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Success factors for implementing low-carbon mobility instruments in cities: Learning from European, American and Asian case studies

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This report extends previous work concerning the design, census and typology of the public policy tools of urban mobility management. It looks at the key factors that facilitate (or jeopardize) their economic efficiency and their implementation. Focusing on the instruments that weigh on CO_2 emissions, we expand on evidence-based case studies in London, Singapore, New York and Portland. We identify the success key factors for policy implementation in each cities. Results are extrapolated so as to deliver some recommendations for Beijing (which shares key factors with Singapore for the issue analyzed here) and the French city of Lille (comparable to some stylized facts of Portland).

Keywords: Parking charging, urban tolling, second-best instruments, CO_2, international evidences, success factors analysis.

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SUCCESS FACTORS FOR IMPLEMENTING LOW-CARBON MOBILITY INSTRUMENTS IN CITIES: LEARNING FROM EUROPEAN, AMERICAN AND ASIAN CASE STUDIES

Abstract

This report extends previous work concerning the design, census and typology of the public policy tools of urban mobility management. It looks at the key factors that facilitate (or jeopardize) their economic efficiency and their implementation. Focusing on the instruments that weigh on CO_2 emissions, we expand on evidence-based case studies in London, Singapore, New York and Portland. We identify the success key factors for policy implementation in each cities. Results are extrapolated so as to deliver some recommendations for Beijing (which shares key factors with Singapore for the issue analyzed here) and the French city of Lille (comparable to some stylized facts of Portland).

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OUTLINES

Introduction

Managing road passengers' transport is a primary target for climate policy-making. The transport sector is indeed one of the largest energy consumer and CO_2 emitter, next to the manufacturing industry, building and energy sectors. It represents more than 23 % of the world-wide fossil fuel combustion (ITF, 2010). Road mobility represents 72 % of European emissions in the transport sector in 2009 (EEA, 2009) and 82% of the EU-27 final energy consumption in 2010 (EEA, 2012). In urban zones, the share of car trips is the dominant form of transport. In France for instance, the circulation of private cars represents close to 60% of road transport energy consumption. Road freight (trucks and light commercial vehicles) consumes around 35.7 % (ADEME, 2012). In developing countries (particularly in China and India; see IEA, 2012), managing road mobility is also becoming a priority for regulators.

Table 1 below exhibits the possible policy-instruments as concerns the management of road passenger transport in urban areas:

Table 1: Overview of policy instruments in road passenger transport

	Instruments
Planning	Land use planning, high density mixed use developments, travel planning, freight movements;
Regulatory	Traffic management measures including: ***parking restrictions***, road space reallocation for public transport and non-motorized transport, restrictions on specific vehicle types, speed limits;
Economic	Pricing instruments including: fuel taxes, vehicle taxes, ***parking pricing, congestion charging***, transit fares, low emission zones;
Information	Travel awareness campaigns;
Technology	Teleworking, teleconferencing, eco-driving schemes, biofuels, hybrid electric vehicles and plug-in hybrid electric vehicles, electric vehicles, hydrogen.

Source: EEA (2010)

This report focuses on economic and regulatory instruments which affect parking conditions and road use, parking charges and spaces regulation and urban tolling. Indeed, beyond regulating tools, policy instruments that modify the generalized cost of car trips such as vehicle fees, fuel prices, public transit fares, congestion tolls and parking charges are found to influence the most modal split (VTPI, 2013) and belong to the levers identified by Schipper and al. (2007) for reducing CO_2 emissions from transport activities. Complementary measures combined with parking and road pricing measures will also be investigated. Price signals (cf. third row in the table 1) will be analyzed as far as their effect on travel mode choices is concerned (Ortuzar and Willumsen (2011)), Santos and al., 2010; VTPI, 2013).

This report reviews the efficiency properties and shortcomings of parking measures and urban tolls when implemented alone (1.1. and 1.2.) and when combined one with another (1.3.) or with other complementary measures (1.4.). The key factors for a successful implementation of these schemes are investigated in big cities located in Europe (London), North America (Portland) and Asia (Singapore). The third part presents numerical application, forecasting scenarios and possible policy recommendations for two other cities (Lille, characteristic of medium-size cities dependent of car-mobility and Beijing, representing immerging cities where car mobility explodes).

1. Efficiency properties of congestion charging and parking policies to influence the modal shift and cut CO_2 emissions

1.1. Relevance of (stand-alone) parking measures

Automobiles are parked 95 % of the time on average, either in on-street public parking (charge-free but of limited resource) or in private off-street parking (VTPI, 2013). Residential off-street facilities can be provided by building owners, in line with the high requirements from local housing regulators and the belief that a tight link exist between dwelling choice and level of parking services. As a result, land use can be inefficiently occupied by barely used parking slots, especially in areas with low vehicle ownership (Shoup, 1999) like city-centers. Consequently, parking policies can be perceived as a low-hanging fruit for mode shift and CO_2 mitigation – and in particular residential parking.

Bonsall and Young (2010) explain that urban parking policies may contribute to six different goals: "*healthy economic climate; efficient use of transport and land resources; ease of mobility/accessibility; equity of resource distribution; improvement of environmental quality; and enhanced amenity/ cultural attractiveness*". Parking charging deals with road use and congestion challenges (and with *concentrated* congestion in particular, i.e. when much of the traffic is terminating in a same area). It has less distributional consequences than urban road pricing, lower costs of operation and is easier to regulate (Button, 2006). Parking charging "*may appear preferable as a second best device for containing congestion and other externalities [than urban toll]"*.

Increasing travelling costs of automobiles through parking charging is usually recommended by economists (Kaufmann and Guidez, 1996) to trigger mode shift to mass-transit. Indeed, 'parking problems and costs' appear to be the main reason to switch from private car to public transport (Hensher, 2007).

The different goals of parking policies (*e.g.*, environmental objectives, accessibility, public transit system's performance, or regional attractiveness) can be conflicting. Button (2006) highlights the difficulty to sort out the different policy-objectives of parking activity regulation. The public or private governance can modify policy goals, particularly in dense areas where ever higher space constraints must be combined with accessibility extension for disabled persons or goods delivery issues. Button (2006) explains the inefficient allocation of road space as a consequence of regulators' tendency to distribute parking slots according to the willingness of individuals to spend *time* for parking purposes, rather than (driving out) spending *price*.

The lack of homogeneity between municipalities' decisions and the regional scale policymaking adds more to the governance challenges. Street parking regulation is generally part of the road system management but it can also belong to the wider transport network regulation or land-use policy of a community. At least, real time information on the availability of spaces and/or on pricing rules can be missing and lead to asymmetrical information problems between off-street parking providers (who possess the information) and parking spaces "consumers".

Beyond governance and institutional challenges, some other factors need to be considered upfront for a successful implementation of parking pricing schemes (Bonsall and Young, 2010):

- **Spatial adverse effects**. Parking activity can be diverted from the charged area onto un-priced nearby streets, where negative external effects from car use can be stronger (air pollution, congestion, noise, phenomenon of "urban heat island", etc.). Second, bad geographical coverage of motorists, e.g. as an effect of subsidized parking spaces at workplaces which puts a significant target of car users out of the pricing control, can hamper the efficiency of the scheme. At least, because the charging regime is not, by definition, distance-differentiated, parking pricing can play over the long run on housing decision (the additional fixed fee rendering longer trips relatively less costly than shorter ones), thus leading to urban sprawl, and potentially re-increasing overall emissions.

- **Trip-makers 'acceptability**. Increasing parking fees, especially at workplaces – as part of a corporate travel plan for instance – is known for leading to high staff opposition, particularly in the public sector (Ison and Rye, 2003). Also, again, because parking fees take the form of a fixed amount added to the generalized cost of a trip by car and impact proportionally less individuals making longer trips, equity and acceptability issues can be raised if one assumes that high income groups are commuting longer distances (particularly in American cities; see Bonsall and Young, 2010). Another undesirable consequence deals with the worsening-off of local economic activity (e.g. the suppression of shopping trips and adverse impact on retail turnover; see Bonsall and Young, 2010). Nevertheless, empirical studies (e.g. the on-worksite car parking charging experiment in the Netherlands; Ison and Rye, 2003), show that opposition to such measures usually vanishes right after their introduction – as long as they are carefully designed (e.g. income-based charges) and that revenue hypothecation directly or indirectly benefits to the commuting staff (e.g. transit improvements for the journeys to work, etc.).
- Finally, a common feature of any new policy implementation's success conditions is the **hysteresis phenomenon**. Indeed, people's behaviors are difficult to move to optimal ones due to stranded cost and uncertainties (Button, 2006).

1.2. Relevance of (stand-alone) urban road pricing in the light of CO_2

Urban road charging is a sound instrument usually recommended by economists to "*raise revenue, reduce traffic congestion, rationing road space, improving the local environment, mitigating climate change, and enhancing social inclusion and equity"* (Bonsall and Young, 2010) through the pricing of the social marginal cost of a trip.

More precisely, the social optimum (see De Borger and Proost (2012) for a political economic model) requires to set a tax $t = cn^*$ at the marginal external cost (c) of the optimal traffic flow (n^*). Tolling vehicle drivers who enter a specified geographical zone for the cost of the congestion they impose on other drivers is indeed a useful instrument to deter from car use and encourage low-carbon emitting modes.

Estimates from the Stockholm charging trial introduced in January 2006 show for example (Eliasson, 2008) that close to one-fourth of the work trips by car passing the cordon disappeared (between September 2004 and March 2006), of which the big majority moved to public transit and the rest adapted to the scheme by changing frequencies, combining trip purposes and increasing trip chaining.

The literature review from Li and Hensher (2012) on the impact of congestion pricing on travel behaviors shows that changes in departure times was the major effect from the scheme (when it is time-differentiated, for example in Stockholm), followed by reduced car use, modal shift and relocation of work and/or residential activity. Besides, the use of congestion tolling also avoids having to resort to road capacity investments (to address congestion) that usually induce road traffic (the 'Downs-Thomson paradox', see Ding and al. 2008) and therefore other negative externalities (namely environmental impact, unsafety or infrastructure use).

However, if toll revenues can be hypothecated to public transport improvements (as for parking fees), **political acceptability** of urban tolling is usually lower than for parking charging (Zatti, 2004)[1], especially due to its wider charging coverage (e.g. targeting the commuting staff only in the case of parking measures in the frame of a corporate travel plan for example; see Ison and Rye, 2003 versus a whole region in the toll case).

Referring to the conditions of Gunn (1978) for a *perfect implementation* of a policy measure, Ison and Rye (2003) highlight the following success factors relating to congestion charging:

- **External circumstances** – e.g. the quality of the public transport system, revenue perception and use, technological conditions and the severity of congestion – strongly play on the level of public acceptability. As an illustration of the technological factor, the technology used in the electronic road pricing scheme (ERP) in Hong Kong raised public opposition due to the fact that it was a western European (British) patented technology (Ison and Rye, 2003), thus undermining the trust of the population with regard to the overall introduction of the scheme. On the latter condition, the low level of congestion in Cambridge for instance partly explains the failure in implementing the scheme in 1993. On the contrary, the excessive congestion level in Bergen (relatively to the size of the city) was key in the approval of the scheme. Nevertheless, some authors tend to nuance this idea: Eliasson (2008) claims that there was no statistical evidence in the case of Stockholm of a relation between the level of congestion and the degree of accepting the toll.

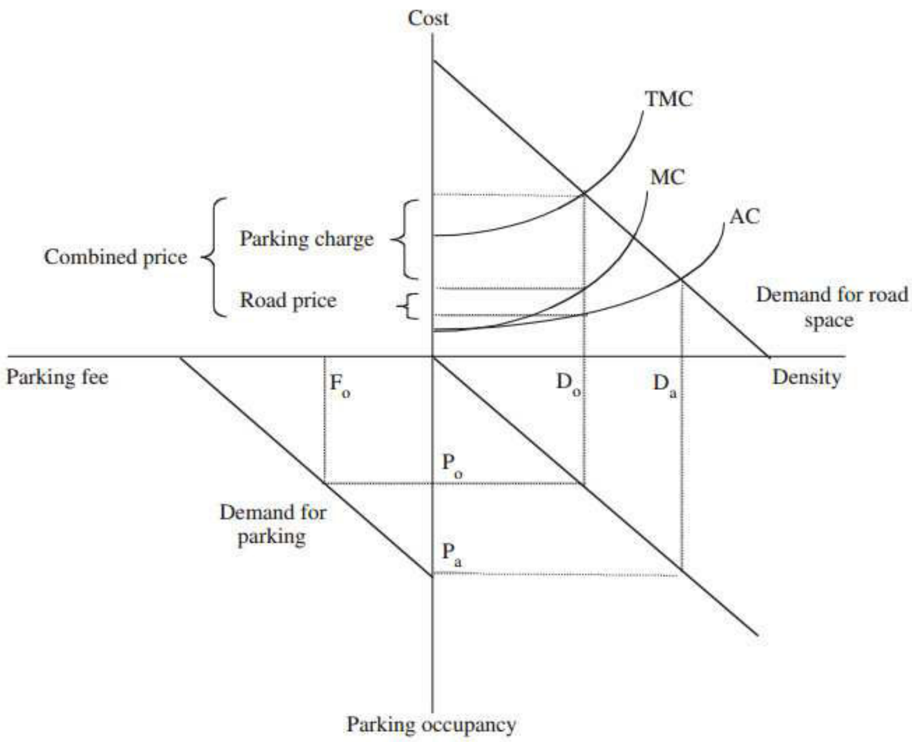
- **The availability of financial resources** (operating expenditures, administration and enforcement costs – in particular for congestion metering on beforehand of the implementation of the scheme and public transit system strengthening afterwards) along with a **good traffic predictability** (limited by the intrinsic uncertainties due to the dynamic pattern of trip-makers adaptation strategies) generally secure the core functioning of the scheme;

- **A consistent theory of the cause** (need for an analysis of the nature of the problem – what drives demand for private transport and traffic congestion) **and of the effect of the policy** (more visible if the implementing groups – i.e. county, city, district councils, etc. - are cooperating on the measurement of the results and have an interest in metering the outcomes) should be communicated to the individuals.

- **Objectives of the scheme and use of the revenues** should be clearly stated. New elections or political instability to a larger extent (e.g. opinion divergences between the electorate and the politician, opportunism of the decision maker and associated moral hazard and adverse selection problems; see De Borger and Proost, 2012) can affect the goals – and even the existence – of the scheme. Edinburgh, Birmingham, Manchester or New York's attempt cases illustrate such failure. However, changes over time in the definition of the scheme's objectives may happen, in line with the new political agenda, without being detrimental. For instance in Norway, the Oslo, Bergen and Trondheim cordon tolls schemes' objectives have moved from road investments and public transport improvement funding to gridlocks reduction, as a result of growing congestion problems and were still well accepted by the

[1] In Santos (2010).

population. Secondly, political uncertainty with respect to the use of revenues can increase the probability that voters will be against the introduction of the toll. To be noted in this regards that public transport subsidization is preferred over toll-revenues redistribution to all voters (De Borger and Proost, 2012). Dealing with the enforcement of urban toll and the planning of its objectives, the specification and **correct ordering of the corresponding tasks** is an additional challenge in the case of congestion charging since experiences abroad are relatively poor (even if practices have largely increased over the last years since Singapore (1975), Bergen (1986), Oslo (1990) and Trondheim (1991) with: London (2003), Stockholm (2006), Durham (2002), Milano (2008), Rome (2001) and Valletta (2007); The Netherlands, Copenhagen, Budapest, Gothenburg, Djakarta and San Francisco (to be planned)) and thus offer little possibility of comparison.



1.3. Efficiency of combining parking charging and road pricing tools

Economic efficiency properties for road space allocation – and thus environmental outcomes – of combining parking measures (here parking charging) and urban road pricing schemes are illustrated in the figure below (Button, 2006).

Figure 2: Combining parking charging and urban road pricing. Source: Button (2006)

Reading note: When no regulating tool is implemented, the traffic density on a given road is D_a. This results from the intersection of the line for marginal benefit of using road space (*Demand for road space*) and the average congestion cost curve, *AC*. If congestion charge is introduced, set at the marginal cost of congestion *MC*, and if it is combined with parking fees, set at the opportunity cost of parking – altogether forming *TMC,* the total marginal cost of road space use – the demand for road space reaches its optimal level, D_o. Now if parking charges *only* are implemented (F_o), assuming that congestion pricing is impossible to put in place (e.g. due to too high transaction costs or acceptability problems), users are charged only at the end of their trip, without distinguishing between road use and parking space pricing (all is included in the parking fee).

However, this situation is highly context-specific since such an optimal parking occupation P_o, resulting from a fee F_o, can be hindered by capacity constraints or heterogeneous traffic patterns (dissimilar parking duration among road users). Therefore, the use of upfront road space rationing tools (congestion charge) is strongly needed, and the parking fee acts here as a complementary device to road price and must be adjusted accordingly.

Bonsall and Young (2010) add an interesting point to the literature dealing with congestion charging and parking pricing combination. While they consider that roads and parking spaces regulation should be planned in concert, that both share the same broad social, economic and environmental aims relying on pricing signals to influence drivers' choices and that they can generate revenues to finance alternative modes to car use, they also advocate for an implementation of congestion charging (recommendation of a cordon toll during weekday peak periods) while *abolishing* parking fees (removal of the charges for all publicly owned parking spaces and replacement by a time duration limit only). The underlying assumption is that an increase in parking charges is unwanted, as it mostly leads to undesirable destination changes (resulting from the research for cheaper parking alternatives elsewhere) rather than e.g. mode shift or car trip cancelations. Correspondingly, the proposed policy-package seems to provide wider beneficial effects on equity (by encouraging parking turn-over and preventing that all-day parkers subsidize those who park for free, those who do short stop or transit trips in the city) and on the retail economy (encourage off-peak parking and visitors).

1.4. Complementary measures

Public transit pricing can illustrate an additional measure to congestion charge and parking regulation tools. The France-England comparative analysis of Bresson and al. (2003) shows that public transport demand is largely responsive to a change in fares, making transit subsidization another relevant driver for modal shift. Transit price elasticities are however different according to the frequency of use of the trip maker (e.g. minor bus user being more sensitive), its working status (active are more sensitive) and driving license holding (less responsive). Moreover, trip makers seem to react more to fare increase (reflecting higher travel conditions, lower trip duration, etc.) than to free fare programs (beyond being costly to implement, they largely decrease the service attractiveness in line with saturation effects).

From a broader perspective, May, Kelly and Shepherd (2006)[2] identify four ways in which policies (parking charging, congestion pricing and additional measures) can combine with each other:

- Complementarity: the use of two instruments has greater impacts than the use of either alone;
- Additivity: the benefit from the use of two or more instruments is equal to the sum of the benefits of using each in isolation;
- **Synergy**: the simultaneous use of two or more instruments yields higher benefits than the sum of the benefits of using either one of them alone (Additivity and synergy can be considered as two special cases of complementarity (May et al., 2006, p. 321)); and
- Substitutability: the use of one instrument completely eliminates any benefits from using another instrument.

At least, accompanying 'pull' measures (disincentives) with 'push' tools (incentives) reinforces the success of implementing a policy (Ison and Rye, 2003).

[2] In Santos (2010)

To sum up, when combined one to each other, parking charging and urban road tolling can lead to synergy effects once implemented. In part 2., we take a closer look at the key factors for a successful implementation in the cities at focus, before testing a numerical application with scenarios forecasting and policy recommendations for two other cities in particular (part 3.).

2. Learnings from case Studies

2.1. Different regional contexts relating to urban passengers mobility

A few cities have been selected in Europe, North-America and Asia in order to highlight distinct mobility contexts and specific challenges for the discussion.

The **European zone** is characterized in most of empirical studies by road space constraints in downtown. In these zones, public policies essentially strive to reduce car mobility and to encourage the use of public transport and soft modes. In addition, urban sprawl is particularly marked and results in increasing distances traveled associated with negative road externalities (Arribas-Bel, 2011).

The **North American** region is the most car-dependent. Major capitals of medium size observe externalities problems, urban mobility being almost exclusively dependent on the automotive (Guo, 2013).

In **Asia**, mobility patterns are not as mature as in Europe and North-America, but the booming economic growth is very likely to be accompanied by increasing car mobility. Indeed, whereas developed western countries show an average car ownership growth rate of 16 % between 2000 and 2005 (case of Canada, Netherlands, UK and the USA), developed Asian countries have observed an average increase of this share of 34 % (Hong Kong, Japan, Singapore and South Korea), and this percentage grows to 40% for developing Asian countries over the same period (China, India, Malaysia and Thailand; see more in Prevedouros and An, 1998).

2.2. Selection of cities

2.2.1. Europe: London

London has been selected for our empirical application for several reasons:

- A congestion pricing scheme is applied.

- Parking charges are high. As a part of its decentralized parking management, the London Borough has introduced high charges (see *Band A* pricing; LondonCouncils, 2014) and a CO_2-based pricing scheme for parking spaces in the Borough of Barking and Dagenham (information obtained from residents vehicle's engine capacity and the time of the vehicle registration; Lbbd, 2013). In this regards, London contrasts with major European cities such as Paris or Madrid for using parking fees as a real help to restrict automobile.

- A smart combination of policy-tools is applied for deterring automobile use. London has simultaneously adopted parking charges, congestion toll and low emissions zones. For the comparison, both Italian cities of Florence and Bologna have also introduced low emissions zones[3] but without introducing simultaneously any of the other pricing tools as in London (yet potentially leading to synergy effects, as mentioned in the previous part of the report).

2.2.2. North American cities: New York City/Portland

Portland has been chosen for the following reasons:

3 http://www.lowemissionzones.eu.

-Portland is an American *counterexample*. The capital of Oregon is an exception to American cities judging from its successful deployment of public transport facilities. Despite a significant presence of automobiles in the USA (with a rate of motorization approaching 80% in 2010; cf. World Bank data, 2010), Portland has massively invested in public transit projects, such as light rails, underground stations and multimodal platforms (Rice, 1997).
-Parking management is stated as a tool to protect the environment. Since 1975, Portland is concerned by the problem of air pollution and use parking restrictions to limit car use and associated externalities in the central business center (CBD) and to promote modal shift.
- Portland is the birthplace of carsharing. In 1998, Portland was the first city in the world to develop a network of private car-sharing, promoted by public actors.

New York was also selected as a relevant case for illustrating the **failure of the congestion charge.** In 2006, The New-York City Mayor Mr. Bloomberg announced the project of congestion charging in Manhattan. The project was part of the wider sustainable development plan of the city for reducing congestion and CO_2 emission. However, this project was a political failure, essentially explained by the diverging interests of the Council of State on the one hand and the city of New York on the other hand. Since it was planned to only impact a small part of the population, equity issues were raised. Aborted in 2008, the project of congestion pricing also came in a difficult context for North American economy, at the eve of the financial crisis.

2.2.3. Asian area: Singapore

Singapore was chosen for the following reasons:
-Singapore is the pioneer of congestion pricing. The early introduction of the Area Licensing Scheme (ALS) in 1975 shows the extent to which Singapore was visionary about congestion pricing. Even if many Asian cities (such as Jakarta, Bombay, Nanjing and Shenzhen) have been studying congestion pricing project, none of them chose or managed to apply it (Walter, 2008)
-An Upstream approach with the Vehicle Quota System (VQS). To anticipate demographic problems associated with the insular form of Singapore, the city introduced in 1990 the VQS in order to regulate upfront the number of vehicles on its territory.

2.3. Summary of the congestion charging, road pricing and additional measures experiences in London, Portland and Singapore

Main information on the design of the parking management, road pricing and additional policy tools of the selected cities are summarized below, respectively in table 2, table 3 and table 4.

2.3.1. Parking policies

Table 2: Design of the parking policies implemented in the three studied cities

Cities	London	Portland	Singapore
Main goals	Reducing congestion.	Reducing mileage and parking spaces.	Managing road use and reducing congestion.
Introduction date	From 1991.	N/A	N/A

<table>
<tr><td>Measure description</td><td>Controlled Parking Zones
The Road Regulation Traffic act of 1991 gives the parking regulation competence to the local boroughs councils.

CO_2-based parking permits
Ex. : Parking fees in Islington
<table><tr><td>Post-2001 CO_2g/km</td><td>Permits 12months</td></tr><tr><td>0-100</td><td>Free</td></tr><tr><td>101-110</td><td>15£</td></tr><tr><td>111-120</td><td>27£</td></tr><tr><td>121-130</td><td>72£</td></tr><tr><td>131-140</td><td>87£</td></tr><tr><td>256 and above</td><td>420£</td></tr></table></td><td>Flexible system of Parking maximum
No minimum parking requirement in the central city
-Parking maximums in most neighborhoods including downtown.
Transferable parking rights in areas with parking maximums.
Special arrangements for car-sharing vehicles, transit access and bicycle parking.
Context-specific standards and provisions for shared parking.</td><td>Minimum parking requirement.
Transport management tool.</td></tr>
<tr><td>Planning authorities</td><td>Greater London,
The boroughs.</td><td>Portland City,
The Region of Portland,
Private actors.</td><td>National Authority (Land Transport Authority).</td></tr>
<tr><td>Revenues</td><td>212£ M for Greater London.</td><td></td><td></td></tr>
<tr><td>Outcomes</td><td></td><td>Air quality.
Increased transit ridership</td><td>Improving public transport.</td></tr>
<tr><td>Equity</td><td>Transfer of revenues to the Freedom Pass program and for financing transport projects.</td><td>Promotion of mobility conditions for pedestrians.</td><td></td></tr>
</table>

Sources: Institute for Transportation and Development Policy (2010), US Environmental Protection Agency, (2006), Asian Development Bank, (2011)

2.3.2. Road pricing

Table 3: Different road pricing strategies created by the three cities at focus

Cities	London	New-York-City	Singapore
Main goals	Reducing congestion.	Reducing congestion and greenhouse gases emissions by 30%) between 2007 and 2030.	Managing road use and reducing congestion.
Measure description/type of toll	Congestion charge / Zone	Congestion charge / Zone	Electronic Road Price (ERP) / Cordon
Planning authorities	**Transport for London.**	**Mayor of New-York / Department of Transport (US) /Assembly of New-York State** (the Assembly voted against the scheme)	**National authority (Transport land Authority)**
Introduction date	17 February 2003.	Announced in 2006 abandoned in 2008.	Area Licensing Scheme (ALS) since June 1975. ERP since September 1998.
Fee level	£10 daily fee.	Mayor's Plan: $8 daily fee for	ERP fee depends on the time

		cars, $21 for trucks. Since the Traffic Congestion Mitigation Commission (TCMC) revision, $7for low-emitting trucks.	of the journey and gantries (between $0 - $6).
Revenues	£148M generated for 2009/10.	$400 M for the first year fully dedicated to transportation investments (Mayor’s plan). $491M for the first year (TCMC).	ALS revenues between 1975-1988: S$5,33M per year ERP: S$150 M. ERP’s collected revenues go to the Government Consolidated Fund.
Outcomes	Reduction of 16 % of CO_2 emissions in 2003. And between 2003 and 2004, reduction of congestion by 30 %.	Reduction of 6.7 % of car mileage (VMT) on average.	ALS: Traffic and CO_2 reduction. ERP reduced by 15% the volumes on the expressways and speeds increased from 35 to 55 km/h.
Equity/acceptance	Improved public transport (45 % increase in the use of buses and 43% increase in cycling within the zone) has received good public support to the scheme.	One reason of the failure: Minority of users with low income (already identified as loser on beforehand to the congestion pricing project).	

Sources: Tfl.uk, Tfl (2007), TCMC (2008), Land Transport Authority (2008)

2.3.3. Additional measures

Table 4: Additional measures in the three cities

Cities	London	Portland	Singapore
Main goals	Improving air quality.	Improving new business models.	Up-grading mobility regulation.
Measure description	Low-Emission-Zone (LEZ) covers most of Greater London. To drive within it without paying a daily charge (200£ for vehicles over 3.5t; 100£ for minibuses and vehicles below 3.5t). LEZ targets all vehicles types except electric cars and motorcyclists. Penalty Charges between 250£ -1000£.	Car-sharing Portland’s Department of Transport adopted TRN-3.309 and TRN 6.04a series of administrative rules governing Portland’s carsharing parking regulations.	Vehicle Quota System (VQS) The VQS regulates the rate of growth of vehicles at a rate than can be sustained by developments in land transport infrastructure. Since the introduction of VQS in 1990, the growth of the vehicle fleet has decreased to 3 % p.a.
Introduction date’s	8 February 2008.	March 1998. Then March 2004 with the Flexcar pilote project.	May 1990.
Planning authorities	**Greater London, The boroughs.**	**Portland City, The Region of Portland, Private actors.**	**National Authority (LTA), Beijing Authority.**
Revenues			As of June 2003, these

			auctions generated a total of S$20.22 billion (US$11.55 billion) for the Singaporean government.
Outcomes	Estimation done by the AEA technology environment of London's claim a reduction of 2.7% of NO2 and 19% of the PM10 thanks to the LEZ.	Portland Flexcar members reported reducing their vehicle miles traveled by an average of 50.6%, dropping from 4,934 miles to 2,440 miles per year after joining.	

Sources: City of Portland (2005) and Koh (2004)

2.4. Key success factors for policy implementation: a summary

Complementing the rationale behind cities selection (see above in 2.2.), and for a better understanding of the 'do' and 'don't' regarding public policies implementation (and where to implement instruments), we expand more in what follows on the approximation of the key success factors in the kept cities. The key success factors can be classified under the following headings:
-Economic and geographic criterion;
-Public transport policy variables;
-Political acceptability aspects;
-Governance.

These main factors are subsequently used for two main purposes. First, we use them for pointing out similarities/differences between the kept cities and thus for attesting the suitability of the considered city with regard to the scheme to adopt. Then, we use them for constructing scenarios for other cities. This work is useful since it allows to prefigure what would drive (and where) policy implementation. However, it is based on intuitive causality and does not come from a measured explanatory factor analysis between the studied variables. Appendixes 1 and 2 provide with methodological details on the approximation of the proxy-variables.

2.4.1. Economic and geographical components

-Singapore

A relationship exists between the uniqueness of the city-state of Singapore and the implementation of the car restriction policies. Singapore is an island of 710km^2 with a urban population that has doubled within 24 years from 2,846,000 in 1988 to 5,312,400 citizens in 2012 (World Bank Data, 2012). The anticipation of demographic issues has been the main driver for successful car mobility deterrent policies. With the implementation of the Area Licensing Scheme (ALS) in the 1970s, policymakers have succeeded in introducing a price constraint at the CBD level. In addition to the introduction of the Vehicle Quota System (VQS), the increase in passenger car engines could be controlled from 10 % in 1993 to 11.7 % in 2012 (World Bank data) despite the dynamic economic growth which ranks Singapore as the third country in terms of GDP per capita (IMF, 2013 and World Economic Outlook Database, 2013). The adoption of the ALS and the ERP together with the VQS offered a winning combination of instruments to promote sustainable mobility oriented toward public transport. Indeed, whereas the share of public transport in 2008 accounted for 60 % it is on track to meet a modal share of 70 % by 2020 (MOT.sg).

-Inner / outer London economic and social disparities and urban sprawl

Daily distances travelled in London (nearly 14.5 km per journey; TfL, 2010) are comparable to the average in European capitals (such as Paris, with 12 km per journey; CGDD, 2010). Moreover,

economic and social disparities do exist between the Inner and Outer parts of London. If the Inner London population (3,064,507 inhabitants in 2010) is rather close to the Outer London (4,614,276 inhabitants in 2010), the average income of the residents of those zones differs significantly (£25,847 for Inner London residents in 2010 against £17,879 for residents from Outer boroughs; ONS, 2010). The decentralization of parking permits has enabled municipalities to adapt their policies according to such socio-economic disparities, making parking to be a real enabler to boost mobility on all aspects. Indeed, if London downtown remains controlled by an expensive residential parking cost (up to £1,212 per space; cityoflondon.gov), other Inner London boroughs have developed a CO_2-based residential parking policy giving the scheme a fairer dimension (revealing marginal environmental cost instead of pure urban development considerations only). On the other hand, Outer London boroughs have a more flexible parking policy since drivers are dependent on their vehicles for other reasons.
Even if no study has quantitatively demonstrated the effective reduction of CO_2 emissions thanks to this measure, public opinion (relayed by media) can conclude that it has clearly contributed to the promotion of cleaner vehicles.

2.4.2. The public transport policy

-Quality of public transportation in Portland, the small town in a high car dependent country.
Public transit policy was the most important objective of Vera Katz (politician of Oregon) in the early 1990s. Indeed, Portland was one of the first cities to develop its public transport network (The Oregonian, 1991). This policy was consistent with parking regulation and carsharing measures. In order to incite modal shift, public transport facilities mentioned before (the express regional railway network going to Portland; the tramway network in the city and bus lines with different levels of services – frequent, standard, and rush hours) are interconnected with Park&Ride lots and bike parking (Trimet, 2013).

-Singapore developed and cheap public transport.
An important developed and cheap public transportation was applied by Singapore policy-makers in the same time as the VQS and ERP schemes. Singapore won 14.4 % of public transport modal shift between 1990 and 2008 thanks to an increase of 36 % of bus services and 138km growth of rail network (Land Transport Authority, 2008).
Furthermore, Singapore developed a cheap public transportation system (average subway and bus fare of 0.54€ and 0.39€ compared to e.g. London, with 1.44€ for subway and 0.57€ for bus; and New-York, with 0.68€ for the subway and 0.51€ for bus). These transport prices have to be put in relation to the price of access to car mobility in Singapore (of about 77,876€ for a vehicle).

-London development of public transit services to develop modal transfer.
Transport for London developed in the same time as the congestion charge and the decentralization of parking the quality of its public transport for modal shift purposes. Between 2000 and 2009, the performance of TfL's network grew judging from capacity increase of more than 82% for the buses and 31% for the London underground (TfL, 2010).
This improvement of public transportation services allowed an increase of the modal share of public transportation in London between 2000 and 2009 of 7% (TfL, 2010)

2.4.3. Trust in the government and acceptability

- Public trust towards Singaporean public institutions:
As a part of the implementation of policies restricting car, political acceptability was a real key factor. People's Action Party founded by Lee Kuan Yew obtained a wide public backing during the last general elections (over 60%).

-Low minority of potential losers from the scheme in New York

In an ex-post study on the congestion pricing scheme in New York City, winners and losers were identified. Even though only 5.2 % of voters (blue collars leaving in New York) would have potentially been affected by the charge (Drum Major Institute, 2007), a policy can be difficult to apply when winners and losers are clearly identified on beforehand (AASHTO, 2009). Thus a strong opposition from the minority political representatives "losers" has contributed to the failure of this project.

2.4.4. Governance

- London / Singapore: a successful policy implementation when a few actors are deciding

In the cases of London and Singapore, the establishment of economic policies has been entrusted into a single actor (the Land Transport Authority in Singapore; and Transport for London in London). To the contrary, in the aborted congestion charge project of New York City, this is a group of transport policy actors who were involved: the New York City Department of Transportation (NYCDOT); the New York States Department of Transportation (NYSDOT); the Metropolitan Transportation Authority (MTA) and the United States Department of Transportation (DOT). All these groups participated in the establishment of the project after its publication and its amendment before being proposed to the Assembly in 2008.

-The local control of the city of Portland over parking regulation

An important capacity to govern parking policies in the official registers (code of Portland, 2013) allowed the city of Portland to impose these measures.

3. Projecting the key factors to other cities and constructing scenarios

3.1 Context of the second range of cities

3.1.1. The case of Lille (France)

Considering the case of Lille allows emphasizing three cornerstones if one wants to make policy recommendations and scenarios for medium-sized French cities regarding the local policy-tools to combine in order to steer modal shift. The French Urban Community of Lille Metropole counts 85 districts for an area of 611.45 km^2, two urban poles (Lille and Roubaix-Tourcoing), and a total population of 1,107,861 inhabitants in 2006 (ADEME, 2006).

With an average of €15,000 per year at the observation period at focus, the gross disposable income in the Nord-Pas-de-Calais region is the lowest of France (Insee, 2005), and it coexists with a tiny share of very wealthy population, with e.g. Croix in the region Nord belonging to the top 50 French communes with the highest number of capital transfer taxpayers in 2012 (data.gouv.fr). **Socioeconomic factors** play a key role in the success of implementing urban transport policy-tools. In this regards, the fact that the city of Lille belongs to a region with very heterogeneous and rather low personal incomes is of interest.

The effectiveness of urban transport policy-tools would also depend on existing **travel demand patterns** as shown above. Insights on this can be found in the level of households' car equipment (74% in Lille in 2006), the average age of the vehicle fleet (8.4 years in Lille versus 7.9 in France; ADEME (2006) – revealing a fleet of less efficient vehicles and marked by a large share of diesel cars), the modal split (e.g. 8.5% of public transport use in Lille in 2006) or the geographical location of trips (with larger distances travelled in periurban areas (25,000 km) than in the city center (12,500km; Bureau, 2013) and their frequency.

Eventually, the transport system as existing prior to the new policy implementation is very important too, and in particular its **governance**. In this respect, the public transport system in Lille is jointly provided by the public transport authority and external operators. Such an intermediate situation (competitive tendering model) between public monopoly and full deregulation is also characteristic of London,Swedish and Danish cities and breaks with the trend of most European cities, where public transport organization remains largely under the control of the local transport authority only (Fiorio and al., 2013). To be noted also that mode shift was the central objective of the first urban mobility plan of Lille Métropole in 2000 ("promotion of alternative modes to car" and "public transport supply strengthening"), among other environmental and social policy targets (Lillemetropole.fr). Thus, this prospective work focussed on mode choices analysis aims at serving the practitioners to follow up on the outcomes of the first urban mobility plan – in particular, the development of bus rapid transit lines, reduced speed zones and bicycle facilities.

3.1.2. The case of Beijing (China)

Considering the case of Beijing allows emphasizing three cornerstones if one wants to make policy recommendations and scenarios for emerging major cities regarding the local policy-tools to combine to steer modal shift:
Despite a booming economic growth, transport demand in Beijing is strongly dominated by public transport use and soft modes (Schipper and Ng, 2004). For Example, the car and motorcycles modal shares were under 10% in Shanghai in 2000, whereas walking and cycling represented more than 50%. Nevertheless, nowadays cars are getting more and more important in China with an increase from 5.54 Million in 1990 to 105.78 Million in 2011 (Zhong-Ren and al., 2012).
This change in the Chinese mobility is under way in Beijing too and leads us to explore the ways for moving towards low-carbon urban mobility instead.

Table 5: Demographic and automobile development in Beijing

	1990	2009	Evolution
Population	10,8 M	17,6 M	+63%
Urban area	150 km^2	750km^2	+500%
Average motor speed	45km/h	17km/h	-265%
Vehicule ownership	1 M (1997)	4.76M (2010)	+476%

Source: Zhong-Ren and al. (2012)

The table 5 above shows the joint development of the urban population, spatial extension, speed increase and number of cars in Beijing in twenty years. Due to the huge growth of cars in Beijing, there has been a corresponding increase of car externalities. In response to these challenges, three policies were considered or applied to solve these issues.
-Parking pricing: since December 2010, Beijing has introduced 28 specific measures for congestion mitigation. In these 28 measures, five were about parking (Beijing Transport Research Center, 2012):

- Build more than 50,000 public parking spaces in central city;
- Build more than 200,000 basic parking spaces depending on local conditions;
- Build up Park and Ride parking lots accommodating more than 30,000 parking spaces along the subway lines;
- Increasing parking fees and thus reducing traffic volume in the central city;
- Enforcing parking management.

-Driving restriction: the introduction of driving restrictions in august 2007 made Beijing the first city to apply this controversially policy. This policy affects 20 % of private cars, which are banned based on the number of the license plate. This measure applies between Monday and Friday from 7AM to 20PM within the 5th ring road (Beijing Transport Research Center, 2012). However, the effectiveness of the driving restriction is limited. With a decrease of 9% of cars, 47.8% of drivers don't follow the restriction rules (Wang and al, 2013).

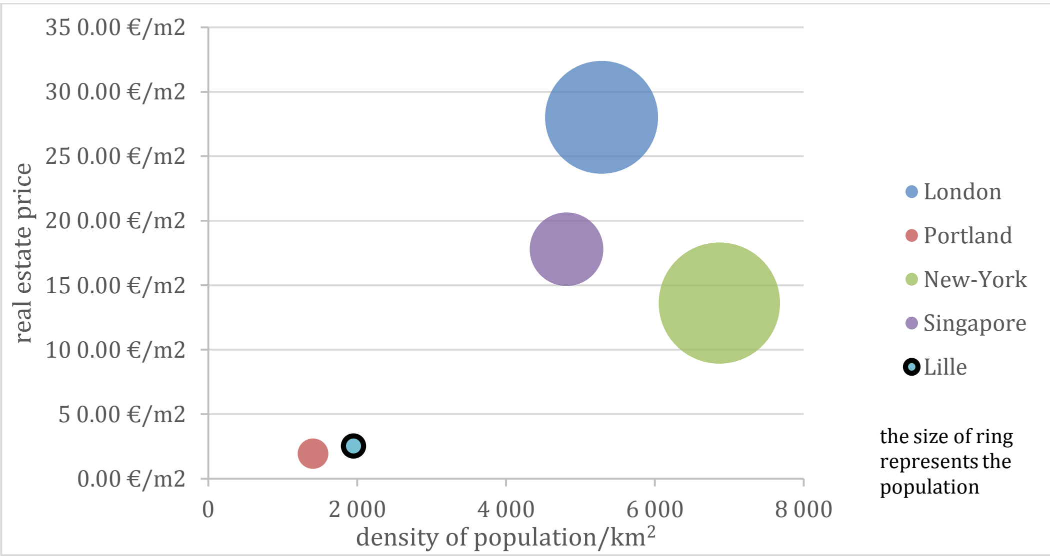
-Project of a congestion charge: In September 2013, all Chinese media precised the project of a congestion charge in Beijing, according to the Clean Air Action Plan for a reduction of 20% of local air pollution (USA daily China, 2013). In this plan, a combined congestion charge and low emission zone were subjected to be discussed in 2014 (Beijing Transport Research Center, 2012).
For these reasons, we will propose different scenarios for the city of Beijing.

3.2. Scenarios and discussions

3.2.1. Case of Lille: Portland scenario

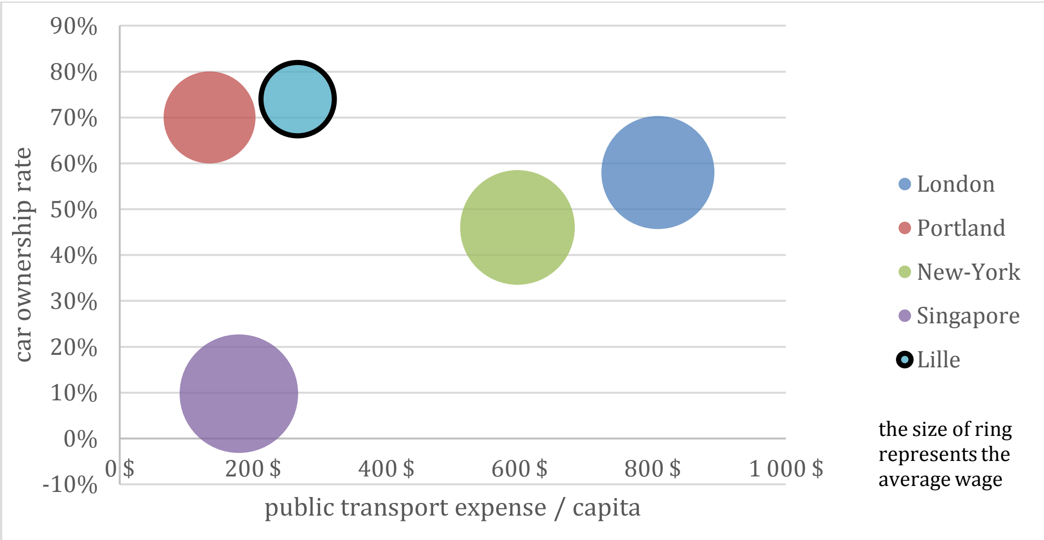
In order to demonstrate the connection between Lille and Portland, we used both geographic and economic key factors – i.e. population data (population density on the X axis; and population count in the circles) and the real estate prices (on the Y axis). The figure 1 below shows the similarity of urban form between Portland and Lille, regarding their population number and density. A wealth distinction according to the real estate price and the density is obvious between major capitals (London, New-York and Singapore) and middle-sized cities (Portland and Lille).

Figure 1: Economic and Geographic comparison criteria



Additionally, in order to represent demand mobility and transport policies variables we choose, below in figure 2, three others approximates to emphasize the similarity of Portland and Lille: car ownership rates (in Y axis), public transport expenses per inhabitant (in X axis) and average wages (in the circles).

Figure 2: Demand mobility and transport policy comparison criterion



Expenditures to public transport investments somehow represent the political commitment of the transport planner, even though it should be balanced of financial issues, and other administration and depreciation costs. On this regard, Portland and Lille can be associated by their same level of car ownership rate and their lower wages than major cities. Here, lower public expenses have probably contributed to encourage the development of car mobility. Indeed, with a smaller public transport network than in major cities, daily urban mobility is more dependent on car. The average wage highlights the special socioeconomic context of medium size city.

Table 6: Similarities between Lille and Portland's success factors

Key success factors	Variables	**Scenario per variable for Lille**	
	Population	Portland	
Geography	Density	Portland	
	Urban area	Portland	**Portland**
	Wages	Portland	
	Share of national GDP	New-York	
	Economic Growth	New-York	
	Unemployment rate	London	
Economic	Real Estate price (€/m^2)	Portland	**Portland/New-York**
	Car ownership rate	Portland	
	gasoline price	Singapore	
	Automobile price	Portland	
Demand mobility	Modal share of public transport	London	**Portland**
	Metro price	Portland	
	Bus price	Portland	
	Parking price	New-York	
Transport policy	Cost of public transportation according to the population	Portland	**Portland**

	concerned		
	CO_2 emission	Portland	
	Congestion cost	Portland	
	Road Accident cost	Singapore	
	Noise cost	*	
Externalities	air pollution cost	Portland	**Portland**
	Number of entity in the governance of transportation	Portland	
	Political power	London	
Governance	Rates of participation	New-York	**Portland/London**

This table summarized for each proxy-variables which cities between London, New-York, Singapore and Portland are connected to Lille's pattern. This table illustrates the preceding remarks on the most remarkable between Lille and Portland.

The dominant scenario for Lille, judging from shaded key factors, is Portland.

Portland and Lille share similar characteristics, notably regarding their urban form, economic situation, transport policies and governance. One could recommend to Lille policymakers to refer to the Portland parking policies rather than using the congestion pricing as in London or Singapore.

Indeed, the structure of the governance in Lille and the fact that the city can rely on an efficient public transport system would allow to successfully implementing parking management tools. Besides, other French cities like Strasbourg have started to think about "parking management" as a low-hanging fruit for carbon emission reduction in urban mobility.

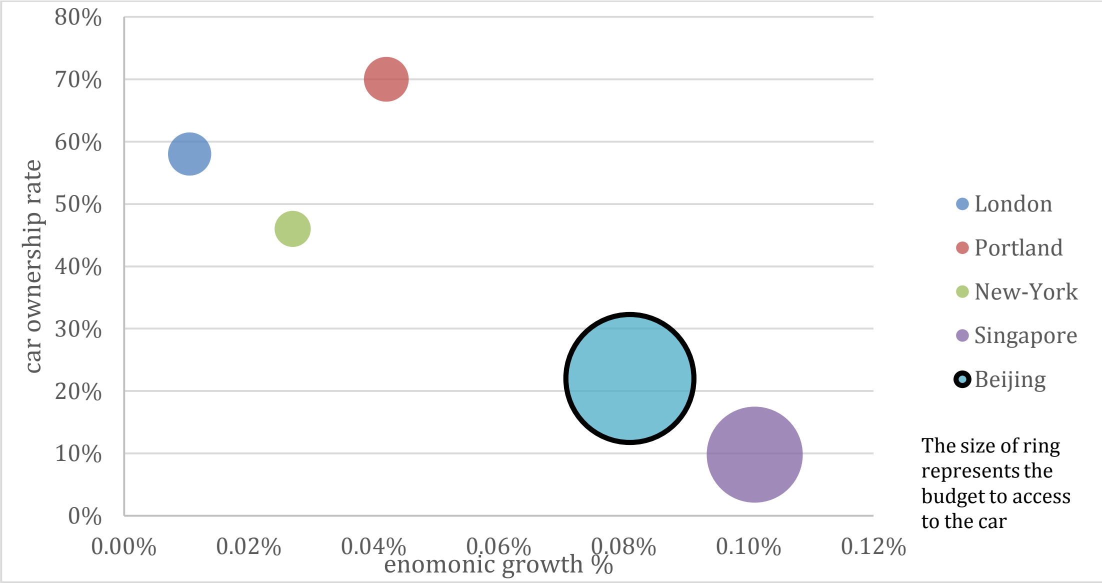
Lille could also develop additional measures such as car-sharing, by using parking policies' generated revenues. At least, policy-makers could apply additional innovative measures, such as smartphone applications related to parking management and smarter circulation of vehicles.

3.2.2. Case of Beijing and the scenario « Singapore»

In order to demonstrate the connection between Beijing and Singapore, we are using some variables from mobility and economic keys factors: the economic growth (in the X axis), car ownership (on the Y axis) and the budget of car mobility access[4] (including car automobile and gasoline price; in the circles).

[4] We used to calculate the budget (B) : (W) The average wage (ref : proxy-variables) , (Pc) price of an car (ref : proxy-variables), (Pg) price of gasoline (ref : proxy-variables) . The car specificity: a gas consumption of 8,5l / 100Km (Cs) and an annual distance travelled of 20 000km (D). $B = (Pc + (Cs * Pg * D / 100)) / W$.

Figure 3: Demand mobility and economic variables comparison criteria



The figure 9 above shows the integration of car mobility depending on economic growth. Singapore and Beijing are at different levels regarding car mobility comparing to London, New-York and Portland. Currently, Beijing is still at an emerging situation with a high economic growth and low standard of living. This situation restrains the massive development of car mobility but this is very likely to change in the near future (as mentioned earlier in 3.1.2). The likeliness of Beijing and Singapore is visible and could be strengthened though the implementation of the Singaporean policies of VQS and ERP, in order to constrain further car accessibility and create welfare for the society.

In order to further demonstrate the suitability of Singapore policy to Beijing, we also use the following variables: modal share of public transport (in Y axis), the electoral performance (X axis) and the economic growth (in circles). The electoral performance is used here to approximate the capacity of policymakers for imposing a policy.

The figure 10 below presents the relation between the political power of local transport planners and their capacity to increase the modal share of public transport through a good (forced?) acceptance of corresponding public instruments.
In a nutshell, Beijing and Singapore (with VQS), by their similarity in local transport governance assets (few actors), have the legitimacy to put in place the policies which will developed the public transport. These issues are even more relevant when taking into account an increasing population (see in 3.2.1) as it is the case in Beijing. China has the possibility to fight car externalities for sustainable mobility as Singapore does, thanks to its authoritarian regime.

Figure 4: Demand mobility and governance variables comparison criterion

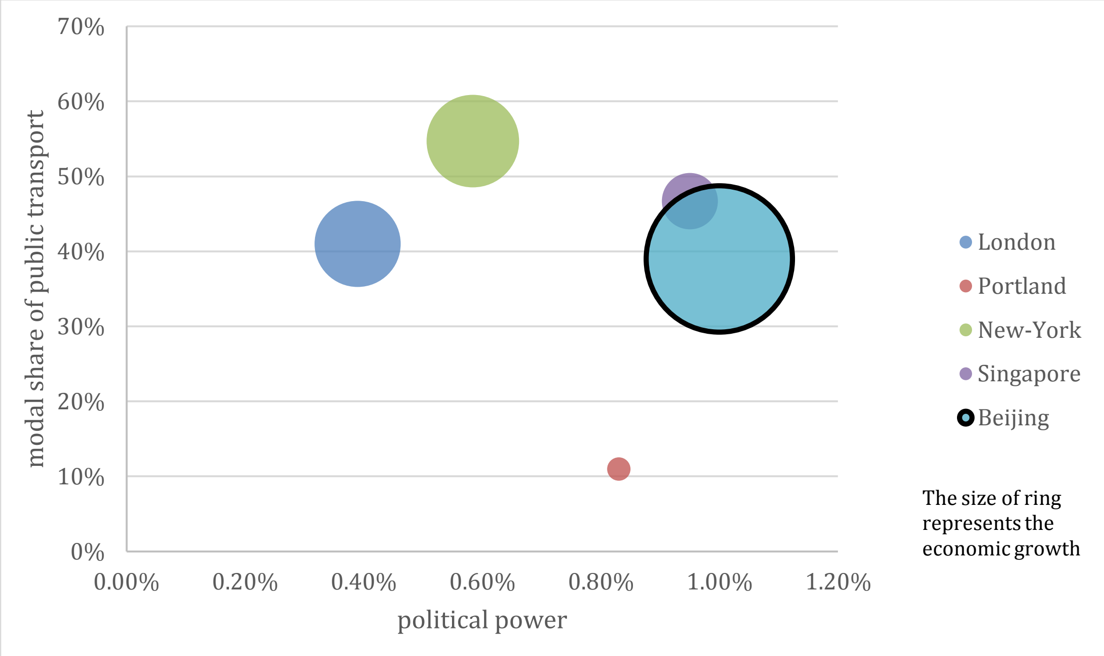


Table 7: Similarities between Beijing and Singapore's success factors

Key success factor	Variables	**Scenario per variable for Beijing**	
Geographic	Population	**New-York**	**Singapore**
	Density	**Portland**	
	Urban area	**Singapore**	
Economic	Wages	**Portland**	**New-York/Singapore**
	Share of national GDP	**New-York**	
	Economic Growth	**Singapore**	
	Unemployment rate	**Singapore**	
	Real Estate price (€/m2)	**New-York**	
Demand mobility	Car ownership rate	**Singapore**	**Singapore**
	gasoline price	**New-York**	
	Automobile price	**New-York**	
	Modal share of public transport	**London**	
Transport policy	Metro price	**Singapore**	**Singapore**
	Bus price	**Singapore**	
	Parking price	**Portland**	
	Cost of public transportation according to the population concerned	/	
Externalities	CO_2 emission	**New-York**	**London**
	Congestion cost	**London**	
	Road Accident cost	**Singapore**	

Governance	Noise cost		
	air pollution cost	**London**	
	Number of entity in the governance of transportation	**New-York**	**Singapore/New-York**
	Political power	**Singapore**	
	Rates of participation	**Singapore**	

This table summarizes for each of the proxy-variables which cities between London, New-York, Singapore and Portland fitted the best with Beijing's specificities.

The dominant scenario for Beijing, judging from shaded key factors, is Singapore.

The combined implementation of a congestion charge like the ERP along with additional measures as done in Singapore could be of relevance for Beijing. However, the design of the instruments and their implementation must correspond to the local context – i.e. in the case of Singapore, the urge of health problems for the population and the situation of a single actor for transport decision-making. Therefore to follow the scenario of Singapore, Beijing has to centralize its transport governance for a better efficiency (e.g. if one wants to avoid the case of NYC, described earlier in 2.3.4). In addition, the well-being of the citizens, who currently suffer from air pollution, should be the driving force for policy action. At least, regulation should be put in place carefully: i.e. without hampering the Chinese automotive sector. Developing measures to support the electric vehicles industry in China could work in this direction.

Conclusion

Three different regions are analyzed in this report, Occidental Europe, for its overloading urban and peri-urban expansion; North America for the car mobility dependence and high air pollution and Asia with this high development of mobility. The cities of London in Europe is selected for its smart combining of economic tools (congestion charge and parking policy) ; New-York illustrates, in the North American area, the failure of the project of congestion charge; and Portland the case of a middle-size city with a successful and innovative parking policy. At least in Asia, the city-state of Singapore is kept for the success of the ERP and VQS schemes (in the light of improved modal shift). Key factors of success are highlighted in the subsequent cases. We define as key factors categories: geographic, economic, demand mobility, transport policy and governance.

To draw policy recommendations, proxy-variables are assigned to each category in order to compare these cities with others. Lille, already used as a pilot city for developing new policies (PREDIT, 2008) presents the typical European situation with high travel distances and urban sprawl and is retained for the scenario construction in our report. Beijing is also chosen to demonstrate the challenge of mobility and associated externalities in emerging countries. Indeed, in these areas some policies should be introduced to control the growth of car mobility. Scenarios are constructed using the proxy variables mentioned above, and allow us to draw different prospective situations for Lille and Beijing (i.e. to follow Portland policies in the case of Lille and to follow Singaporean policies in the case of Beijing). Indeed, with an innovative parking policy and car-sharing system, Lille could increase its modal share of public transport.

In the case of Beijing, the important political influence of the policymaker may help to impose a drastic pricing policy, such as the VQS in association with a road pricing, with the aim of developing the social welfare.

Thus, in this study we focused mainly on modal shift but other policy-target and means such car-sharing (increase of the loading factor within a same mode) could be as efficient in the light of CO_2 emission (Fu and Kelly, 2012; Madre and al, 2010). Another way could be a transfer of the sustainable mobility responsibility to private actors. Currently used by some large companies, the Corporate Mobility Plans (PDE) empowers companies to their employees travel. The introduction of a requirement for the introduction of PDEs for firms could be a great potential for reducing travel distances by car.

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Appendix: Proxy-variables used in the key factors and scenarios analyses

The methodology (and the justification) for choosing the proxy-variables used in the scenarios construction are reported below. All prices data are deflated by the index of consumer prices (IMF, 2008).

Geography and population

Population count, density and urban form in each case study are approximated through:

Proxy-variables	Justification	Methodology and sources
Population (Inhabitants)	Informational, validating the consistency of cross-city comparison.	Official records of the city hall and its website.
Urban area (km^2)	Reveals potential dispersion effects (e.g. urban sprawl).	Official records of municipalities or their websites.
Density (Inhab./km^2)	People targeted by the policy-instrument considered.	Ration between the population of the city divided by the size of the urban area.

Local economic context

The favorable/dis-favorable local economic conditions for establishing the policy-tools at focus are captured through:

Proxy-variables	Justification	Methodology and sources
Wages (€)	Purchasing power of individuals for transportation related expenditures.	The data come from the national statistical information center of each country (INSEE, singstat, ons.uk.). They also come from less formal sites like newspapers in the absence of official publication.
Weight of the city in the national GDP (%)	Local importance and economic influence	The share of the local GDP over the national GDP is determined according to the official status register (World Bank).
Economic growth (%)	Economic attractiveness of the city.	Official sources (the website of the city). In the absence of information, the economic growth of the country is taken.

Unemployment rate (%)	Reverse-side of the economic growth (socioeconomic difficulties).	Official documents of each city. If not, it is taken from the official unemployment rate of the country (world bank).
Real-Estate prices (€/m^2)	Value of the land and importance of housing budget (over transport one) for the residents.	Real-Estate prices (city average, in square meters unit) come from specialized websites in property.

Demand-side variables

Proxy-variables	Justification	Methodology and sources
Gasoline price (€/l)	Fuel taxation already existing – reveals car use affordability.	Bloomberg Visual Data.
Automobile price (€)	The price of a car adds information on the affordability of car mobility for residents.	The price of a compact vehicle (to Peugeot 208/Chevrolet/Clio) is chosen on the websites of car manufacturers, except for Singapore (specialized website).
Car ownership rate (%)	Reflects the loan of the car.	National registries (Census, London Transport data). If the local information was not available, national official data is taken from World Bank data.
Modal share of public transport (%)	Shows the level of public transportation modes integration in the local mobility patterns.	U.S. data come from studies comparing the modal share of transit. Other data are from a publication of ETA.

Public transport policy

The data presented below illustrate the control variables for public policy makers to influence the choice of travelers. .

Proxy-variables	Justification	Methodology and sources
Public transport expenditures over population number ratio	Indicates on the priorities of the decision maker, and in particular on the per capita transportation investments choices.	Transport costs data come from financial reports from transport authorities. Population count data are presented above.
Metro price	Affordability of the metro system.	Average price as announced by transport authorities. In the absence of average, the price of a single metro ticket is chosen.
Bus price	Affordability of the urban bus system.	Same as above.
Parking pricing	Constraints imposed on the automobile use on public space.	Average price of parking (on-street) prices as announced by the authority of parking. In the absence of average, the price of the first hour is kept.

Transport externalities

In order to demonstrate the importance of externalities generated by the transport system, we keep the following ones in each city:

Proxy variables	Justification	Methodology and sources
CO_2 (t)	Quantity of CO_2 emitted by the road transportation.	CO_2 emissions come from sustainable report of transport authorities or environmental agency.
Congestion (€)	Monetary estimate engendered by congestion in the city. Allows ranking congestion among other externalities. Defining the most pressing objectives allows guiding which policy to implement.	The cost of the congestion is a national estimation depending on the population involved (for Us cities) or calculated (value of reference) by transport authority.
Road accident (€)	Allows ranking accidentology among other externalities..	Local evaluation or a national estimate per accident.
Air pollution (€)	Same as above.	Same as above.

Governance

In order to demonstrate the importance of political governance, the following variables are taken into account.

Proxy variables	Justification	Methodology and sources
Number of policy actors involved in the governance of transportation decisions	Helps to understand the number of policy makers involved in the governance of transport and the complexity of decisions related to transportation.	Consultation of authorities websites linked with transport issues.
Electoral performance (before the introduction of measures)(%)	Shows the ability of the policymaker to gain the support of the population before the establishment of a policy.	The score is derived from the political electoral registers cities or their archives.
Rates of participation (%)	Shows part of the legitimacy of the political score during his election.	The participation rate is specified by the electoral registers or estimated by the ratio of the number of participants by the number of registered voters.

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