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Measure No.15: e-ticketing



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The introduction and use of new ticketing technologies on public transport systems using what might be generically termed 'smart ticketing' or 'e-ticketing'.

The introduction of a smart ticketing system in a city can improve services to passengers (increasing patronage) and introduce time-saving, marketing and data collection benefits for operators.

15.1 Context and background

This measure considers the range of new ticketing technologies for public transport systems, where the tickets are sold and stored in electronic devices, such as smart cards or a traveller's mobile phone.

These approaches are generically termed 'smart ticketing' or 'e-ticketing'. Such systems are now in use around the world, particularly in East Asian countries, but also increasingly in the US, Australia and Europe. Take up varies across European countries, but most have e-ticketing systems in one or more major cities; albeit many of them only launched in recent years. There is limited implementation at national or cross-border level, although steps are being taken to encourage standards, common approaches and potentially inter-operability (certainly in Europe). Some successful schemes (such as the 'Octopus' card in Hong Kong) are exporting their technology and approach to other countries, creating momentum behind a particular model of implementation. Further progress in inter-operability is perhaps becoming less of a technical issue, and more of a commercial one.

Key messages:

- Major cities (such as London and Hong Kong) have implemented e-ticketing solutions that are used by millions of travellers, and smaller scale implementations are commonplace.
- Traveller aspirations in this area are high.
- There are potential cost savings to be made by Operators from efficiency gains, fraud reduction and reduced 'dwell time' at stops, although there is less clear evidence for increased patronage.
- Initial costs can be high, particularly where none of the necessary infrastructure is already in place. Costs include hardware, software and consultancy for scheme design, with integrated schemes particularly cost intensive, requiring different applications to be connected.
- Cost-benefit analysis may struggle to make a positive case in respect of returns from additional travellers alone.
- Implementation of e-ticketing is rarely done in isolation; it is likely that some changes will also occur to ticketing arrangements (pricing, cross-operator, multi-mode) at the same time which may also impact on customer choices.
- e-ticketing technology is developing rapidly – which brings consequent risks of early obsolescence.

Potential interventions

- Mobile phone ticketing (m-ticketing)
- Smart card ticketing
- 'Contactless' ticketing (including contactless cards issued by financial institutions such as banks and credit card companies)

As noted above, e-ticketing can be delivered on a range of different devices, with the most common in recent years being 'smart cards'. Alternatives such as contactless bank cards and smartphones are also increasingly being used. The characteristics of the three approaches are:

1. Smart cards: Typically the size of a credit card, technologically simple and relatively cheap to produce. The cards either need to be brought into contact with a reader (contact-based) or the card needs to be placed in close proximity to (within about 10 cm of) the reading device to start the communication process (contactless).
2. Mobile ticketing (or m-ticketing): A virtual ticket held on mobile phones (or other mobile devices), purchased via the phone or mobile internet. Phones can also emulate a smart card.
3. Contactless bank cards: Distributed widely in many countries. Uses the same underlying technologies as smart cards, but use of these cards for transport ticketing involves a different approach to payment – and brings other participants (financial institutions) into the process.

Important underlying technologies include 'Radio frequency identification' (RFID) and 'Near field Communications' (NFC). RFID 'tags' embedded in devices can process data or communicate with other RFID tags and are compatible with existing contactless smart card infrastructure. NFC is a more advanced form of RFID technology that also permits short-range communication between electronic devices. NFC is able to emulate RFID readers and tags, allowing it to also potentially use earlier infrastructure.

A wide range of potential benefits are claimed for e-ticketing.

For travellers:

- They are simpler and more attractive than paper based systems.
- They can potentially be used across modes and across operators – again simplifying travel.
- They promote a more reliable service, quicker (less dwell time as drivers no longer deal with cash, or

as many cash transactions in systems that accept both means of payment)

- They provide easier access to tickets and the potential to 'manage' an account online. Tickets may now be sold through a wider network of outlets, or through 'recharging', or online. This may help some user groups (e.g. elderly people or people with reduced mobility). Tickets can also be targeted at different specific groups, such as schoolchildren, students, families, tourists, visitors etc.

- E-ticketing can facilitate 'fare-capping', ensuring the best price for trips across a day is calculated automatically.

For operators:

- They can remove or reduce the costs of handling coins and banknotes, as well as helping reduce the costs of on-bus security, and opportunities for fraud.

- They offer the potential for tailored marketing and more appropriate ticketing products, better adapted to the needs and travel patterns of each person. Smarter-ticketing also provides the opportunity to collect more detailed data on the behaviours of passengers across routes and networks, which can help operators and municipalities optimise networks, and provide services that better match customer demand.

- More passengers are attracted to public transport as a consequence of all above, and the more modern image created of public transport modes.

There are then a range of choices for those looking to introduce systems to replace paper-based ticketing on public transport, with consequences in respect of cost, implementation partners, risk (with respect to the technology), and customer take-up. However, there are other factors to consider. For example, it would not be feasible to move to use of contactless bank cards as payment mechanisms in a transport system if there was not widespread use of such cards in that location. Similarly if mobile phone based ticketing was used. There are also choices to be made about where such a system might be deployed, across a city (or part of), or a wider implementation across a region. Consideration

needs also to be given to interoperability with wider schemes or initiatives.

Evidence related to integrated ticketing (across operators and modes and in respect of pricing reform) is covered in Measure 12.

15.2 Extent and Sources of Evidence

Smart-ticketing is now in use in locations ranging from towns to city-regions, and in some instances across a national transport network (e.g. OV-chipkaart on the rail network in the Netherlands). Thus implementations are being used by thousands in some locations and many millions in others (e.g. the 'Oyster' card in London or 'Octopus' in Hong Kong). However, there appear to be relatively few items of evidence that purely evaluate the implementation of e-ticketing (smart-ticketing or m-ticketing), and as such it is difficult to corroborate the potential benefits claimed above.

In some instances new forms of ticketing have been implemented at the same time as changes to the ticketing and pricing regime, making it difficult to unravel the effects of the individual components of the change. It is also the case that in some instances these ticketing technologies are still very new, and limited evaluation of the impacts / results of these alternatives appears to have been undertaken to date. There are though a limited number of studies and reports which have compared the implementation of such systems in cities and regions across the world. Within the EU there have been many cities within the CIVITAS programme which have deployed 'smart ticketing', and there is some evidence available from these interventions. These might relate to specific routes within a city, or a more widespread implementation. CIVITAS has also provided summary reviews of such measures across a range of cities in its programme. There is also some material looking at the cost-benefit analysis of smart ticketing, particularly from a US context, although also exploring some European implementation. In respect of peer-reviewed literature, there appear to be relatively few sources available which evaluate implementations of this technology.

This measure review has taken material from the wider studies / reports as a starting point, and added to it specific examples from CIVITAS and the academic literature. Whilst the review material considers experience from around the world, the more specific evaluations have in general come from Europe.

15.3 What the Evidence Claims

15.3.1 General reviews of e-ticketing

Drawing on the experience of interventions carried out in the EU funded CIVITAS programme a 'Policy Note' on ticketing¹ suggests that there are some common factors that help to make moves to e-ticketing successful. Amongst these are developing a ticketing system that is 'user-friendly' and simple to use, and that where appropriate a standard technical architecture should be used. The tasks that will need to be undertaken in order to successfully implement an e-ticketing solution are discussed. Experience from the CIVITAS II programme suggests that the introduction of a new ticketing system would take about two years. Up to 16 months preparation and 2-10 months to implement. The policy note also considered complementary measures, interventions which could be undertaken in parallel with the introduction of e-ticketing which could enhance success factors. Those seen to be most appropriate include:

- Offering other services to public transport users via the same e-ticketing mechanism, to make the tickets more attractive to users, and potentially to increase use of other transport modes. Examples include access to car-sharing and bike sharing as well as cultural and leisure activities.
- Offering discounted prices on other transport interventions if using the new ticketing mechanisms, for example for bike-sharing or park and ride schemes in a city,
- Introducing journey and travel planning tools and ticket purchase 'apps' alongside the ticketing itself. Perhaps particularly relevant for m-ticketing solutions delivered on smart phones. Such tools help passengers find the right route, real-time information on

departures, means of access, and provide the means to easily purchase appropriate tickets.

In a second review document, this time produced by transport consultants Aecom², the work undertaken in the European Commission's "Study on Public Transport Smartcards" is documented. This considered the development of smart card fare payment systems across Europe and the rest of the world and specifically the benefits of such schemes to regular travellers, as well as exploring how smartcards might address the perceived and actual barriers to irregular travel. Using a questionnaire to quiz 20+ schemes around the world (including those in Hong Kong, Seoul and London). The report noted that the delivery of smart-ticketing schemes had been achieved through a variety of organisational approaches. These included models with one central scheme provider, or a network of stakeholders (operators, authorities, technical etc.), partnerships between public transport operators and local government(s), and some cases where a private company had taken primary responsibility. The number of (public transport) operators within a single scheme tended to be no more than 10, although it was possible for more established schemes to accommodate upwards of 40 individual operators. Funding had come from a range of sources, individual PT operators, local/regional government authorities, private shareholders or PFI arrangements. Parties involved in the development, implementation and operation of integrated smart ticketing normally fell into the following groups: Transport authorities; transport operators; standards bodies; equipment suppliers; service suppliers; and public transport users. The exact nature of the stakeholders involved, the role they play and how they collaborate between each other varied significantly between the schemes researched.

This report suggests that the main drivers for implementation for operators were efficiency gains and fraud reduction, whilst for passengers the goals were for a simple ticketing system that could cover all modes of public transport. In general, smart-ticketing was seen to be more reliable, convenient, faster and easier to

use than conventional ticketing, delivering a better overall product allowing users to travel more freely. The report concluded that these forms of ticketing may well remove some barriers to travel for irregular and unfamiliar travellers, but that operational as well as technology change is required to achieve all of the proposed benefits. More effective use of the data generated by the cards would be one way of better understanding what some of these changes might be.

The 2014 report from the Science and Technology Options Assessment (STOA) project of the European Parliamentary Research Service (EPRS)³ focussed not just on the implementation of e-ticketing, but more specifically integrating access to touristic sites into systems. In its review of the current status of e-ticketing solutions the report finds that finance, complexity and technology issues have so far hindered a wide scale implementation in Europe³, and that technology is developing at a faster pace than decision cycles. It suggests that successful e-ticketing solutions in cities such as London and Hong Kong were subject to particular conditions that allowed schemes to develop well (for example subway stations were already gated reducing infrastructure costs). Initial set up costs are seen to be relatively expensive (e.g., hardware, software and consultancy for scheme design), with integrated schemes particularly cost intensive, as different applications need to be connected³.

In a report for the UK Department of Work and Pensions that focussed on the wider benefits of the use of smart-cards in the UK⁴, it was noted that such technology may create efficiencies for a municipality in respect of delivering travel services, for example concessionary bus travel for older and disabled people. It might also contribute to image and reputational benefits for the area, from being seen to embrace new technologies. It was though noted that the UK case studies explored in the report had not typically attempted to conduct a full cost-benefit analysis or evaluation of costs of their schemes in a systematic way so no clear conclusions as to the economic factors relating to the introduction of such wider smart-card schemes had been made.

Issues of value for money were though considered in a US report in 2008⁵. This reviewed three smart-card based implementations in the United States. It was noted that each scheme created different costs and benefits, depending heavily on the public transport characteristics of the given region (e.g., whether a single operator or multiple operators are involved, government subsidy structures, existing ticketing infrastructure, etc.). Adopting smart ticketing was seen to be an expensive process, involving purchase of new equipment and revision of fare collecting systems, whilst the benefits were harder to quantify. The main beneficiaries of the smart-card systems were identified as the individual operators and passengers, with individual transit operators and multiple agencies bearing the majority of the deployment costs. The authors noted in the report that there were (at the time) relatively few cost-benefit evaluations of ticketing systems such as this in the US. The studies reviewed are also critiqued for a lack of rigour, and for not having any consistent application of accepted cost / benefit methodologies. Reasons given for this include problems in quantifying benefits, and the variety of organisational structures and political contexts found in the studies. The report concludes that smart ticketing solutions (in these instances smart cards) offer great potential, but that none of the three cases they considered managed to quantify the benefits clearly. They also find that while the underlying studies were informative, they were not comprehensive or generalizable.

15.3.2 e-ticketing specific studies

Considering more specific studies, some evidence can be found in evaluation studies produced by cities engaged in various European sustainable mobility programs, such as CIVITAS. Whilst a number of e-ticketing solutions have been deployed through this mechanism, relatively few evaluation reports were both available and suitable for consideration here. In the main this was because the intervention was still in the process of implementation at the time of review, the evaluation had taken place immediately after the implementation without sufficient time to properly explore any change, or a package of

measures had been introduced making it difficult to isolate results to any specific measure. Two CIVITAS interventions that have been considered are in the Danish city of Aalborg, and the Portuguese city of Coimbra.

In Aalborg⁶, smart card ticketing was deployed in a specific corridor only – a route between the University and city centre. The move was in response to falling public transport use along the corridor, but was also linked to a wider set of plans in respect of use of travel cards in Denmark. The evaluation studied both passenger statistics and acceptance issues to do with the new mode of ticketing. Results suggest higher passenger satisfaction levels, and higher than forecast growth in passengers. This was though an instance where a number of measures were introduced at the same time, so it was difficult to correlate the effects of e-ticketing specifically. Other measures included additional promotion, use of biofuels on the buses and 'on-trip' traveller information. Problems were encountered trying to also integrate taxi use onto the card, and delays in the wider national e-ticketing scheme were also an issue. Lessons learnt in Aalborg included:

- It can take a long time to implement e-ticketing, so it is important to ensure that schemes are flexible to adjust to evolving technology.
- It is important to have a clear data collection strategy, with data well managed.
- It is important to start with a pilot, to gain experience in a small part of the system (for operator and customers).
- When multiple suppliers are involved, it is important to have a clear specification and clear allocation of responsibilities. Involvement of drivers is key, as they are the first contact with passengers.

In Coimbra⁷, smart card ticketing was introduced to public transport services, and to park and ride facilities. The goal was to increase passenger numbers and increase use of park and ride. Cost-benefit projection (looking forward over 15 years) forecast a payback of 5-6 years, compared to

the costs of the existing ticketing systems. Actual results showed a small increase in PT users (1-2%), and 10% increase in park and ride use 9 months after the implementation began. Suggesting perhaps an over-optimistic forecast of potential benefits in this instance. As for Aalborg, a range of measures were implemented at the same time making it harder to isolate specific correlations in results, even though the evaluation did attempt to isolate the effects of e-ticketing in the passenger survey used as the basis for their review. Deployment of the scheme was held up by financial issues. Lessons learnt were that technical design of the system was important, and that by using the same standards as systems in the Portuguese capital Lisbon, technology and systems could be cheaper than for a bespoke delivery. Adopting an 'open' system also meant a range of suppliers could tender, again with potential to reduce cost.

The implementation of e-ticketing in Trondheim⁸ (using smart cards called 't:card') was part of a regional scheme. The intention was to provide a single card (using a single 'contract') which customers could use for buses, trams, and regional coaches operated by 10 public transport operators in and around Trondheim. The scheme was reviewed using social cost-benefit analysis of data after 12 and 24 months of operation (using a 10 year CBA). The scheme is seen to be profitable from a socioeconomic point of view, with an NPV of \$32.5 million and a benefit to cost ratio of 1.96. (The study notes that transportation expenditure in Norway usually struggles to deliver a positive NPV at all). After more than three years of operation, approximately 90 percent of all trips were paid for using the t:card. Incentives to use the card include discounts compared to cash, with further reductions if using monthly passes. This study also considered boarding time for passengers, with time savings of 6.8 seconds per passenger compared to those using cash. The scheme had again faced delays - this time due to technical complexities and some legal issues with suppliers.

Several 'pilot' studies were carried out in the Netherlands in advance of the nationwide OV-chipkaart scheme. One of these

was the 'Tripperpas' smart card study which ran for 2 years on urban buses in Groningen⁹. Passengers who used Tripperpas as well as non-users were surveyed at regular intervals over the length of the study. Some 4000 of the cards were issued (the population of Groningen is 180,000). Results suggest that the people most likely to use the card were aged 25 to 64, using the bus primarily for work or shopping. Reasons cited for use included ease of use and convenience. Some technical issues were experienced which were often quoted as a source of irritation by those surveyed, with the percentage of respondents who had experienced some kind of technical disruption associated with the check-in or checkout procedure using the card reader reaching 61% in the final survey. It was thought an element of this might be poor handling by cardholders - perhaps suggesting more advice should be given. Other lessons learnt included poor customer understanding of the 'best price' guarantee (fare-cap) implemented on the card, and that students (some 30% of the non-users surveyed in this university town) already had a travel pass, and thus had no reason to use the new one. Many users also regarded the lack of immediate, transparent information on what they had been charged as a negative feature of the scheme compared to the previous ticketing mechanisms.

In a study undertaken by the Dutch Ministry of Transport in 2006¹⁰, the potential impacts of implementing a nationwide public transport smart card (later to be called the OV-chipkaart) were explored through a socioeconomic cost benefit exercise. The study considered impacts on a range of stakeholders, and also conducted a range of sensitivity tests on the results. The overall forecast was for a positive NPV, with operators getting the best benefit, followed by passengers. The effects of smart card introduction were estimated against the situation where existing ticketing continued, and also made allowances for probable societal and public transport changes. The smart card technology was assumed to have a life of 15 years, before the underlying technology became obsolete. The results of the exercise were that the NPV of overall benefits would be €3.5 - €4.2 billion, whilst costs would range from

€2.7 - €3.0 billion, meaning a surplus of €0.4 - €1.5 billion. This study then suggested that the scheme was a profitable investment for the Netherlands. Operators would reap the most benefits (€0.4 - €0.9 billion) from nationwide implementation, and passengers as a group would also benefit substantially. The scheme would be most favourable to larger operators, as a high proportion of the costs involved in the smart card project are fixed. In urban areas, the costs involved in equipping all vehicles with smart card apparatuses are relatively high, and they must be recovered from trips of short average lengths. Operators of railways and metro systems would be able to use smart cards to facilitate the introduction of a closed station system, thereby achieving more reduction in fraud and higher fare revenue gains. Looking at partial implementation in the sensitivity test suggested that all of the alternatives examined would render less favourable outcomes than implementation of smart cards on a national scale.

In a further 'forward-looking' study for the city of Budapest in Hungary, a wide range of ticketing options (including e-ticketing) were compared to the current paper-based system by the Centre for Budapest Transport (BKK)¹⁴. The study determined that a system based on contactless cards (including in addition contactless Bank Cards), would provide the optimum solution for public transport in the city, addressing a range of problems including fraud. The formalized feasibility study was prepared in accordance with the methodology required for EU co-financing and included a cost-benefit analysis to support its analysis (although this is not included in the published English-language report).

As well as the evidence on implementation of e-ticketing systems, there is also relevant evidence which considers the problems of using cash on buses as a payment mechanism. As has been noted above, the opportunity to reduce 'dwell time' at a stop whilst passengers board can have significant benefits for journey time, and in reducing the variability of journey time. In a study carried out on bus routes in Zurich¹¹, it was seen that onboard ticket sales involving cash reduced reliability. Up to 20% of the total trip time could be

spent on ticket sales (for the routes studied here), but actually the most significant problem was the variability in time spent in the ticket sales process. This variability made it difficult for schedule planners to develop accurate and reliable schedules, which was seen to increase costs and reduce service efficiency. The authors of the study suggest that the results give weight to strategies that will reduce onboard ticket sales (although they propose that the best situation is to eliminate onboard ticket sales whenever possible). In a further study¹² looking at the issue of dwell time, but this time located in Vancouver Canada, fare payment methods are seen to have a 'substantial effect' on dwell time and thus schedules. The study finds that different payment methods showed a statistically significant positive effect on dwell time, with cash payment having the highest effect, and 'no fare' presented showing the lowest effect on dwell time. Paying in advance of travel, and the use of e-ticketing solutions are recommended in response. Tirachini¹³ (2013) also explored the effect of a range of ticket sales and validation approaches on a number of bus routes in Sydney Australia. Using observed data and a modelling approach it was established in this study that moving from cash-based paper ticketing to e-ticketing solutions could make a difference not only to dwell time and reliability, but also to the numbers of buses and drivers needed to operate a route. In some circumstances changing the method of ticketing (to contactless cards) could offer greater benefit than implementing bus priority initiatives onto a route.

15.3.3 Reflection on methods used in studies

The 'review' documents / reports appear to have a greater focus on desk-based study, and in some instances of submitting questionnaires to cities deploying smart ticketing as a means of collecting data. Most of the individual studies seem to have tried to execute some form of cost-benefit analysis using their own national guidelines, or those provided by CIVITAS.

Aside from this a range of methods have been used, including surveys / interviews / focus groups with passengers and driv-

ers, as well as a range of modelling techniques. Other studies have looked at passenger numbers, cost of operation etc. In general the methods used in evaluation seem to be valid, and have attempted to determine benefits in areas of importance for that intervention.

15.4 Lessons for Successful Deployment of this measure

The fact that e-ticketing systems have been implemented in a range of cities and locales across the world over recent years would suggest that there such systems could be implemented in most cities, and at a range of scales. The case studies considered here do though point to several factors that are important when thinking about deployment at smaller scale, and the potential scale of finance required for larger scale implementations.

There seem to be some common issues to be overcome in respect of the technology used (especially during the requirements definition phase of any intervention), as well as funding (sometimes a significant level required) and political support. There do not commonly appear to be public acceptance issues with the new technology, although the example of the “tripperpas” and poor-understanding of the proposed fare cap perhaps highlights the need to ensure effective communications with travellers.

Other measures that can be seen as complementary, and helpful in respect of improving customer acceptance, include ‘ticket simplification’ and ‘integration’ of ticketing across operators and/or modes. These sorts of changes can not only help to promote public transport options, but also help provide incentives to encourage the move away from cash and / or paper-based ticketing. The introduction of e-ticketing also potentially opens the door to other add-on services using the same payment mechanisms. So for example, access to other modes of transport such as bike hire or car-share schemes. It also provides operators with a rich source of data about travel habits and behaviours, and potentially a marketing tool – possibly facilitating personalised solutions in some cases.

One factor that is evident in some of the studies considered here is that this is an area where technology is changing and evolving, and it is important to be realistic about the lifetime of any solution being implemented, and what might be done to make the most of the technology deployed. Factors such as ongoing maintenance and availability of support for hardware and software need to be considered and planned for. As was seen in the Coimbra example, there is also an imperative to think about wider technical strategies for e-ticketing, at regional and national (EU?) scales. Economies of scale may flow from adopting technologies and standards already in use, or planned at these larger scales.

Experience from the CIVITAS II programme¹ suggests that the following factors are also relevant when thinking about wider and more extensive implementation:

- Gaining political support,
- A willingness from operators to accept the new approach (particularly resolution of revenue sharing issues),
- Ensuring sufficient finance to deploy e-ticketing,
- Resolving the interaction with other systems (where necessary),
- Making sure that any approach is legal (particularly if multi-operator) and there is common purpose and engagement between all the relevant parties in the implementation process.

15.5 Additional benefits

As well as the evidence of economic and financial benefits of interventions discussed above, there are a number of additional benefits that are claimed for these policies:

- Delivery of additional services: The introduction of e-ticketing opens the door to other add-on services using the same payment mechanisms, including access to other modes of transport such as bike hire or car-share schemes.
- Information on travel behaviours: E-ticketing provides a rich source of data about travel habits and behav-

hours, useful in better planning of services, and in understanding existing (and potentially future) transport demand

- Promotional opportunities: Data collected from e-ticketing solutions can also provide operators (and cities) with a marketing tool – and the opportunity to deliver more personalised travel solutions to travellers, increasing use / patronage of systems.

15.6 Summary

Various forms of e-ticketing are now found in cities worldwide. Major cities such as London and Hong Kong have implemented solutions that are used by millions, and smaller scale implementations are commonplace. For municipalities looking to make the transition to such a solution there is plenty of guidance, and explanation of the processes and potential benefits achievable. What is less apparent is simple and clear evidence of benefits specifically attributable to this intervention. This might be for several reasons. Firstly, implementation of e-ticketing is rarely done in isolation. It is likely that some changes will also occur to ticketing arrangements (pricing, cross-operator, multi-mode) at the same time which may also impact on customer choices. It is also the case that technology has been developing rapidly in the ticketing arena, and studies five or ten years ago may be restricted in what they can say about current technologies, costs and traveller aspirations.

Evidence does seem to suggest though that there are potential cost savings to be made, in particular for operators, and that e-ticketing solutions also provide a valuable new source of data for planners and operators alike. What is less clear is if they increase passenger numbers.

Initial costs for this sort of intervention can be high, particularly where none of the necessary infrastructure is already in place, and as evidenced here, pure cost-benefit analysis may struggle to make a positive case in respect of returns from extra travellers, so it will be important to also think of benefits from addressing issues such as reduced dwell time, fraud, image, marketing, cross-selling etc. when

considering implementation of some form of e-ticketing. The magnitude of costs will also be related to whatever the existing system of ticketing is, and how much of a change the e-ticketing solution will require (for example whether a city is moving from a paper-based or an earlier form of smart ticketing system).

In terms of economic evaluation, it appears that in many instances there has been no systematic evaluation of costs in schemes, or attempts to carry out a full cost-benefit analysis. Where CBA has been applied (in the US examples considered here for instance) approaches are seen to be either inconsistent or techniques used not widely accepted. The evidence from Trondheim does though suggest that when wider socioeconomic benefits are quantified, then positive benefits can be seen.

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No.5	Roadspace reallocation	Clark, B ^{2,b}	Ben4.Clark@uwe.ac.uk
No.6	Environmental zones	Calvert, T ^{2,b}	Thomas2.Calvert@uwe.ac.uk
No.7	Congestion charges	Mingardo, G. & Streng, M ^{3,c}	mingardo@ese.eur.nl
No.8	Parking	Mingardo, G. & Streng, M ^{3,c}	mingardo@ese.eur.nl
No.9	Site-based travel plans	Bartle, C ^{2,b}	Caroline.Bartle@uwe.ac.uk
No.10	Personalised travel planning	Bartle, C ^{2,b}	Caroline.Bartle@uwe.ac.uk
No.11	Marketing and rewarding	Rudolph, F ^{1,a}	frederic.rudolph@wupperinst.org
No.12	Public transport enhancements	Shergold, I ^{2,b}	Ian2.shergold@uwe.ac.uk
No.13	New public transport systems	Clark, B ^{2,b}	Ben4.Clark@uwe.ac.uk
No.14	Integration of modes	Calvert, T ^{2,b}	Thomas2.Calvert@uwe.ac.uk
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