The wider benefits of high quality public transport for cities

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Summary

The full value of public transport is often underestimated. The 5E framework, consisting of effective mobility, efficient city, economy, environment and equity supports assessing and quantifying this value. This paper presents the framework and a wide selection of sources illustrating the wider benefits of high quality of public transport for cities.

1. Introduction

Public transport is a service that has a wide array of benefits: for its users, but even more so for a society. Apart from its ability to transport large numbers of passengers efficiently, public transport for instance reduces the negative impact of transport in cities, while meanwhile fuelling business growth, accessibility and improving public health. In an ideal world, all these effects would be taken into account when designing transport policies or assessing (new) public transport links and options. In practice however often only the cost of construction and/or operation and the effects for the public transport users (e.g. time savings) are taken into account. This means that in many cases the true value of public transport is underestimated (Van der Bijl et al., 2014).

Although the current approach provides insight in the performance of public transport to *some* extent, it disregards many other (positive) effects the provision of public services has. Many of which impose an advantage over competing modes of transport. This often results in the postponement or even cancellation of plans, as means are more and more scarce and invested where gains are directly visible. Thus, to allow for a fairer assessment of public transport plans and projects, more insights are required into its (value of) 'wider' benefits.

This paper outlines an array of the 'wider' effects that could be taken into account while assessing public transport options, depending on the specific context. It focuses on the more important effects, with the largest societal impacts. The elements were derived from a selection of international (academic) sources and then grouped under five main aspects (the five E's). The number of relevant references is still growing. The objective of this paper is not to provide a complete literature overview, but to share a set of proven insights that can be taken into account while assessing public transport plans and projects. This should lead to a fairer decision making process.

2. The 5E framework

In our study (Van der Bijl et al. 2014, Van der Bijl et al. 2015), we developed a methodology to quantify the value of public transport using five E's. The five domains of argumentation can be summarised as follows:

- Effective mobility (E1) – effectiveness of transport and mobility.
- Efficient city (E2) – suitability of spatial use and spatial/urban (re)development.
- Economy (E3) – prosperity and wellbeing in/for cities.
- Environment (E4) – decreasing carbon footprints; sustainable cities.
- Equity (E5) – socially inclusive cities.

The latter three E's tend to be grouped together and are also known as the three P's: Profit (Economy), Planet (Environment), and People (Equity).
The Five E framework is illustrated in Figure 1.

The impact of each of the five E's may be quantified in monetary values using numerous international (academic) sources. A selection of these is provided in this paper. Examples are the values of time and reliability (in € per hour), gathered under the first E (effective mobility), the estimated increases in the value of commercial and residential properties (in per cent) included in the third E (economy) and the societal cost of greenhouse gas emissions of cars or of the production of fuel (per 1,000 passenger-km), included in the fourth E (environment).

Figure 1: The 5E framework

2.1 Effective mobility

Public transport is able to transfer a large number of people from A to B in a fast and reliable manner and reduce congestion on roads in the process. Public transport projects often aim at enhanced service quality such as speed, frequency, reliability, comfort and safety.

2.1.1 Comfort and service reliability

High quality public transport, such as light rail, has the potential to increase travel quality. Means to achieve this are higher frequencies, more comfort brought about by new vehicles and an upgrade of stops. The door-to-door travel time is reduced because of more stops compared to regular rail connections and the new vehicles. Mobility reliability has become more important over the years and similarly, reliability is an important aspect of quality in public transport, too. Both travellers and operators benefit from reliable travel times, brought about by shorter and more predictable trips, as well as lower costs (Van Oort, 2011).

However, comfort and reliability are often neglected in cost-benefit analyses. In Van Oort (2016) it is illustrated that these gains may be substantial and should be explicitly taken into account. It is shown that the benefits of improved service reliability might be even larger than travel time gains and an example of a light rail project showed that these benefits were equal to 2/3 of the total project and operational costs. Concerning comfort, Van Oort et al. (2016) show potential societal benefits of improving public transport. Their new approach takes also comfort into account in ridership forecast models. They show that the effect of a frequency increase in a congested public transport line in terms of additional passengers become significantly larger when these comfort effects are included. A case study shows the additional effect on ridership growth. They conclude that the traditional approach, which do not consider comfort benefits, tend to underestimate the additional public transport demand because of this measure with 30% in the morning peak, and with 20% in the evening peak. This means that a substantial part of the benefits of this measure can be attributed to improved comfort levels, which would not be detected otherwise.

2.1.2 Rail bonus

Research has shown that the provision of rail bound public transport might lead to greater benefits than comparable road bound public transport. Bunschoten et al. (2013) identified this effect as the ‘rail-bonus’. Since rail services requires considerably larger financial investments than a road bound public transport, its implementation must be thought through very carefully. The ‘rail bonus’ would be the added value causing more travellers to use rail than bus. Some experts in the field are convinced there is such a thing as rail bonus, even though no explanation for this phenomenon can be given. Others claim that bus and light rail are comparable means of transport.
To better understand this phenomenon, a choice experiment was conducted amongst inhabitants of large cities in the Netherlands (Bunschoten et al., 2013). Respondents were recruited both in cities with and cities without urban rail. The choice experiment required respondents to choose between a bus alternative and a rail alternative. Both alternatives differ in the same aspects, so the difference in mode-specific constant indicates the difference in preference. The perceptions of a number of mode characteristics of bus and light rail were measured to explain the difference in preference. Finally, the transition from difference in preference to the number of travellers was made using a traffic model.

The ratio indicates that when a minute travelled by bus is valued as 1 minute, this minute in light rail is valued as 47 seconds. Travelling by rail is therefore perceived 22% as shorter than travelling by bus. Applying this number in a study of transforming a bus line into a light rail line in Utrecht, it resulted in a prospect of an increase in travellers of 4.3% solely by this rail bonus (Bunschoten et al., 2013).

2.1.3 Accessibility

USA consumers place a high value on urban amenities such as shorter commute time and neighbourhood walkability: 60% of prospective homebuyers surveyed reported that they prefer a neighbourhood that offered a shorter commute, sidewalks and amenities like local shops, restaurants, libraries, schools and public transport over a more automobile-dependent community with larger lots but longer commutes and poorer walking condition. 46% find being in walking distance of public transportation very or somewhat important (Belden, Russonello & Stewart, 2004).

Because public transport riders tend to travel on congested urban corridors, they tend to have much larger congestion reduction impacts than their regional mode share. For example, although only 11% of Los Angeles commutes use public transport, when a strike halted public transport service for five weeks, average highway congestion delay increased 47%, and regional congestion costs increased 11% to 38% (Anderson, 2013), with particularly large speed reductions on rail corridors (Lo and Hall, 2006), indicating that higher quality, grade-separated service is particularly effective at reducing congestion (Anderson, 2013; Lo and Hall, 2006).

Another example, in Baltimore showed that the roadway congestion index increased on average 2.8% annually before light rail service started in 1992, but only 1.5% after; Sacramento's congestion increased 4.5% annually before and 2.2% after light rail service started in 1987; St. Louis congestion increased 0.89% before and 0.86% after light rail service started in 1993; and Dallas experienced no change after rail service started in 1996 (Litman, 2015).

2.1.4 Option Value

Public transport services provide a so called option value, referring to the value people place on having a transport option available even if they do not currently use it (ECONorthwest and PBQD, 2002). Public transport can provide critical transportation services during personal and community-wide emergencies, such as when a personal vehicle has a mechanical failure, or a disaster limits automobile traffic. This is similar to ship passengers valuing lifeboats, even when they don't use them. This involves assigning an additional value to each public transport trip made by infrequent users, taking into account the cost to consumers of each trip, the volatility of demand and the expected frequency of such trips. In typical conditions this appears to be in the range of $1-10 annual per resident who expects to use public transport a few times each year (Litman, 2015; ECONorthwest and PBQD, 2002).

2.2 Efficient cities

Public transport is efficient in its use of land and space and by accessing and unlocking areas spurs and sustains urban (re)development and improvements of public realm (e.g. Van der Bijl, 2006). Previous study found that gross urban population densities would be 27% lower without public transport systems to support compact development, and this increased density reduces urban vehicle travel, transport fuel use and GHG emissions by 8% (Gallivan et al., 2015). Based on fixed infrastructure, high quality public transport modes can play an important role in urban planning/design and traffic planning/design. Knowles and Ferbrache (2015) appreciate these qualities because public transport in this respect can attract "inward investment, employers, business and tourist visitors". Various new tramways and BRT (Bus Rapid Transit) systems show the iconic effect and value of public transport. Hence, cities may develop their own brands around their public transport system. In addition, public transport is able to (re)structure and to (re)shape the city (Van der Bijl, 2006).

2.2.1 Designing public space

Firstly, high quality public transport can play a decisive part in designing public space. Over the past years many examples have been gathered in best practice guides, like the Interreg project HiTrans (Van der Bijl et al., 2005), in which principles and strategies were developed to create high-quality public transport in cities and urban regions.

Secondly, public transport is an efficient tool for urban and regional planning. Examples of this have been assembled for projects like the previously mentioned HiTrans (Van der Bijl et al., 2005). High quality public transport turns out to be able to restructure the city and urban region. The same goes for neighbourhoods, quarters and precincts, including the areas on the decline. Public transport as urban-regional public transport is a powerful tool to oppose unrestrained urban growth.

Thirdly, public transport can be considered a major condition for urban development and planning. Light rail and similar forms of public transport on imbedded and fixed infrastructure (like metro) can improve urban connection and local accessibility. Their fixed infrastructure guarantees a technical and economic life span of at least thirty years, while sixty years or more is possible, too. This entails that the connections and local accessibilities brought about by this infrastructure can be useful for a very long time. More remote areas further away and difficult to reach can be connected and accessed when the infrastructure is extended. This helps create new, favourable conditions for further (re)development of these areas.

The fourth function of public transport is contributing majorly to the realisation of Transit Oriented Development (TOD). The fixed infrastructure that comes with for instance light rail can provide structure, which is useful for TOD because it helps centre real estate and property investments around stations and stops, in particular stops that function as transfer hubs. Multiple studies in America, Europe, and, more recently, Asia have proved the value of TOD. TOD has been applied in China. It turns out from our cases in Japan (Toyama) and Taiwan (Kaohsiung) that the combination of TOD and light rail offers promising integration of space and mobility.

2.2.2 Modal shift

The potential of public transport to lower traffic congestion also stems from the fact that a relatively small reduction in vehicle use can lead to a significantly larger reduction in hinder, once roads reach their maximum capacity. For example, a reduction of traffic volumes from 90% to 85% of a road's capacity can reduce delays for all users by 20% or more (Litman, 2009). Considering the societal cost of congestion, estimated at an annual €2.3 to €3 billion in the Netherlands (SWOV, 2017) or between £7 and £30 billion per annum in the UK (Shaw and Dochterty, 2014) there is an enormous potential.

A recent study in the Randstad region in the Netherlands, using measured data and focusing on the Amsterdam region, found that public transport is far more reliable in peak hours than traveling by car. Although journey times are generally longer, the time spent on trips is often the same on various days, whereas for car travel the variation could be up to two times the off-peak travel time (Goudappel Coffeng, 2016). Taking into account that the average societal value placed on reliability is about half of the societal value of travel time (€5.75 for car, €5.50 for train, €3.75 for bus opposed to €9.00, €9.25 and €6.75) enormous societal benefits can be obtained when car travellers revert to public transport, or when the whole public transport system becomes more reliable (Kennisinstituut voor Mobiliteitsbeleid, 2013).

In the UK, congestion costs between £7 billion and £30 billion per annum and urban areas are responsible for 89% of transport delays (Shaw and Dochterty, 2014; Eddington, 2006),

At a minimum, shifting from driving to public transport saves fuel and oil, which typically total about 10¢ per vehicle-mile reduced in the USA (Litman, 2015). In addition, depreciation, insurance and parking costs are partly variable, since increased driving increases the frequency of vehicle repairs and replacement, reduces vehicle resale value, and increases the risks of crashes, traffic and parking citations. These additional mileage-related costs typically average 10- 15¢ per mile, so cost savings total 20-25¢ per mile reduced. Savings may be greater under congested conditions, or where public transport users avoid parking fees or road tolls. More savings are available when better public transport allows vehicle ownership reductions. For example, if improved public transport services allow 10% of users to reduce their household vehicle ownership (e.g. from two vehicles to one), the savings average $300 annually per user (assuming a second car has $3,000 annual ownership costs), or 6¢ per public transport travel passenger-mile (assuming 20 miles of public transport travel a day, 250 days per year) in addition to vehicle operating cost savings.

2.3 Economy

Public transport improves the competitiveness of an area by attracting companies and inhabitants to its direct surroundings. Well served public transport stops and stations present favourable conditions that can elicit investments or other economic incentives. Particularly improved accessibility of sites is very meaningful for development, hence for the (future) land and property value. Research (e.g. Hass-Klau et al., 2004) showed public transport can represent an important condition for creating urban situations with positive economic effects, but always in combination with other interventions, such as additional actions, initiatives and investments, supportive policies, etc.

2.3.1 Urban (re)development

It is confirmed by research that (the introduction of) public transport often has had a direct impact on urban areas, for instance by speeding up development and increasing property and land values. In many cases. The introduction or improvement of public transport is seen as a key success factor when developing (new) sites, for instance because many companies see it as an essential element before relocating to a new site. A public investment in the MediaCity UK light rail-extension in Manchester was a perquisite for BBC to become a local tenant of the newly developed area (Conventz et al., 2013).

The impact of public transport on urban development is especially apparent at the former Docklands area in East London, which was redeveloped into business district Canary Wharf. A public investment of £77 million in the Docklands Light Railway, intended to provide the area with speedy connections to the City of London and, among others, London City Airport, enabled Canary Wharf to be developed by Olympia and York (Conventz et al. 2013). The firm also invested itself in the public transport development: £25 million in the construction of Canary Wharf station and £68 million in the DRL-extension to Bank underground station (Carter, 1991). Subsequently, land values in the Isle of Dogs area (located in the Docklands area) rose from of £70,000 an acre in 1981 to of £4,9 million in 1988 (Knowles, 1992). This theory is confirmed by other cases; for instance in Bremen, where sites adjacent to tram lines had land process roughly 50% higher than those with no direct public transport access. In the Rouen area housing prices rose more than 10% when public transport was improved and the same happened in Portland (+6.5%) (Hass-Klau et al., 2004).

2.3.2 Property values

Concerning commercial values, several sources report on impacts. In San Jose rents on commercial lease transactions between 1984 and 2000 were 13% higher within 400 m. of light rail stations than those more than 1200 m. away. In Dallas it was 22.7% and Santa Clara 10% to 7% (Weinberger, 2001; Crocker et al., 2000; Hass-Klau et al., 2004; Mohammad et al., 2013).

Similar situations of high quality public transport stimulating inward investment occurred in Ørestad (relocation of Danmarks Radio), West Midlands, Montpellier, Rouen, Calgary, Vancouver, St. Louis (Conventz et al., 2013).

2.3.3 Employment

High quality public transport has several potential impacts regarding employment, such as (Sanchez, 1999):

- **Direct effect**: jobs that are immediately generated by transport projects in feasibility studies and infrastructure works;
- **Indirect effect**: jobs in the supply chain and in the services that are involved in the construction phase of public transport infrastructure;
- **Induced effect**: jobs generated in the local economy through the commercial activities surrounding public transport infrastructure;
- **Catalyst effect**: jobs linked to urban regeneration and urban development around public transport infrastructure that allows for improved connectivity and accessibility.

2.3.4 Welfare dependency

The provision of, and access to, public transport services can help to reduce the welfare dependency of a society (Multisystems, et al., 2000). In Clarksville, Wisconsin, it was found that the introduction of a jobs access public transport service led to a reduction of welfare spending by $5.89 per dollar spent on public transport. About 90% of the 283 people that found employment via the Delta Area Rural Transportation System-program would have been unable to do so without public transport (Burkhardt et al., 2003).

2.4 Environment

Public transport is friendly for the environment and is essential for keeping cities and urban areas green and liveable. Public transport can favour smaller urban footprints/sizes since it requires high demand volumes hence dense environments. A model shift from individual to collective transport forms the foundation of sustainable transport, which in this regard is more efficient for all relating issues, such as energy consumption and greenhouse emissions.

Public transport lower emissions mostly in the urban areas, where the problems are most profound. It is estimated that public transport consumes about half the energy and only produces 5% as much CO, 8% VOC and 50% of the CO2 and NOx emissions per passenger-mile as an average car (Shapiro et al., 2002). This is why typical households can reduce their greenhouse gas emissions by 25% to 30% when they shift from two to one cars (Davis and Hale, 2007). When shifting to public transport entirely (from car dependent becoming transit-oriented dependent), a typical household can reduce its energy consumption and harmful emissions by about 45% (Bailey, 2007).

A study (Gallivan et al., 2015) found that gross urban population densities would be 27% lower without public transport systems to support compact development, and this increased density reduces urban vehicle travel, transport fuel use and GHG emissions by 8%. In addition, shifts from automobile to public transport directly reduce VMT, transport fuel use and GHG emissions by 2%, indicating that indirect emission reductions leveraged by land use changes are four times larger than the direct benefits from mode shifting.

2.5 Equity

Public transport has a large beneficial social impact that is often overlooked or underestimated. It helps in establishing a safe and healthy society with equal opportunities for all inhabitants. Public transport systems allow people that cannot use private transport, e.g. due to lower incomes or a disability, to access education, employment centres or healthcare facilities. This raises among others, the employment level, aides social inclusion and improves the level of public health. This could lead to significant overall cost reductions in the public funding of health care and welfare.

2.5.1 Accessibility of functions

The fact that public transport serves as a vital lifeline for lower income households is illustrated by their large share in the number of riders. The Federal Transit Administration (2002) found that in the USA lower income riders (annual household income <$20,000) represent 63% of all riders in small public transport systems, 51% percent in medium transport systems and 41% in large transport systems.

Many commuters would not be able to continue their current job when public transport services would cease (Crain & Associates, 1999). It can therefore be no surprise that the availability of transport for many people plays a major role in the decision making process about whether to apply for, to accept or stay in employment. Especially when considering that in some cases almost half of the job seekers say that a lack of personal transport or poor public transport is a key barrier from preventing them from getting a job (Social Exclusion Unit, 2003). Looking at this from 'the other side of the table', this also implies that a lack of public transport services has a direct negative impact on the labour pool available for companies (Knowles and Ferbrache, 2015). It is also investigated that people living near public transport services tend to work more days each year than those who lack such access (Sanchez, 1999 and Yi, 2006).

2.5.2 Public Health

The impact of public transport on public health is overwhelmingly positive. As identified in the fourth E (Environment), more public transport use leads to lower carbon emissions and hence reduces the risk on several diseases and premature deaths. This can have an enormous impact, as recent European (EU) figures show that 400,000 premature deaths per year can be attributed to air pollution, be it from all sources and thus not limited to transport (European Environment Agency, 2015). To put this figure in perspective; the annual death toll by traffic accidents is around 25,000 (Eurostat, 2016).

Apart from reducing the risk on pollution related diseases there are more health benefits associated with using public transport. As most public transport trips involve walking or cycling to access stops or stations, riders average about three times as much walking as people who rely on car transport. Public transport users average nearly 22 minutes of moderate physical activity (Besser and Dannenberg, 2005). An Australian study revealed that in Melbourne, public transport users average 41 daily minutes walking or cycling, which is five times more than the 8 minutes averaged by people travelling entirely by car (BusVic, 2010). This observation is confirmed by Lachapelle et al. (2011), who found that public transport commuters average five to ten times more daily minutes of moderate-intensity physical activity. As a result the odds of becoming obese for elder (60+) public transport users are up to 25% lower than for those who do not use public transport in the same age group (Webb et al., 2011).

Looking on a broader scale, increased public transport use has a positive impact on public health. Especially when growth in public transport means that the number of car trips declines, and with that also the number of accidents. The Dutch institute for road safety research (SWOV, 2017) estimated the societal cost of traffic accidents in 2015 to be around €14 billion. This comes down to 2% of the GDP and indicates that the cost of accidents is far larger than other transport borne societal costs, such as congestion (€2.3 – 3 billion) and environmental damage (€ 4.8 billion). Every fatality or heavy injury avoided would save around €2.9 million and €0.3 million respectively.

Public transport can support government agency activities and reduce their costs. For example, without public transport services some people are unable to reach medical services, sometimes resulting in more acute and expensive medical problems. The Social Exclusion Unit (2003), a governmental advisory board in the UK, found that nearly one third of all people without a car have difficulties accessing their local hospital (compared to 17% of people owning a car). Public transport can have a crucial role in improving this accessibility. This is illustrated by a study in Rural North Carolina, where public transport users averaged four more chronic health care visits than non-users (Arcury et al., 2005). This use of transport services for preventive medical trips (therewith avoiding hospital stays) was in a study in Florida estimated to result in a social benefit of $11.08 per dollar invested (Cronin et al., 2008). Given the costs involved, it is no surprise that the social benefit of health care-related public transport trips (in relation to home health care costs) was found to be around $5.66 per trip in Wisconsin; much higher as the benefit per work-related trip, which 'only' came to about $1.55 (HLB Decision Economics, 2003). In Florida similar benefits were recorded of the availability of public transport in relation to preventive medical trips

A downside to property and land value increases, as described in Section 2.3, is that it can displace lower and middle income groups. They are less able to afford higher prices. Even while these groups are generally more dependent on public transport. This social exclusion is shown in the former Docklands area (Knowles and Ferbrache, 2015).

Conclusions

Investments in public facilities can be justified based on several grounds. This also goes for high-quality public transport, which is an obvious facility. It is an (urban) facility and has far-stretching spatial consequences because of the infrastructural components. It turns out that there are five essential domains in argumentation for public transport. They have been successively branded as effective mobility, efficient city, economy, environment, and equity and are also known as the five E's. In this paper, this framework is presented and a selection of sources has described, supporting the quantification of the aspects.

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