THE EFFICIENCY OF CONGESTION CHARGING: SOME LESSONS FROM CBA EXERCISES

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World Conference on Transport Research, 11-15 July 2010

Abstract:

Despite suspicion on the reality of travel time savings, it is argued that these savings are a conservative value of surplus gained from improvement in speed following from congestion charging implementation. The methodology of measurement of travel time reliability (or variability) is not yet stabilised, but recommended estimates and current empirical work suggest that it may take a growing share in benefits in the future. A simulation model is implemented in order to test the sensitivity of time savings to various parameters in the London and Stockholm case studies. The results exhibit a high sensitivity and point at the need to accurately measure these parameters but also at the recognition of unavoidable uncertainty. Finally the impact of costs of public funds on public accounts is greatly significant and may increase in the future, according to new empirical figures about these costs.

31 May 2010

INTRODUCTION

Road (or congestion) pricing is politically risky, especially in urban areas. This is why, at least to help the decision-maker, cost-benefit analyses are performed in order to determine whether this kind of policy when implemented in a specific area, increases the welfare or not.

Based upon assessment of the two current congestion charging schemes of London and Stockholm, this paper seeks to identify main lessons and research issues at stake when performing a cost-benefit analysis (CBA) on congestion charging.

The London and Stockholm congestion charging schemes are well known and are described in detail elsewhere, see for instance Leape (2006) for London and Eliasson (2008) for Stockholm. Table 1 below shows a summary of cost-benefit analysis for these two schemes. Differences in the global balance may appear when compared with these references (for instance because of the inclusion of bus extensions in the Stockholm case) but we will not enter this debate here.

The examination of this table confirms that travel time savings are at the core of cost-benefit analysis, for assessing whether transport infrastructure projects or policy measures like road pricing schemes. It shows that in the London case, car and bus users time savings and reliability benefits amount to 93% of externalities benefit (79% for the sole car users time savings). In the Stockholm case these figures are respectively 79% and 60%.

Table 1: Summary of cost-benefit analysis for London and Stockholm

Summary (€ million per year)	London (5£ charge)	Stockholm
Benefits		
Car users travel time savings	284	55
Car users reliability benefits	39	8
Bus passengers (time savings and reliability)	62	20
Society (accidents and environment)	25	22
Total	410	105
Costs		
Charging costs (amortization +operation)	-194	-28
Additional buses	-26	-60
Deterred trips (car users)	-29	-1
Car users compliance costs	-32	0
Total	-281	-89
Net benefit	129	16

Sources: Tfl (2007) for London, Transek (2006) for Stockholm and authors' calculation[1].

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[1] Currency equivalence is set at €1.45 for £1 (in 2005) and €0.10512 for 1 SEK.

The paper is organised as follows. First we discuss the issue of time savings and their relevance for assessing congestion charging schemes: we argue that these savings are a conservative value of surplus gained from improvement in speed following from congestion charging implementation. Second we review recommended estimates and recent empirical and theoretical work about travel time reliability. Third we implement a simulation model in order to test the sensitivity of time savings to various parameters in the London and Stockholm case studies and show that this sensitivity is very high. Fourth and finally we analyse the impact of costs of public funds on public accounts.

1 THE ISSUE OF (MARGINAL) TIME SAVINGS

Much criticism has been put on the reality of time savings, for instance by Metz (2008) who denounces the "myth" of travel time saving. The argumentation may be summed up as follows. Empirical observations support the hypothesis of individual constant travel time and trip number in the long run. Speed improvements would yield a transient (short-term) situation of travel times reduction but a long term situation where transport users transform the benefit of speed increase into further travel, thus maintaining a constant (daily or yearly) travel time. The increase of travel would not be higher frequency of existing travel but rather access to new destinations, the so-called "induced" traffic which involves more traffic, so more accidents and more harmful atmospheric emissions, thus offsetting the other benefits. Accordingly cost-benefit analysis should consider the value of access to destination in lieu of travel time savings. Unfortunately such methodology for assessing the value of access in a CBA framework is not yet available. Moreover, the value of travel time savings would not provide a conservative approximate of the value of access, since trips have also an intrinsic utility (e.g. the pleasure of travel or the opportunity of performing parallel tasks such as work, while travelling in public transport).

A different view may be defended. Time devoted to travel generally results in a disutility since this time may be used to perform other activities. Time saving in trips made previously to the policy implemented can be capitalized on by the traveller into two components: the first is time saved for other activities (other than travelling) and the second is supplementary travel performed to same destinations as previously or to new destinations. These two components reflect a surplus for the travellers and they can be estimated indirectly by the time savings transformed into monetary benefits thanks to the values of time empirically measured.

However since there may be an intrinsic utility in travelling, which could be lost while travel time is saved, the point here is whether this intrinsic utility is higher or lower than the disutility of travel (in absolute terms). There are obvious cases where this intrinsic utility is higher than the disutility of travel: consider for instance strolling trips, e.g. whether by walking or driving, or even some shopping trips, where the utility of destination merges with the intrinsic utility of the trip. In these cases empirical values of time should demonstrate null or negative figures. This refers to "undirected travel", that is to say when travel is the activity that is demanded (Mokhtarian and Salomon, 2001).

Another case where intrinsic utility of travel may be high when compared with its disutility is when travelling by public transport (i.e. with no need to pay attention to vehicle operation), especially in non crowded situations: other activities such as relaxing, reading, or working may be performed, so making this a priori "empty" time as being used "productively" (Lyons and Urry, 2005). Even in some cases (perhaps anecdotal but empirically observed by the authors) some (research) managers may take the train solely in order to get some working time for themselves, freed from the pressure of the office: this is a case of “ultra-productive” travel time as identified by Lyons and Urry.

Regarding travelling by car as a driver, the potential use of travel time for other activities is more limited since physical and mental attention is much needed for the operation of the car.

Overall it is reasonable to assume that, except for the specific case of strolling trips evoked above, this intrinsic utility is lower than, or at most equal to the disutility of travel (in absolute terms). Moreover, since the empirical measure of the valuation of travel time is performed by observing the behaviour of travellers whether by reveal or stated preferences studies, it incorporates de facto the balance between disutility and intrinsic utility of travel.

When it comes to the congestion charging cases studied here we can consider that the intrinsic utility of trips is much limited. Time savings are computed on car travel, where the possibility of performing parallel activities while driving is much limited by the additional stress of driving in congested conditions. The pleasure of travel may also be considered very limited, especially concerning commuting or business trips. In other words the intrinsic utility of this kind of trips may be neglected.

The other issue regarding potential induced traffic concerns its incidence on environment and accidents. In the case of London benefits from reduction in accidents and harmful atmospheric emissions represent only 6% of the overall benefits (see Table 1). Moreover, according to TfL (2005) no significant increase occurs in the traffic surrounding the Charged area. So even if additional travel may be performed as a result of time saved from the new traffic conditions, its incidence on environment may be neglected compared with the amount of benefits coming from time savings estimation.

The Stockholm case is different from this point of view since benefits from reduction in accidents and harmful atmospheric emissions represent a noticeable part of the overall benefits, i.e. 22% (see Table 1). Besides, an increase in traffic has been observed on a bypass around the charged zone recently opened at the time of the trial: according to Transek (2006) this increase in traffic should not be attributed to an effect of congestion charging but rather to the usual progressive increase of traffic in newly opened infrastructures. However one cannot exclude that in the long term induced traffic following a speed improvement in the access to the centre would wipe out these benefits. In this case one can expect that the new traffic equilibrium would reach the same equilibrium as previously, thus wiping out the short-term benefits as currently estimated but no more.

Last, one should consider the simplification made when considering average values of time. Both in London and Stockholm cases distinction is made between business trips and private trips (of which most are commuting trips). However, regarding private trips individuals have different values of time reflecting heterogeneity for instance in wages for workers. Drivers who remain on the road value their time higher than the ratio of time saved on toll paid: some of them would be ready to pay a higher toll. Thus the computation of monetary benefits from time savings with an average value of time represents an underestimation of this surplus for drivers.

Overall our conclusion is that while time savings resulting from congestion charging may be wiped out in the longer term by induced traffic (or by a subsequent reduction of road capacity as in the London case; see TfL, 2008), these can reasonably be taken as a conservative estimate (in fact an underestimation) of the benefits obtained by access to new destinations for transport users. This rejoins the conclusions of Mackie (2008) and Van Wee and Rietveld (2008).

Since these time savings are crucial in the CBA, their assessment needs some scrutiny.

Which time savings in the London case?

For instance in the London case the overall time savings of car users are estimated by TfL (2007) to be about €280 million per year. As indicated by Tfl these savings may be broken down according to areas where travel occurs. TfL distinguishes the “Charged area”, the “Inner area” and the “Outer area”.

Table 2: Breakdown of time gains per area in London

	unit	Charged area	Inner area	Outer area	Total
Post-charge veh km	1000 per day	1 276	14 722	32 708	48 706
Time saved per veh km	minutes	0.59	0.06	0.01	
value of time vehicle	€ per hour	44	32	25	
time gains	million € per year	135	117	37	290

(Source: Tfl; 2007, appendix and authors calculation)

As shown in Table 2 the saving per kilometre amounts to 0.06 minute in the Inner Area and 0.01 minute in the Outer Area. Weighted by the corresponding traffic volumes (respectively 14.722 millions and 32.708 millions vehicle-kilometre), these savings per kilometre yield 14,245 hours saved per day in the *Inner area* (more than the 11,953 hours saved in the *Charged area*) and 5,812 hours saved per day in the *Outer area*. Combined with the values of travel time in these areas, this gives added monetised time savings of respectively €117 million and €37 million per year: overall this doubles the time savings computed on the sole *Charged area* (€135 million).

When it comes to the perspective of user behaviour, the savings per kilometre in the Inner and Outer areas look very low when compared to the significant level of saving in the Charged Area, i.e. 0.59 minute per kilometre. For instance, for a 10 kilometres trip these savings of 0.06 minute and 0.01 minute per vehicle-kilometre represent respectively 36 seconds and 6 seconds: this should be compared to the total duration of the trip which is about 30 minutes according to TfL.

Welch and Williams (1997) offer an in-depth analysis of the impact of small time savings on transport investments benefits, and provide sensitivity tests. They note that CBA in a large number of transport schemes is dominated by small travel time savings less than five minutes. They recommend that particular scrutiny should be given to these savings under five minutes. On the same time, following Mackie et al (2001), there is no justification for not assigning a constant unit value per minute of time saving regardless of the size of the time saving.

However we are considering here average journey time savings of 6 or 36 *seconds*. It is unlikely that these savings would allow the road user to accumulate sufficient time savings to perform another activity or even reschedule her activity-travel pattern. The low level of these figures questions the relevance of including such benefit in the evaluation.

This is why in order to obtain a conservative value of the benefits of time savings following from the reduction in traffic, the scope of savings to take into account in the London case should stick to those measured within the charged area, that is to say €135 millions as given by TfL. However these benefits do not include the gains from improved reliability in journey times, an issue that is addressed hereafter.

2 THE RELIABILITY OF TRAVEL TIME

What is the extent of reliability gains? Are they worth computing accurately? In the London case the gains in reliability are significant since the proportion of time spent by drivers while stopping traffic or stuck in jams has decreased by one third according to TfL (2004). TfL (2007) gives an estimation of reliability gains for car users, based on a study which calculated link speeds and estimated the reliability of total journey time by highway modes: for this the standard deviation of travel time is estimated from a relationship between current time and free-flow time. The reliability benefit on each link was estimated as 0.79 times the reduction in the standard deviation of the link time (which is approximately the practice recommended in the UK for the “reliability ratio”[2]: see WebTAG Unit 3.5.7). From this, reliability savings are estimated to be 30% of travel time savings in the charging zone and zero elsewhere.

Reliability gains accrue also to bus passengers since they benefit from a reduction in excess waiting times which is estimated at 30% inside the charged area (TfL, 2005). This gives a reliability gain amounting to nearly half the time savings of bus passengers.

In the Stockholm case a significant reduction in travel time unpredictability also occurred (Stockholm’s Stad, 2006): travel time variability measured as the difference in journey times between the best (10th percentile) and the worst days (90th percentile) was at least halved on morning peak on inner approach roads toward the city centre, and at least divided by five on afternoon/evening peak on the opposite direction. In Sweden the recommended reliability ratio is 0.9, like in the UK. Overall the benefits for improvement in travel time reliability is estimated at 15% of total travel time savings.

These amounts of reliability gains when compared to time savings are not abnormal. Brownstone and Small (2005) estimate that in the case of Californian toll motorways the value of the reliability of journey time is in the range of 95 to 140% of the median value of time. They conclude that two-thirds of the value of the service provided by a toll motorway in relation to a toll-free motorway is due to journey time and one third to reliability. Bates et al (2001) provide a detailed discussion of the valuation of reliability both on theoretical and empirical aspects.

Van Lint et al (2008) underline that there exist several definitions of reliability beyond the common use of indicators of the variance of travel time distribution. They observe heavily skewed distributions in empirical data and argue in favour of indicators that should take into account not only the variance but also the skew of travel time distribution.

These calculations which relate the mean and variance of travel times and reflect current practice in appraisal are based on empirical approaches. However a theoretically sound alternative approach may be used.

The standard behavioural hypothesis is that transport users, whatever the mode they use, attempt to minimize their generalized cost of travel by combining the cost of travel time with the cost of late or early arrival: this is known in the literature as the “scheduling theory” introduced by Small (1982) on the grounds of the Vickrey’s bottleneck model (1969).

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[2] reliability ratio = value of standard deviation of travel time / value of travel time

De Palma and Fontan (2000) have measured the parameters of the scheduling model for home-to-work trips in the Paris Region, and arrived at €12.96 per hour for travel time (which is roughly consistent with the recommended value of time in France, see CGP, 2001), €8.61 per hour for early arrival and €30.22 per hour for late arrival, i.e. more than twice the value of travel time.

However, on the basis of their SP survey on rail travel, Bates et al (2001) show that punctuality is highly valued by travellers and suggest that in the case of public transport where departure times are discrete, there would be a disutility of unreliability distinct from that of scheduling delay. Moreover, they indicate plausible values for the reliability ratio in car travel of 1.3 which are substantially higher than those used in current CBA practice (see above).

More recently Fosgerau and Karlström (2010) have shown that under some assumptions the scheduling model can be unified with models that include the standard deviation of duration directly as an argument in the cost or utility function.

These various works show that this is an active research field, aiming at building a consensus on valuing travel time reliability (or rather travel time variability). Higher levels of reliability ratio would imply a much higher share given to travel time reliability improvement when compared to mean travel time reduction. More empirical work is needed in measuring the parameters of the scheduling model with SP or RP surveys.

3 THE SENSITIVITY OF TIME SAVINGS TO VARIOUS PARAMETERS

Since time savings bear the greatest share in benefits of a transport policy CBA, it is relevant to ask to what extent these time savings vary according to different sources of errors or uncertainties. That is why we have implemented our own model of simulation of congestion. First we present the methodology of implementation, which is successively applied with sensitivity tests in the London and the Stockholm cases.

3.1 The static short run congestion model

Figure 1 shows the basic model of static short run congestion with traffic volume on X-axis and cost on Y-axis (see for instance Button, 2004). *AC* is the average cost, i.e. the private cost incurred by the drivers (including cost of car operation and time devoted to travel), *MC* is the marginal cost adding to *AC* the congestion externality imposed by additional drivers to all other drivers. The demand curve is figured straight for the sake of simplicity. At the equilibrium B before implementation of congestion charging the volume traffic is Q_c. Q_0 is the traffic when optimal charging *r* is implemented, Q'_0 the actual traffic corresponding to the actual charge *p* that is implemented. *ADB* is the “deadweight loss” coming from congestion and *A’B’BA* is the actual time savings gained from the implementation of charge *p*. *B’C’B* is the loss of evicted users.

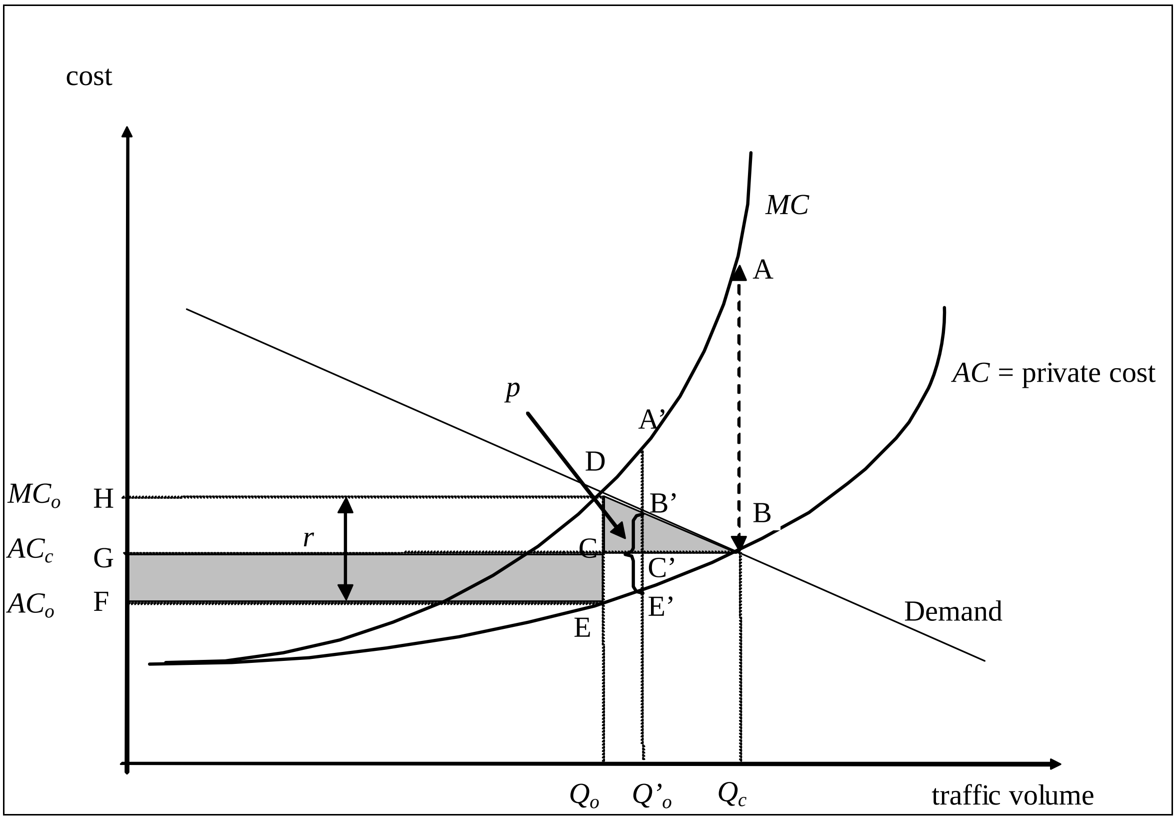

Figure 1: The static short run congestion model

The basic motivation for congestion charging and the core of its benefit lies in this time savings *A'B'BA*.

In order to estimate this time savings and to perform some sensitivity analyses we have implemented this model on a data sheet.

For this implementation we need to estimate the function of speed according to traffic level, the average charge (*p*) and the value of time for car trips.

For the speed function we use a common specification (as in Prudhomme and Bocarejo, 2005)

$$v(q) = v_0 - bq$$

where v_0 is the free-flow speed, q the traffic and b a parameter to estimate. This function describes the technical capacity of the road network.

This function is calibrated from aggregate traffic and average speed before and after charging implementation. Average charge per vehicle-kilometre is computed from annual revenues and traffic volume (in vehicle-kilometres).

Average cost *AC* is assumed to vary only with the trip duration, thus with the traffic speed. Marginal cost *MC* is obtained by derivation of average cost. Thus cost functions can be easily implemented. Demand function can also be implemented from the knowledge of speed function (see above) and both average costs and traffic level before and after charging implementation (following the methodology described in Prudhomme and Bocarejo, 2005): thus the slope of the demand function (assumed to be a straight line) varies according to value of time, speed and traffic volume before and after charging implementation, and average charge.

3.2 Implementation in the London case and sensitivity of the model

Implementation of the model in the London case

Data for calibrating speed function are provided by TfL (2007): these include before and after aggregate traffic volumes (respectively 1,531 and 1,276 thousands of veh-km), average speeds (resp. 14.10 and 16.40 km/h) and average charge per veh-km 0.85 €. The value of time by car is given by TfL (2007), i.e. 37€ per person in the Central Area[3].

From this computation we obtain monetised time savings of €133 million per year in the Charged Area which can be compared to TfL estimates of €135 million. This gives at least a partial validation of our model implementation.

Sensitivity in the London case

Equipped with this model, we can use it to assess the sensitivity of monetised time savings to various parameters which influence both supply and demand curves estimated as described above (assuming the same relative error in the measurement of these parameters, i.e. plus/minus 10%). The figures of impacts in Table 3 show that the parameter that influences the most the amount of time savings is the speed measured before or after: the order of magnitude of time savings variation in response to variations of ± 10% of speed is about 80 to 100% of time savings. In comparison the sensitivity to errors of the same kind in the value of time, traffic levels or the average charge is almost negligible.

Table 3: Sensitivity of monetised time savings to various parameters in the London case

	Reference	variation	Impact on time savings
individual value of time (€/h)	37.00	+10%	12%
		-10%	-12%
average speed before (km/h)	14.10	+10%	-79%
		-10%	+102%
average speed after (km/h)	16.40	+10%	+72%
		-10%	-83%
traffic before (000 veh-km)	1531	+10%	-5%
		-10%	+5%
traffic after (000 veh-km)	1276	+10%	+15%
		-10%	-15%
average charge (€/veh-km)	0.85	+10%	-2%
		-10%	+2%

3.3 Implementation in the Stockholm case and sensitivity of the model

Implementation of the model in the Stockholm case

In the Stockholm case we have implemented the same model but with a modification in order to take into account the impact on traffic on radial access to the charging zone. So the average cost AC is broken down into two components, one relating to traffic and speed on radial

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[3] 1.45 € for 1 £

routes to the city centre the other relating to traffic and speed in the charged area. Thus the speed, demand and supply functions are calibrated separately for both radial access to and traffic within the charged area.

Our data are taken from Prud'homme and Kopp (2007) who based their analysis on data from the Stockholm city for traffic entering and leaving the city center, and from a 2004 Transport Survey for traffic having both their origin and destination within the city center. However part of the decline in traffic can be attributed to the increase in fuel price at the same time and the figures are corrected accordingly by the authors (but they assume that traffic within the city center remains constant since it doesn't pay the toll). The final figures for before and after traffic entering and leaving the city center are respectively 390 and 328 thousands of veh-km, and for central traffic 103 thousands of veh-km (this last adds to entering traffic to form the overall traffic in the charged area).

Average speeds on radial routes before and after charging implementation are respectively 49.87 and 51.05 km/h; the figures for speeds within the center are resp. 23.72 and 26.19 km/h. The former are computed from thousands of measurements on traffic densities at various points in both directions, the latter by the means of floating car speed data (see Prud'homme and Kopp, 2007). The average charge per veh-km is 9.7 SEK (1.02 €)[4]. The average value of time in Stockholm is 122 SEK per hour and vehicle, thus with an average load factor of 1.25, a personal value of time of 97.6 SEK per hour (10.3 €).

From these figures we obtain monetised time savings of €18 million per year: this is one third of the estimate of Transek which amounts to €55 million.

In the estimation made by TRANSEK (2006), the calculation of traffic flows and travel times is based on a mix of statistical method (in the charged area) and model calculations elsewhere (Stockholm's Stad, 2006). Indeed the statistical method needs a great input of data. Traffic flows are measured on a large number of roads in 15 minutes time intervals while for other roads a "matrix calibration" technique is used. For travel times, cameras, floating car surveys, speed detectors and model calculations are used. According to Eliasson (2008) this explains the difference in estimations of time savings, since Prud'homme and Kopp basically use point speed measurements from traffic counts detectors (and the speed is dependent on the location of the detector, e.g. if it is near a junction where traffic is queuing or not) in order to estimate the aggregate speed and aggregate traffic before and after charging implementation.

It is not possible here to settle the question between these two methods of measurement which both involve their own batch of measurement errors. However our main interest is to analyse the sensitivity of the results in (monetised) time savings to measurement errors of various parameters inputted in our simulation model. This is why we will again use this model to test this sensitivity in the Stockholm case. One should also note that the variations in traffic and speed that are tested roughly include the potential differences in measurement between the TRANSEK and Prud'homme and Kopp studies.

Sensitivity in the Stockholm case

Here again as in the London case we test the impact of relative errors of plus/minus 10% in the input parameters. This level of variation of 10% may be justified by the 95% confidence levels shown in traffic measurements in the inner city (Stockholm's Stad, 2006; p. 41).

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[4] €0.10512 for 1 SEK.

Table 4: Sensitivity of monetised time savings to various parameters in the Stockholm case

	Reference	variation	Impact on time savings
individual value of time (€/h)	10.3	+10%	15%
		-10%	-14%
average radial speed before (km/h)	49.48	+10%	-60%
		-10%	71%
radial traffic before (000 veh-km)	410	+10%	-7%
		-10%	21%
average radial speed after (km/h)	51.05	+10%	57%
		-10%	-71%
radial traffic after (000 veh-km)	328	+10%	13%
		-10%	-5%
average central speed before (km/h)	22.89	+10%	-89%
		-10%	106%
central traffic before (000 veh-km)	513	+10%	-51%
		-10%	298%
average central speed after (km/h)	26.19	+10%	76%
		-10%	-95%
central traffic after (000 veh-km)	431	+10%	102%
		-10%	-38%
average charge (€/veh-km)	1.02	+10%	-4%
		-10%	5%

As in the London case, the figures in the Stockholm case (see Table 4) show a very high sensitivity of time savings to speed measured on radial access (about 60-70% of variation in response to a ± 10% of speed variation) and even more in the charged ("central") area (about 90-100% of variation in response to a ± 10% of speed variation). However, the difference here with the London case is the significant sensitivity of time savings to the measurement of traffic in the charged ("central") area which can be much greater than the sensitivity to speed measurement. This difference between London and Stockholm reflects obviously differences in congestion levels (see the difference in measured speeds) and even in demand response after charging implementation with translate in different slopes of demand and supply curves.

To conclude on this sensitivity issue what do these results tell us? The estimation of time savings is extremely sensitive to the measurement of both speeds and traffic volume before and after charging implementation.

4 THE ISSUE OF PUBLIC FUNDS

Modern CBA adds now to the analysis of real effects the financial consequences from the point of view of public funds. This is the marginal cost of public funds (MCPF), defined as "the direct tax burden plus the marginal welfare cost produced in acquiring the tax revenue" (Browning, 1976). MCPF seems to be ignored in the UK appraisal current practice (at least in

TfL, 2007), but it is taken into account in Sweden (set at 1.3), distinctly from the opportunity cost (rate set at 23%)[5].

However, Jansson (2008) argues that MCPF should not be taken into account. Indeed the standard CBA of transport investment or policy assumes only marginal effects on other markets than the transport one, so that these effects should be ignored. This is not the case here since congestion charging affects the supply cost and concentration of labour force in the city center. This effect is generally ignored but Venables (2007) argues that transport improvements may impact the city size and hence the productivity of workers: according to this author the econometric estimates suggest a large effect.

Table 5 below illustrates the impact of these costs on the public accounts in the case of London and Stockholm, with a MCPF of 1.3 and an opportunity rate of 15% (in order to ensure a common level of comparison).

We have added the example of Oslo, which is not a “congestion” charging but a simpler “road user” charging scheme which started in 1991. In Oslo there was no objective of reducing the traffic or the pollution from automobile, but rather to levy new funds in order to finance a package of new infrastructure investments. The charging system is simpler than in London or Stockholm, with basically embarked on-board units and dialogue with road-side beacons at a few gantries. Thus the costs of charging (operation plus depreciation) amounts roughly to 10%-12% of toll revenues.

Table 5: The impact of costs of public funds

Public accounts (€ million per year)	London	Stockholm	Oslo
Congestion charge revenues	312	80	77
Additional bus revenues	28	19	
Congestion charge costs (operation + depreciation)	-194	-28	-9
Additional bus costs (operation + depreciation)	-26	-60	
Variation of fiscal revenues (excise fuel + VAT)	-55	-6	
Total Public Funds	*65*	*2*	*68*
MCPF Congestion charge revenues	94	24	23
MCPF Congestion charge costs	-58	-8	-3
MCPF Additional bus revenues	8	6	
MCPF Additional bus costs	-8	-18	
MCPF Variation of fiscal revenues	-17	-2	
Opportunity costs Congestion charge expenses	-29	-4	-1
Opportunity costs Additional bus expenses	-4	-9	
Total Cost of Public Funds	*-14*	*-13*	*19*
Total	51	-11	87

Sources: Tfl (2007) for London, Transek (2006) for Stockholm and authors’ calculation.

Two main lessons can be drawn from this table. First, the total impact on public accounts is significant in the three cases (compare the “total costs of public funds” item to the “total public funds” item) and may even put the accounts in the red (see Stockholm). Second, the MCPF has a multiplicative effect on the difference between revenues from congestion (or

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[5] Confusion occurs sometimes in the literature between these two kinds of costs. The MCPF refers to the distortion effect of the tax levy and the opportunity costs (sometimes called a “shadow price”) refer to the value in the best alternative use of these funds.

road user) charging and the expenses needed to levy them (compare the two first lines of MCPF in Table 5).

Moreover, if as suggested by the results of Kleven and Kreiner (2006) much higher levels of MCPF than usually considered would occur, then the multiplicative effect of MCPF would have also a greater impact on public accounts.

CONCLUSION

Despite time savings may be wiped out in the longer term by induced traffic, they provide a conservative estimate (and probably an underestimation) of the benefits gained from improvements in speed following from congestion charging implementation. However there is a need to be also conservative and cautious when considering (very) small time savings.

The methodology of measurement of travel time reliability (or variability) is not yet stabilised, but recommended estimates and moreover current empirical work suggest that it may take a growing share in benefits in the future. Perhaps a lesson from the point of view of transport policy would point at preferences toward reliability in travel time rather than increased speed in the near future.

The sensitivity tests performed in the London and Stockholm case studies indicate an extreme sensitivity of time saving benefits to errors in the measurement of speed and traffic volumes, whether before or after charging implementation. This points at the need to accurately measure these parameters but also at the recognition of unavoidable uncertainty: this is in favour of interval values in the CBA balance sheet rather than unique figures.

Finally the impact of costs of public funds on public accounts is greatly significant. The MCPF has a definite multiplicative effect on the difference between revenues from congestion (or road user) charging and the expenses needed to levy them, this effect being magnified by higher MCPF figures that would be suggested by the relevant literature.

ACKNOWLEDGEMENTS

This research has benefited from a grant of the Direction for Research and Innovation in the French Department in charge of transport (MEEDM), Grant no. 07MTE042.

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ANNEX

Table 6: Detailed breakdown of time gains per area in London

	unit	Charged area	Inner area	Outer area	Total
Pre-charge veh km	000 per day	1 531	15 100	32 929	49 560
Post-charge veh km	000 per day	1 276	14 722	32 708	48 706
Reduction in veh km	000 per day	255	378	221	854
Veh hours saved per day	hours per day	11 953	14 245	5 812	32 010
Time saved per veh km	minutes	0.59	0.06	0.01	
value of time vehicle	pence per min	51	37	29	
time gains	£ per day	365 762	316 239	101 129	783 130
time gains	million £ per year	93	81	26	200
En euros (1£=1.45€)					
value of time vehicle	€ per hour	44	32	25	
time gains	€ per day	530 355	458 547	146 637	1 135 538
time gains	million € per year	135	117	37	290

(source : Tfl, 2007 and authors calculation)