 with REN – net impacts of the REN***
- The reference scenario 002B includes the scenario 001B with, in addition, the implementation of the new Regional Express Railway Network, REN (*Réseau Express Régional - RER*), without any accompanying measures.

The comparison of the reference scenario 002B with the reference scenario 001B shows that the new high quality public transport service, which links the central area and the suburban area, will induce urban sprawl, i.e. out-migration of households from the central agglomeration towards the periphery. At the same time, the REN will induce a concentration of employment (namely retail and services) in the central area. The implementation of the REN, of course, also induces a modal transfer from private car to public transport.

In this context, the other policies which are tested in SCATTER are considered as accompanying measures to the REN. Therefore they should be aimed at reducing the negative effects of the REN (out-migration of households and urban sprawl) or reinforcing its positive effects (reduction of the vehicle-km travelled by car).

- ***Scenario 003B (=711B)- Local investment plan – includes the REN and priority measures***

In the case of Brussels, the "local investment plan" is made up of the REN and of a set of measures which go in the sense of the objectives of the federal/regional authorities and which very probably will be implemented in the near future.

Each of the measures making part of the "local investment plan" was first assessed individually. Then these measures were combined into the scenario 003B or 711B.

The "local investment plan" scenario is therefore equal to the reference scenario 002B (including the REN), completed with the following additional measures:

- implementation of a new network of express buses (19 new lines in all), throughout the study area, that completes the REN railway network[9];
- within the Brussels-Capital Region (central urban area): increase of the commercial speed of surface public transport services to 18km/h (517B);
- in the periphery: increase by 20% of the commercial speed of the local buses which drive the users towards the REN railway stations (519B);

[9] This measure is similar to the scenario 112B, except that the commercial speed of the express buses is 18 km/h inside the Brussels agglomeration, instead of 24 km/h.

- in the city-centre (5 communes): improvement of the quality of life in the residential neighbourhoods through diversion of the transit traffic, traffic calming, greening, improving the safety for children (302B);
- in the whole territory of the Brussels-Capital Region: implementation of a hierarchy of the road network, which goes together with the reduction of the network capacity by about 15% (301B). This is a necessary corollary of the previous measure (diversion of the transit traffic and traffic calming) and is also necessary in order to build dedicated lanes and rights-of-way for the public transport.

As regards the impacts on spatial structure and land use, the combination of better public transport services and the establishment of residential zones without through traffic results in a slight increase in households and employment in the urban centre.

A final remark is that, as the local investment plan was very likely to be actually implemented, the combinations of measures (scenarios 811, 812, 813) were simulated on this reference scenario 003B.

4.6.2. The accompanying measures to the REN

In the case of Brussels, according to the interests expressed by the regional and federal authorities which were co-funding the case study, the accompanying measures were mainly assessed against two criteria:

- reducing the urban sprawl and favouring urban concentration:
  - residential concentration (households)
  - concentration of economic activities (jobs)
  - concentrate towards the Brussels-Capital Region as well as in urban centres of the periphery;
- reducing the car mileage and the emission of pollutants and CO_2.

The main impacts of the accompanying measures are commented below.

Objective of urban concentration

Land use regulatory measures, land-related fiscal measures and car pricing measures are the most effective ones to reduce urban sprawl

Indeed, the scenarios of the set 31x, 32x and 33x and 41x are the ones which contribute most to the re-concentration of households and/or jobs, in the Brussels-Capital Region or in all the urban zones together. The ranking between these 3 types of policy is of course highly depending of the levels of the parameters which were tested (level of the taxes, level of the car cost increase). Roughly, the territorial fiscal measures and the regulatory measures appear to be as effective as the increase of car use cost.

Regulation of land use by fiscal or regulatory measures: direct and indirect effects

The measures simulated in the scenarios 311-312-313 (development impact fee applied to households in suburban/rural areas and fiscal incentive applied to households in the urban areas) directly affect the cost of location for the households and hence, have a significant effect on the part of population located in urban zones. In particular they significantly increase the number of households in the Brussels-Capital Region (BCR), which in turn attracts employment induced by the households. The average ratio is about 0.3 induced job attracted in the BCR/induced household locating in the BCR.

On the contrary, the scenarios 321 and 331 affect directly the location of the jobs in the sector “business services”. As a consequence of these scenarios, the number of induced jobs significantly increases in the Brussels-Capital Region, which in turns attracts households. Here, the average ratio is about 0.6 induced household attracted in the BCR/induced job locating in the BCR.

These ratios of course depend on the levels of the policy variables and of the general context (i.e. the other parameters) and cannot be generalised, but it is nevertheless worthwhile noting that in the case of Brussels, the "indirect" effects (on households) of measures directly attracting employment appear to be higher than the "indirect" effects (on employment) of measures directly attracting households.

The improvement of the residential urban environment through traffic calming is also effective for the objective of urban concentration

This measure especially targeted to families is expressed through the local scenarios 301 and 302. Globally, the sum of the 2 scenarios lead well to a slight increase of households in the Brussels-Capital Region. The impact on the number of households and on employment in lower than in the scenarios 311, 321, 331, but the area where the measures 301 and 302 are implemented is small: it consists in only 5 central municipalities of the agglomeration.

Objective of reduction of the car mileage and of the emissions from road traffic

Most effective measures to achieve a significant modal shift towards public transport and to reduce the car mileage

The most effective measures to reduce the car mileage are the measures which restrict the parking facilities (through decrease of capacity or increase of parking tariff) (scenarios 422, 423, 424), the measures increasing the car use cost (scenarios 411 and 412), and the implementation of high quality express buses (scenarios 113 and 114).

The most effective measures with regard to the modal shift towards public transport are the parking policies (scenarios 422, 423, 424).

The measures which most reduce the congestion are again the parking policies (scenarios 422, 423, 424) and the measures increasing the car use cost (scenarios 411 and 412).

On the other side, land use policies (scenarios 311, 321, 331) seem to have minor effects on transport, and in particular on the number of vehicle-km travelled by car, except in the case of scenario 321 (regulatory measure), which indeed leads to a significant increase in the modal share of public transport and a decrease in the car mileage.

This result that land use policies alone have low effects on the mode choices and the level of emissions are confirmed in the 2 other city cases. Potential explanations are given in the section 7.3.2 (inter-city comparison).

Some particular interactions between land use and transport

"Increase of car use cost" versus "cordon pricing": similar effects on the households, opposite effects on the jobs

Within the group of scenarios 411-412 (increase of car use cost), it is worth comparing the results of 411 (increase of the car use cost by 50 % on the whole study area) with those of 412 (cordon pricing – cordon located just inside the "Ring" – tariff: 7.5 €/day). Both policies have a strong effect on the location of households (stronger effect with 412, but the supplement of cost applied is higher), but they have opposite effects as regards employment: when the car use cost increases everywhere, the employment tends to re-centralise, because in that case, the central agglomeration, better served by PT and more generally by radial-form transport networks, remains the most efficient place where to be, but when a cordon pricing is implemented, the employment tends to move outside the cordon, sometimes in municipalities located close to the external border of the cordon. Anyway, in both scenarios, the average home-work trip distance decreases.

Restrictive parking policies have a repulsive effect on employment

Generally speaking, the simulation results confirm that strong parking restriction measures can put to flight tertiary employment.

The results of the scenarios 421, 422, 423, 424 highlight the fact that the effects of the measures are quite different, as regards the attractiveness of the central agglomeration, according to whether the restriction measures are applied essentially to the Brussels-Capital Region or as well to the urban centres in the periphery. In the former case (see scenario 421), the measure leads to a decrease of employment in the Brussels-Capital Region, and a loss of economic vitality. In the latter case (see scenario 423), the central position of the agglomeration makes it more attractive than the other urban centres, and the Brussels-Capital Region is winner in this competition.

In conclusion, the spatial competition between municipalities or regional entities has to be carefully taken into consideration, when implementing restrictive parking policies.

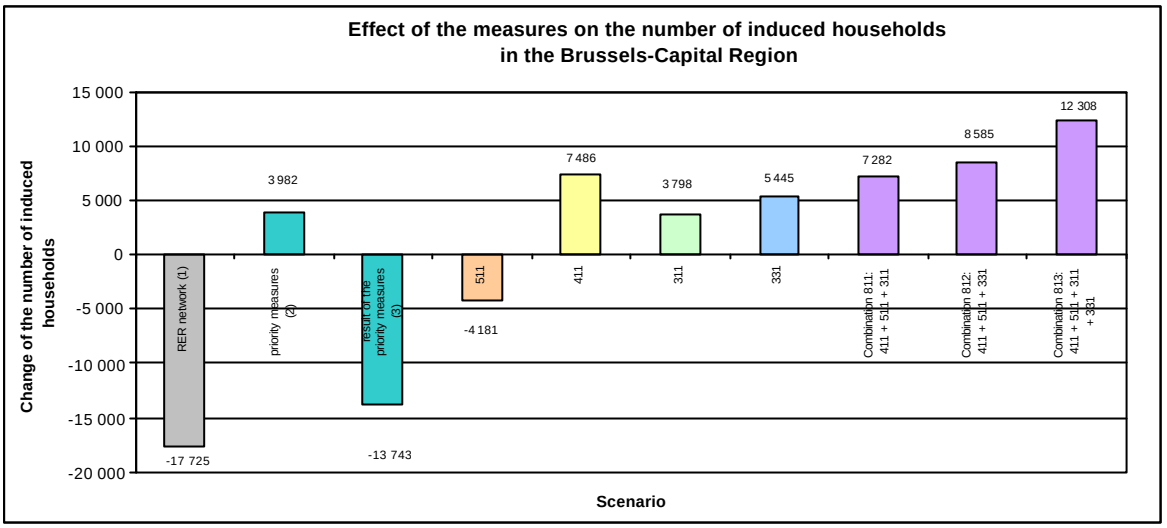
Any improvement of the transport system at regional scale is an incitation to urban sprawl

Experts agree on the fact that the main causes of the residential sprawl are the increase of household income, the inadequacy of the housing market compared to the demand, and the reduction of travel times and costs.

The consequence is that, generally speaking, any measure decreasing the *generalised transport cost* (i.e. the travel time or the travel cost) results in an increase of the urban sprawl, i.e. a decrease of the part of population locating in the urban zones. This concerns in particular the scenarios 518 (improving the inter-modality at railway stations), 519 (optimising the transport networks driving users towards the REN) and the scenarios 511-514 (decrease of the public transport fare).

On the contrary, an improvement of the public transport when it is territorially limited to the central urban area makes this area more attractive both for households and economic activities and leads to a concentration of activities

The scenario 517 in which the public transport speed is improved only on the territory of the Brussels-Capital-Region leads to an increase of both households and employment in the Capital Region. In the scenarios 112-113 (HOV lanes, implementation of express buses + decrease of road capacity on the main radial roads), the combination of the improvement of public transport (including in the central agglomeration) and of the lower road capacity leads to a slight increase of households in the Brussels-Capital Region.

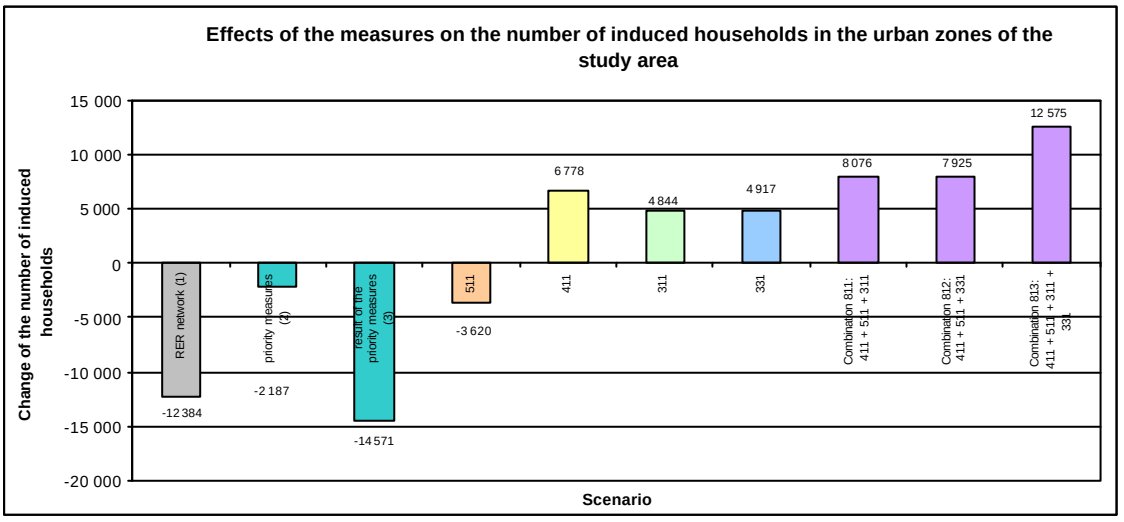


Types of scenarios:

- 2021 RER network
- Priority measures (new 2021 reference)
- Decrease of PT fare
- Increase of car use cost
- Fiscal measure on housholds
- Fiscal measure on services to business
- Combination of measures

(1) The effect of the RER network is calculated in comparison with the 2021 reference scenario
(2) The effect of the priority measures is calculated in comparison with the 2021 RER scenario
(3) The effect of the priority measures is calculated in comparison with the 2021 reference scenario
The effects of the other meaures are calculated in comparison with the priority measures

Figure 4.18 : Effect of the measures on the number of induced households in the Brussels-Capital Region



Types of scenarios:

- 2021 RER network
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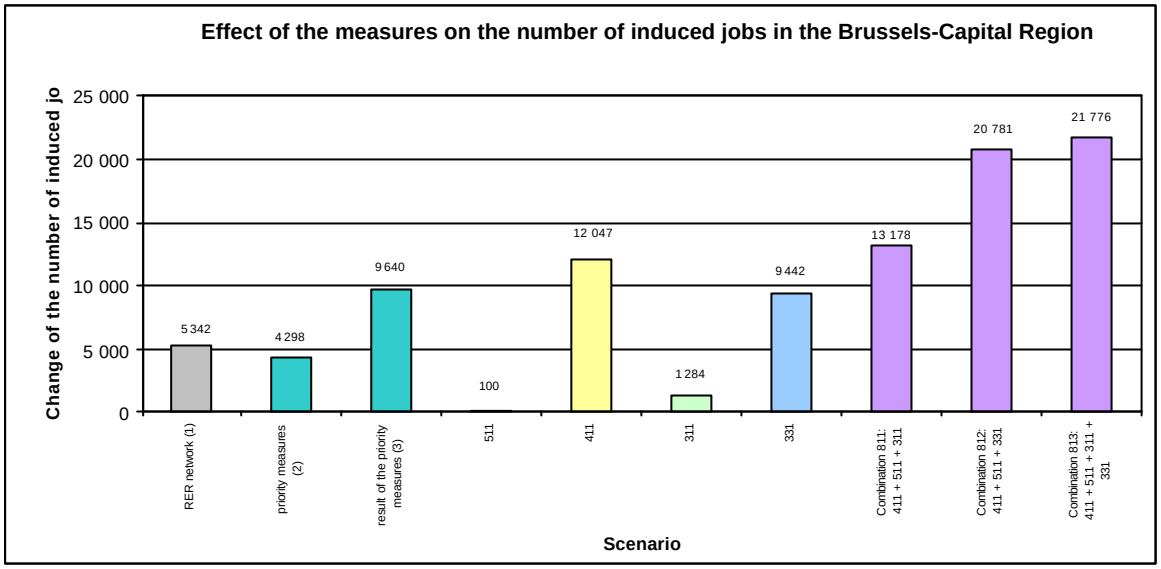
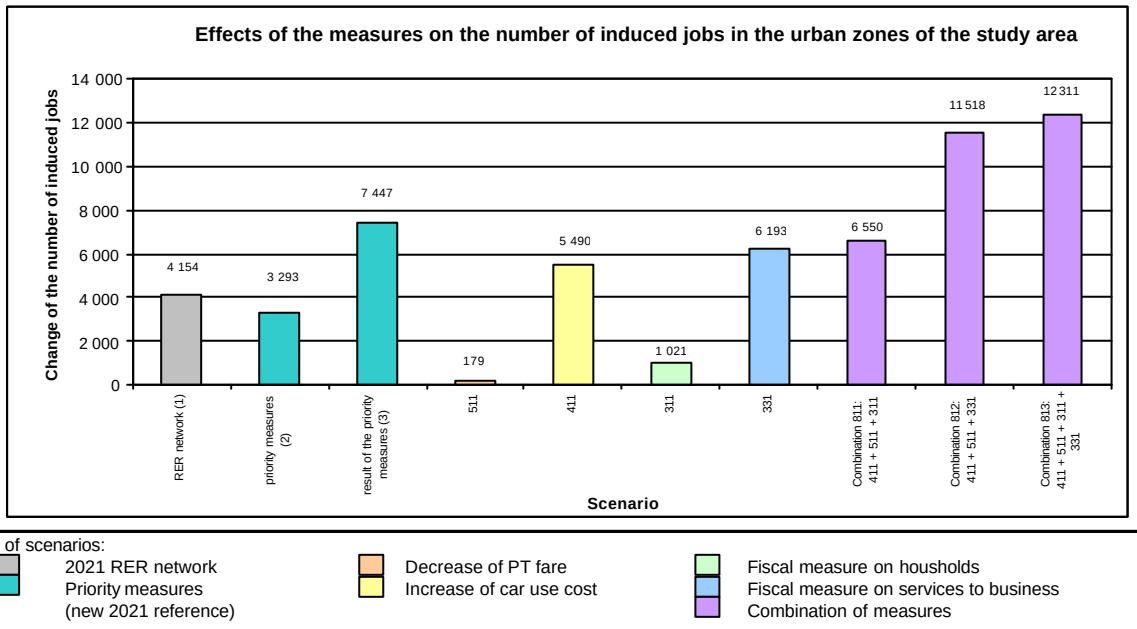
(1) The effect of the RER network is calculated in comparison with the 2021 reference scenario
(2) The effect of the priority measures is calculated in comparison with the 2021 RER scenario
(3) The effect of the priority measures is calculated in comparison with the 2021 reference scenario
The effects of the other meaures are calculated in comparison with the priority measures

Figure 4.19 : Effect of the measures on the number of induced households in the urban zones of the study area



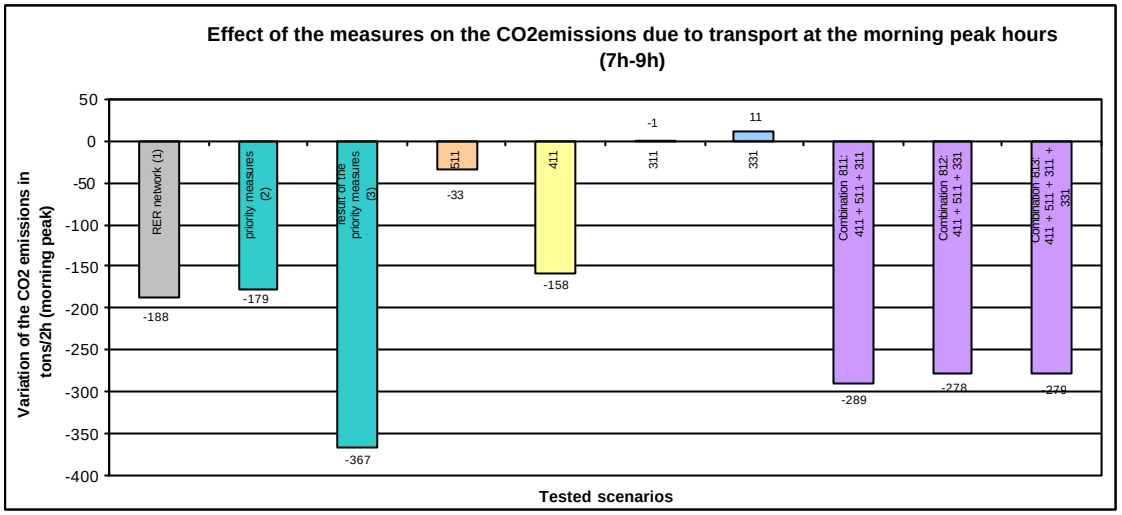
(1) The effect of the RER network is calculated in comparison with the 2021 reference scenario
(2) The effect of the priority measures is calculated in comparison with the 2021 RER scenario
(3) The effect of the priority measures is calculated in comparison with the 2021 reference scenario
The effects of the other meaures are calculated in comparison with the priority measures

Figure 4.20 : Effect of the measures on the number of induced jobs in the Brussels-Capital Region



(1) The effect of the RER network is calculated in comparison with the 2021 reference scenario
(2) The effect of the priority measures is calculated in comparison with the 2021 RER scenario
(3) The effect of the priority measures is calculated in comparison with the 2021 reference scenario
The effects of the other meaures are calculated in comparison with the priority measures

Figure 4.21 : Effect of the measures on the number of induced jobs in the urban zones of the study area



(1) The effect of the RER network is calculated in comparison with the 2021 reference scenario
(2) The effect of the priority measures is calculated in comparison with the 2021 RER scenario
(3) The effect of the priority measures is calculated in comparison with the 2021 reference scenario
The effects of the other meaures are calculated in comparison with the priority measures

Figure 4.22 : Effect of the measures on the CO2 emissions due to transport at the morning peak hours (7h-9h)