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The prospects of fare-free public transport: evidence from Tallinn

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Abstract The subsidy level of public transport systems varies considerably among systems worldwide. While limited-scale free-fare public transport (FFPT) services such as limited campaigns and fare evasion for special groups or specific services are prevalent, there is only limited evidence on the consequences of introducing a full-fledged FFPT. The case of Tallinn, Estonia offers a full-scale experiment that provides a unique opportunity to investigate the impacts of FFPT. This study examines travel pattern changes based on individual travel habit survey shortly before and almost 1 year after the introduction of FFPT policy in Tallinn based on interviews and travel diaries of a random sample of 1500 household. We analyse modal shift effects and whether they are driven by trip generation or trip substitution, travel attitudes and satisfactions as well as impacts on equity, employment prospects, and trip destination choices. Almost a year after the introduction of FFPT, public transport usage increased by 14 % and there is evidence that the mobility of low-income residents has improved. The effect of FFPT on ridership is substantially lower than those reported in previous studies due to the good level of service provision, high public transport usage and low public transport fees that existed already prior to the FFPT.

Keywords Pricing policy · Free public transport · Travel behaviour · Mode split

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Introduction

Maintaining and increasing public transport market share has become one of the main priorities for local authorities and policy makers. The continuous growth of transport demand along with the increased traffic congestion has negative consequences on the environmental conditions and the economic competitiveness in Europe. Providing an attractive and reliable public transport service is considered to be an important element for creating sustainable mobility (European Commission 2004). Consequently, many transport stakeholders, such as the Transport Administration of Stockholm County Council in Sweden, make the increase of public transport share as one of their main policies goals (Stockholm County Council 2011).

Pricing is one of the policy instruments that can be devised to bring about a modal shift in favour of public transport. A pan-European survey conducted by the European Commission (2013) found that the Europeans believe that the two best measures to improve urban transport are lower prices (59 % of all respondents) and better (56 %) public transport. The support for these measures was high among all travel mode users and particularly high among those that consider road congestion to be an important problem. In half of the 28 EU member states lowering fares was the most frequently selected instrument. In contrast, only 9 % believe that road pricing is a good measure. Some activist groups, non–governmental organizations and political parties advocate for completely revoking fares in public transport systems. While free–fare public transport services exist in numerous countries, they remain the exception. The term Free–Fare Public Transport (FFPT) is used here rather than the common 'free public transport', since this policy is not free-of-charge. While passengers have no out-of-pocket costs, the public transport system does not run for free. Service provider will have to cover for the lost fare revenues in order to fully subsidize the service. Urban public transport systems are subsidized in virtually all European cities. However, the extent of subsidy varies considerably among cities (e.g., 15 % in Hannover, 50 % in Stockholm, 68 % in Den Haag). Most Baltic cities including Stockholm, Copenhagen, Malmö, and Turku have a subsidy level between 30 and 60 % (Nielsen et al. 2005a). Note that this is true across various procurement strategies as these cities have adopted different contracting schemes. Moreover, the public transport pricing scheme also varies considerably among these cities.

Public transport fares is a topic that steers public debate from the 2013 protests in response to a rise in fare and in favour of FFPT in Brazil to local initiatives encouraging fare evasion. Even though FFPT has been a subject of vivid public and policy making debate, there is lack of knowledge on the consequences of this policy instrument and its effects on individual travel behaviour. Previous studies were either concerned with limited-scale campaigns that were limited to specific periods, service or user groups, or reported aggregate changes in ridership for small–scale systems that simultaneously multiplied their supply provision. The case of Tallinn, Estonia pertains a full-scale experiment that provides a unique opportunity to investigate the impacts of FFPT. A previous study by Cats et al. (2014) analysed the immediate impacts of FFPT by measuring changes in system indicators after 3 months of fare-free operations. However, an analysis of the short-term ridership effects does not allow drawing conclusions on whether the policy objectives have been attained.

This paper examines travel pattern changes based on individual travel habit survey shortly before and almost 1 year after the introduction of FFPT policy in Tallinn. In contrast to previous studies which looked into aggregate changes in ridership and service performance, this paper analyses detailed individual travel survey and diary data. The study is based on a large-scale annual survey commissioned by the City of Tallinn. The survey is based on face-to-face interviews with a random sample of 1500 households, enabling the investigation of the impact of FFPT on individual travel habits before and after the policy implementation. The analysis considers modal shift effects and whether they are driven by trip generation or trip substitution, travel attitudes and satisfactions as well as impacts on equity, employment prospects, and trip destination choices. Given that FFPT policies are meant to increase the mobility and accessibility of local residents, it is crucial to analyse and understand how the travellers adopt the policy and how the policy have influence their daily activity-travel patterns. Whilst the theoretical discussion attempts to conclude on aggregate FFPT impacts based on changes in individual decision making, empirical analysis heretofore attempted to deduce travel pattern changes at the individual level based on aggregate changes. In this paper, we empirically analyse travel behaviour changes at the individual level.

The following section provides a theoretical background on arguments for and against FFPT based on transport economics literature. Section "The fare-free public transport policy landscape" provides a comprehensive review of the landscape of experience with FFPT and its evaluation. The case of Tallinn is presented in Sect. "The case of Tallinn" followed by details on the data available for this study (Sect. "Data collection"). Results and the analysis of the effects of FFPT are described in Sect. "Analysis and results" followed by a discussion on their implications and future studies in Sect. "Discussion and conclusion".

Theoretical background

The identification and analysis of the main determinants of demand for public transport has been a subject of extensive research. Previous studies have confirmed that public transport demand is affected by various factors from socio economic to supply factors. The latter includes improving the level of service and altering pricing schemes. Public transport pricing schemes can range from full-economic market price charging to a fully subsidized free of charge service. Most public transport agencies opt for a middle-way, i.e., offering a partly-subsidized service, where users finance the remaining cost (Van Goeverden et al. 2006).

The impacts of pricing on public transport usage have been investigated by a number of meta-analysis of fare elasticity (Kremers et al. 2002; Paulley et al. 2006; Holmgren 2007). The values reported in the literature for fare elasticity exercise large variations ranging from −0.009 to −1.32 with a mean value of −0.38 (Holmgren 2007). The frequently used rule-of-thumb, Simpson–Curtin rule (1968), suggests that an increase of 3 % in fare reduces ridership by 1 % (i.e. elasticity of −0.33). Like most rules-of-thumb, this correlation can be used for a quick-and-rough impact prediction but may be too simplistic for detailed planning and behavioural impact modelling (Litman 2012). Paulley et al. (2006) examined how fare elasticities depend on travel mode, type of area, analysis horizon, type of fare change, current fare levels as well as the specific local circumstances. Moreover, fare elasticity depends on the magnitude, sign and time-span of the fare change. Chen et al. (2011) concluded that fare elasticity is strongly asymmetric—passenger demand decreases in response to an increase in price but the effect associated with a price reduction is insignificant. Holmgren (2007) found that the long-run fare elasticity was found significantly higher (in absolute terms) than the static or short-run elasticity. This suggests that travellers gradually adjust their travel behaviour to price changes. In addition, due to the strong inter-relation, supply changes should be treated endogenously when analysing public transport demand. Previous studies have also found that fare elasticities vary among travellers groups. Elasticity goes down with age, goes up with income and is higher for off-peak and non-commuting trips (McCollom and Pratt 2004; Litman 2012). Overall, the sensitivity analysis from previous studies has shown that people are more likely to shift from their private car to public transport when increasing the price of car usage rather decreasing the cost of travelling by public transport.

FFPT actually is hardly a new idea. It has been in public debate for decades for various reasons including the idea that public goods should be free, providing universal accessibility, counteracting road congestion, and relieving the negative environmental impacts caused by urban transport. The notion of free-of-charge public goods refers to the idea that services such as schools, libraries, roads and parks are free to use for everyone. Applying the same notion to public transport implies that as a measure of mobility, it should be free as well, especially when cities are growing rapidly and people are forced to live further and further away from the centre, where education and job opportunities are located. High transport costs—whether paid by the employee, the employer or shared—can become a barrier in the labour market because of their impact on the cost of employment or the disposable income. Other arguments in favour of FFPT include enhancing social inclusion and improving service efficiency due to the decreasing marginal cost that characterize public transport operations.

FFPT could potentially induce a fundamental demand change that cannot be assessed through fare elasticities.

The main argument against FFPT is based on the abovementioned findings concerning price elasticity. Since the elasticity of ridership to public transport fares is lower than the cross-elasticity to car usage price, FFPT is a second best pricing policy for promoting a modal shift towards public transport. Moreover, travelling by car is often under-priced. Disincentives for car usage such as congestion pricing, parking fees and fuel prices might result with a greater model shift from car to public transport than those gains by reducing public transport fares (Cervero 1990; Litman 2012). Depending on the extent to which the cross-elasticity dominates the direct elasticity, a larger public transport fare reduction would be required than an increase in the cost of car usage, in order to attain the same modal shift effect. Since the marginal operational cost is the highest in the peak period, it is preferable to introduce a differential fare scheme that would attract demand to underutilized segments of the public transport service. Targeted concessions can be made for disadvantaged groups resulting with progressive redistribution effects instead of a universal fare evasion.

FFPT could also be considered as a marketing strategy. Previous studies suggest that travel mode choice does not only depend on objective attributes, such as cost, but is also influenced by subjective factors such as beliefs, attitudes, and habits (Verplanken and Aarts 1999; Fujii and Kitamura 2003). Thøgersen and Møller (2008) and Thøgersen (2009) pointed out that in the field of subscription services, temporary price promotions, offering a trial period for free or at a heavily discounted price, is widely used as a mean of spurring initial interest. Such an offer can potentially disrupt the consumer's habitual activity and encourage experimentation. Arguably, changes in service attributes may influence travel mode choice if and only if they influence subjective factors that the behaviour depends on. Moreover, even if service attributes do not change, travel mode choice may change if related subjective factors have changed. For example, Shampanier et al. (2007) argue that decisions about free-of-charge products are fundamentally different because people do not simply subtract costs from benefits but instead they perceive the benefits associated with free products as higher. Thus, the impacts of FFPT could exceed the impacts anticipated based on findings from fare reductions and related elasticity coefficients.

Whilst previous studies provide insights on the relation between fare changes and ridership, there is lack of knowledge on the impacts of public transport pricing policies on individual travel patterns. In particular, FFPT policy may lead to distinct behavioural responses, including targeting new market segments that will determine the cost effectiveness of this measure. The following section reviews empirical findings from various FFPT experiments.

The fare-free public transport policy landscape

In the last few decades, there have been a considerable number of FFPT implementations, primarily in Europe and North America. Most of the implemented schemes were limited period campaigns, limited to specific services (e.g., circular city centre line, short feeder service) or limited to certain user groups (elderly, students, tourists, etc.). There are only several cases where a full-fledged FFPT for all users were introduced and sustained for an indefinitely or a considerably long period. Unfortunately, only a small number of such experiments were followed by a rigorous empirical analysis that could facilitate a sound evaluation. As a result, empirical evidence on FFPT schemes and their impacts is scarce and often of limited validity.

In this section we provide a review of the FFPT landscape by examining empirical findings from recently completed or ongoing FFPT experiments and practices. FFPT implementations can be divided into full-fledged implementation and cases where one its features—continuation, comprehensiveness or universality—is missing. First, promotion campaigns of FFPT that were introduced for a limited period from the outset. Second, cases where FFPT concerns a specific service rather than system–wide policy. Third, FFPT implementations which are valid only for specific user groups rather than applied universally. Finally, full-fledged FFPT implementations are described. We reflect on the evidence available from the FFPT landscape in a synthesis.

Limited period FFPT campaigns

In an effort to promote a behaviour shift towards PT, agencies and operators offer non-regular users free rides for a pre-defined limited period. The success of such campaigns can be assessed by measuring the extent of behavioural change that lasts beyond the promotion period. Several such experiments were conducted in Scandinavia and followed by an empirical evaluation in recent years. Stavanger, Norway, experimented with FFPT between August and December 2011 which included a circular line and feeding services (Fearnley 2013). The evaluation concluded that there is no evidence for reduced car usage whereas the induced demand was caused by modal shift from walking and 'fun riders'. Transport authorities in Gothenburg, Sweden, carried out campaigns in both 2008 and 2013, providing tens of thousands of motorists with FFPT for a limited period. The findings indicate a 25 % short-term (2 months after the campaign ended) success rate of motorists that shifted from car to public transport as the primary transport mode for commuting trips (Personal communication with Mats Nyström, sales manager, Västtrafik). However, long-run effects were not measured. Thøgersen (2009) provided a sample of 373 car owners in the Copenhagen area, Denmark, a free month travel card and compared their mode choice with a control group. During the experiment, the share of participants that commuted by public transport increased from 5 to 10 % and 6 months later decreased to 7 %.

Several limited-period FFPT experiments were conducted in the United States during the last 50 years. Most recently, FFPT was implemented in Asheville, North Carolina, for 3 months in 2006. Ridership increased 59 % during the implementation and capacity was cited as a major problem during this experiment. An increase of 9 % in ridership was retained after the experiment was terminated. The experiment was also subject to some complaints by the bus operators, who reported problems with disruptive passengers and on-board crowdedness (Volinski 2012).

Limited scale FFPT experiments

There are numerous cases worldwide that provide FFPT on a specific service or small-scale system. Such services are often shuttle or feeder (e.g., airport, park and ride), inter-campus (e.g., university, technology park) or tailored for tourists (e.g., ski-resorts, old city). In a comprehensive review, Volinski (2012) identified 39 agencies that offer FFPT in the United States to all passengers on some of their services. He found that all of them operate small-scale fleets (less than 100 vehicles) in university, resort or rural communities. Agencies reported an increase of 20–60 % in ridership following the introduction of FFPT, albeit from low initial levels. Furthermore, only 5–30 % of the new trips were made by people who switched from private car.

Another example of a limited-scale FFPT pilot study is from The Hague, Netherlands, where two existing bus lines and one new route were made free for everyone on workdays. The time span for this policy was 1 year and the objective was to investigate the potential to reduce congestion from a parallel freeway. Ridership on the pilot bus corridor was tripled with 16 % new trips. The large share of the substitution came from cars (45 %) and public transport alternatives (30 %) due to the relatively long-distance context. It was concluded that although the pilot size was insufficient to achieve its objective, it led to a better utilization of service capacity (Van Goeverden et al. 2006).

The City of Chengdu, China, introduces a series of limited FFPT measures designed as demand management tools starting from 2007. These measures include FFPT for senior residents (70+, since 2007), when transferring within 2 h, in the early morning hours (5AM–7AM, since 2013) and for trips shorter than 1 km on several community lines. In addition, the frequency increased by 70 %. Following these measures, public transport mode share increased by 1.87 % (Tao 2013).

FFPT limited to specific user groups

While most FFPT implementations are arguably not entirely universal and exclude certain groups (most notably non-residents), many cities offer FFPT to specific user groups. Youth, students and senior citizens are most commonly exempted from paying public transport fares. One example of a large-scale program is the free–fare travel card available to higher-education students in the Netherlands who can travel for free across the country since 1991. Students can choose either have a weekdays or a weekends free pass. Public transport share increased from 11 to 21 % of students' trips following the introduction of this scheme. Most of the new users changed from cycling (52 %) followed by former car users (34 %). Additionally, the average trip length (kilometres travelled) increased by 15 %, mostly for urban transport modes (Van Goeverden et al. 2006). An increase in on–board crowding, especially on trains and weekends, led the national railway carrier to increase service frequency, thus benefiting also other travellers with a more frequent service. The Dutch government has repeatedly threatened to scrap the plan due to the costs and congestion it induces but has recently approved its continuation as part of a financial deal with higher-education institutions.

Another FFPT policy that has attracted researchers' attentions in the past is the one that was introduced in 2004 by the Flemish council in Brussels, Belgium for students admitted to Flemish universities (Macharis et al. 2006; De Witte et al. 2006). The FFPT applies only for parts of the public transport network that are administrated by Flemish operators. The impacts of this scheme were analysed based on a travel survey, mental map questions and in–depth interviews. New trips were generated by 26 % of the students with 1.7 additional trips per week on average. The substitution effects were 60 % from car, 15 % from other public transport alternatives, 19 % from walking and 5 % from bike. The average reduction in car trips among students who have a car available amounted to 82 km per week per student. However, French students still use public transport more extensively than their Flemish counterparts. The scheme was since abolished while offering a discounted annual fee.

One-third of all bus trips in England are fare–free because of concessionary travel passes. Nearly 80 % of those eligible for a fare-free pass on the grounds of age have one (a total of 9 million passes in 2011/12), where this share decreases with the size of urban area and from urban to rural. Bus companies are compensated for the lost revenue and the extra costs induced thereof. The price tag of this scheme amount to £1 billion a year, covered by the British taxpayer. This is equivalent to £92 for each pass, with each pass being used for 109 trips on average (Macket 2015). The direct costs to the public sector are quite explicit, whereas the scale of the benefits generated by the scheme is much less evident. Andrews et al. (2012) analysed the impacts of the fare-free pass on the mobility patterns of older people. Prior to the introduction of free local bus travel nationally in 2006, about 30 % of those aged 60 or over used the bus at least once a week. This share rose to 40 % in 2010. Conversely, the proportion that never travel on a bus fell from about 46 to 32 %, suggesting that offering fare free passes has induced some older people who did not travel by bus to do so. About 20 % of the trips being made using passes would have been made by car if the pass had not been available.

Full-fledged FFPT

Full-fledged FFPT policy was introduced and followed up by an empirical evaluation in several cities in the last decade. Hasselt (c.a. 70,000 inhabitants), Belgium, was arguably the most well-known showcase of FFPT. The city introduced a truly universal (not only for city residents) FFPT scheme on 1996 together with substantial additions to the relatively small network supply with a momentarily fivefold increase in fleet size. Van Goeverden et al. (2006) reported that ridership increased tenfold and 37 % of the new trips were attributed to new users—more than half of them substituted walking or cycling. This implies that former bus users carried out 567 % more bus trips. Notwithstanding, the market share of buses in 2013—after 15 years of FFPT—was merely 5 % (Verachtert 2013). This underlines the problems associated with incomplete information and reporting percentile change without providing the overall context which may result with misconceptions. Due to a rapid increase in the operations costs, the FFPT scheme became unviable for Hasselt and was withdrawn. Fees were re-introduced on January 1, 2014 with exemptions for special user groups. There are no indications of long-term implications on car ownership with more than 90 % of the households owning a car (motorization rate of 2.1 cars per household).

The small city of Templin (c.a. 15,000 inhabitants), Germany introduced a FFPT policy on 1997 (Storchmann 2003). Since then the local public transport system is universally free. The ridership increased by 1200 % within 3 years with the vast majority of this increase reported to be among children and youth. This led to an increasing problem of vandalism. Similarly to the case of Hasselt, the absolute ridership level portraits the results in a dramatically different light as the number of annual passenger trips performed prior to FFPT was merely 41,000, or 115 per day, and thus increased to 0.1 trip pas passenger per day with FFPT. Furthermore, the vast majority of the substitution effects were due to shift from soft modes—30–40 % from biking and 35–50 % from walking. Only 10–20 % of the substitution effects were associated with previous car trips. A cost–benefit analysis suggested that the FFPT policy resulted in considerable safety benefits due to the undesired shift from the more dangerous soft modes.

Since 2009, all public transport services in the city of Aubagne and nearby municipalities (c.a. 100,000 inhabitants in total), France, are free for all users. The main motivation was social and supported by the fact that user fares accounted for only 9 % of the public transport system budget. No systematic analysis was carried out, but there are some indications that ridership doubled and more resources were allocated to increase system capacity. Similarly, Chapel Hill (a population of c.a. 60,000) implemented in 2002 after conducting an analysis that showed that revenues from fares (full paying passengers) were relatively low—around 8 % of the operating costs. After the implementation of FFPT, the ridership increased by 43 % during 9 months period. This was introduced simultaneously with an increase in service supply (Volinski 2012).

Several towns in Sweden—Kiruna, Avesta and Kristinehamn (each with a population of c.a. 20,000)—implemented FFPT, as well as the medium-size city of Örebro (c.a. 100,000). In Örebro and Kristinhamn it was abolished soon afterwards with indications that ridership first decreased when fees were reintroduced but returned to the level prior to the policy or slightly higher within a year. An evaluation based on interviews and passenger counts indicates a 80 % increase in ridership in Avesta, with most of the increase attributed to more frequent trips by public transport users (Ramböll 2013).

Synthesis

Even though the impacts of FFPT were investigated only for a minority of these experiments, there is a substantial literature concerning FFPT implementation. FFPT promotion campaigns seem to have a moderate effect on modal shift. However, the results of such evaluations arguably have limited transferability to full-fledged FFPT. The immediate campaign effect may not be indicative of habitual changes which may bounce in the long-term, while the post-campaign effects do not correspond to FFPT conditions.

Even though there is a large number of FFPT experiments that were limited to specific services, the particularities of limited-scale FFPT hinders the generalization of their results. Furthermore, these services are often introduces as part of a marketing or mobility program steered by business interests such as business clusters, campuses and tourist sites.

Only a handful of full–fledged FFPT were implemented and evaluated. The evaluation was often performed by the local agency or municipality. Universal system–wide experiments were introduced in cities with a highly subsidized public transport system to start with and a low public transport market share with a population of up to 100,000 inhabitants. The effects of some of the experiments that became known as success stories were in fact very humble when observing the absolute numbers. Moreover, the small increase in the number of passengers was not triggered by a modal shift and was accompanied with a significant increase in resources (due to an increase in coverage, accessibility and frequency).

While previous implementations of FFPT shed some light on the anticipated impacts of such a policy measure, there is lack of analysis which limits its validity and prevents their quantification and generalization. A review of over 20 FFPT programs in the United States by McCollom and Pratt (2004) concurrences these findings as they concluded that most of the reported results are anecdotal. Notwithstanding, Hodge et al. (1994) and Volinski (2012) concluded that the introduction of FFPT can be expected to yield an increase of at least 25–50 % in ridership. Furthermore, smaller systems are in a position to benefit more from FFPT due to their lower fare–box recovery rate and the availability of reserve capacity. Furthermore, previous studies did not examine the impact of FFPT at the individual traveller level and thereof policy implications on activity and travel patterns.

The case of Tallinn

Tallinn, with approximately 420,000 residents, is the first European capital and the largest city in the world so far that offers FFPT services to all of its inhabitants. The City of Tallinn introduced this policy as part of its overarching agenda to promote sustainable transport solutions. The FFPT policy was introduced on January 1, 2013. This section presents the context and background of the FFPT initiative, its objectives and implementation.

The public transport system in Tallinn consists of 5 tram lines, 8 trolley bus lines and 57 normal bus lines. The high-frequency lines are displayed in Fig. 1. Public transport in Tallinn had in 2012 a substantial market share, with 40 % of all trips in the city performed by the urban public transport system. Moreover, 30 % of the trips were performed by foot. However, this favourable modal split followed a negative trend. The share of public

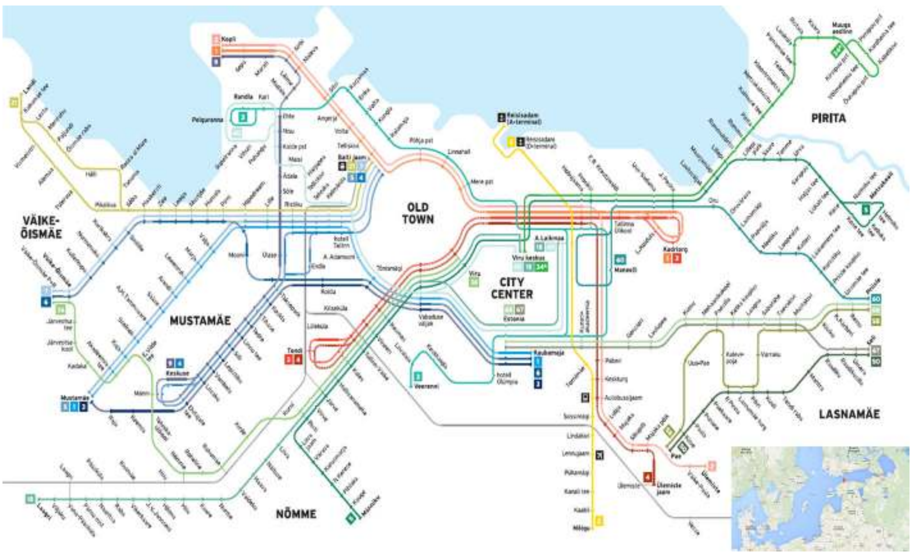

Fig. 1 Tallinn rapid public transport network (*bottom right* Tallinn in north-east Europe)

transport trips decreased dramatically during the last two decades, since Estonia regained its independence in 1991. The motorization rate—the number of private cars per 1000 inhabitants—has more than doubled during the same period, up to the current level of 456 cars per 1000 residents (Estonian Bureau of Statistics 2012).

Even though public transport retained a substantial market share in Tallinn, ticket sales covered in 2012 only one-third of the system operational costs. This is a very low fare–box recovery rate in comparison to other European cities (Nielsen et al. 2005b). A single ride ticket costed 1 euro in December 2012. Since 2003, a smart identification card was launched in Estonia which was also used as a public transport smartcard. This was accompanied with a 40 % fare reduction for residents of Tallinn. In addition, many user groups including children, elderly and certain occupational groups had fare exemption. In 2012, the share of users that were exempted amounted to 36 % with additional 24 % of the users (e.g., students, low-income) having special concessions. The full-scale FFPT can therefore be conceived as the final stage in a sequence of steps aimed to make public transport in Tallinn more attractive and affordable. Nevertheless, public transport fares were identified as a primary problem area in Tallinn. On an annual municipal public transport satisfaction survey from 2010, fare was the most commonly mentioned source of dissatisfaction with 49 % of the respondents, followed by crowding (29 %) and frequency (21 %).

A full-scale FFPT policy for all city residents was initiated with the following objectives: (a) promoting modal shift from private car to public transport; (b) improving the mobility of unemployed and low-income residents, and; (c) stimulating the registration of inhabitants as residents of Tallinn in order to increase the municipal income tax. This led the City of Tallinn to initiate a popular referendum where 75 % of the voters supported the new policy albeit the voting rate was only 20 %. Following the referendum, the city council approved the measure. Notwithstanding, the FFPT became a controversial political topic in Estonia in general and in Tallinn in particular. The policy was introduced 8 months before the municipal elections, where the campaign and media coverage revolved around this policy and the ruling party in the city council secured a majority and maintained the FFPT policy.

When initiating the FFPT policy, the City of Tallinn proclaimed that the lost ticket revenues will be covered through increased municipal income tax. The annual revenues from ticket sales amounted to 12 million euros in 2012. In Estonia, a share of the income tax is charged by the municipality at which a person is registered. Some of the people who migrate to Tallinn do not change their registration and thus continue pay their income tax to their city of origin. This is especially prevalent among students and people who migrate from the countryside and feel affiliation towards their place of origin and thus prefer to support it financially. While the exact number of Tallinn inhabitants that are not registered is unknown, municipal officials estimate it at about 25,000–30,000. It should be noted that the fare reduction for Tallinn residents in 2003 resulted with 30,000 newly registered residents. City authorities estimate that each registered resident contributes $\sim$1000 euro in annual municipal tax. Hence, if the FFPT is successful in attracting more than 12,000 non-registered Tallinn inhabitants to register themselves in order to be benefit from the new policy, then the increased municipal tax collection can compensate for the lost ticket revenues.

The immediate effects of the FFPT policy were analysed by the authors in an earlier study based on detailed automatic vehicle location (AVL) data and aggregate automated passenger count (APC) data (see Cats et al. 2014). An increase of 3 % in passenger demand was observed, of which 1.2 % were attributed to FFPT after controlling for simultaneous changes in service provision. This relatively small effect could presumably be attributed to the short-term measurements, 3 months after FFPT was introduced. The analysis of passenger load profiles also indicated that the average passenger trip length decreased by 10 %, suggesting that FFPT led to a modal shift where public transport substitutes walking. However, behavioural changes at the individual level, as well as their variations amongst users, remained unknown. The detailed mobility data collected and analysed in this study allows investigating the mid-term impacts of FFPT at the individual level.

Data collection

The City of Tallinn conducts every fall an annual municipal survey for measuring the satisfaction of city residents with various aspects. The survey collects data on respondents' socio-demographic characteristics, satisfaction with municipal facilities and services, including public transport services. In the years 2012 and 2013, additional questions designed to measure the impact of FFPT were included, as follows:

- Mobility patterns: car availability and modal usage patterns
- Satisfaction with public transport service aspects
- One-day travel diary: a detailed activity-travel report for a given day, including start and end locations, departure and arrival times, travel mode and trip purpose
- Destination choice: preferred locations for shopping and leisure
- Opinions concerning FFPT: perception of personal and general impacts

The survey was conducted in November 2012 and November 2013, as part of the annual municipal survey, before and after the implementation of FFPT. Data was collected among more than 1500 residents of Tallinn in each period, randomly selected. The summary statistics of both samples are shown in Table 1. In general, sample composition is similar in both years and is representative of the city population. The increase in the share of registered residents of Tallinn in the sample is consistent with the reported increase of 10,000 newly registered residents between January and November 2013. It is thus estimated that $\sim$25,000 residents of Tallinn are registered elsewhere in the end of 2013.

To correct for any potential distortion in the sample between 2012 and 2013, survey data was weighted based on gender, age groups, city districts and ethnicity, the shares of which can be assumed unchanged in the analysis period. First, the weight of the districts population was found. The weighted sample was then proportionally weighted based on the age group distribution, followed by ethnicity and gender. This procedure was performed only once, because it was sufficient for obtaining a sample that fits the actual distribution of these attributes in the population.

Analysis and results

Changes in modal split were first analysed and examined for various user groups (Sect. "Travel mode choice"), followed by an investigation of accessibility and equity effects (Sect. "Accessibility and equity"). Finally, differentiation of attitudes and public satisfaction concerning the policy are discussed.

Table 1 Summary socio-demographic statistics of the before and after survey samples

	Fall 2012	Fall 2013
Gender (%)		
Men	43.0	43.9
Women	57.0	56.1
Age group (%)		
15–19 years old	5.3	4.7
20–29 years old	18.7	17.8
30–39 years old	18.9	18.8
40–49 years old	14.2	15.5
50–59 years old	15.8	15.5
60–74 years old	18.7	18.1
75 years old or older	8.6	9.7
Ethnicity (%)		
Estonian	56.0	54.0
Russian	37.7	36.0
Other	6.3	10.0
Net monthly income (%)		
Up to 300 €	17.9	13.4
301–400 €	19.2	22.6
401–650 €	20.2	20.0
651–1000 €	12.4	12.6
1000 € and above	3.1	4.1
No answer	27.2	27.3
Primary occupation		
Working	59.9	62.9
Pensioner	22.5	22.3
Home/parental leave	4.0	3.5
Student	9.4	6.9
Unemployed	3.2	2.2
Other	1.0	2.2
Registered residency		
Tallinn	90	93
Elsewhere	10	7
Sample size (N)	1538	1511

Travel mode choice

The average number of trips per person remains almost unchanged, 1.98 in 2012 and 1.96 in 2013. The modal shares in the before and after periods were calculated based on the analysis of the detailed travel diary records for the entire survey results as well as for different socio-demographic groups and city district. Figure 2 shows the modal split in 2012 and 2013. It is evident that the modal share of public transport increased from an already high level of 55–63 %. This implies an increase of 14 % in the number of trips performed by public transport. This trend clearly differs from the rest of Estonia, as the modal share of PT in the entire country decreased from 23.1 to 22.9 % between 2012 and

2013. The increase in the market share of public transport stems from a decrease of 10 % in the number of car trips and a staggering decrease of 40 % in the number of trips for which walking was the main model of travel.

The market shares of different travel modes was further analysed by segmenting the population based on socio-demographic variables. Table 2 presents the modal split for different gender, age, income, occupation, car availability, and registered residency user groups. The last column shows the annual increase in the first year of FFPT in the market share of public transport for each user group. It is evident that the effect of the new policy on modal split is far from universal as it varies considerably for different user groups. Public transport share increased dramatically among age groups 15–19 and 60–74, very low–income (up to 300 € net/month) and people who are out of employment and education. These groups are arguably the most sensitive to price and while they benefited from special discounts already prior to the new policy, the FFPT promoted greater public transport usage. Interestingly, the share of public transport trips performed by very high income group (beyond 1000 € net per month) decreased substantially, possibly due to image and crowding issues (see Sect. "Satisfaction, attitudes and acceptability"). In contrast, public transport share increased for pensioners even though they travel for free in both analysis periods.

Modal split was very similar for registered and non-registered residents of Tallinn in 2012 but has followed a contradictory trend in 2013. The decrease in the share of public transport users among residents registered elsewhere is presumably attributed to the selection-bias among those that were prompted following the introduction of FFPT to register in Tallinn, namely frequent public transport users, in order to become eligible to FFPT.

Spatial variations in modal splits and their evolution following FFPT were analysed. Figure 3 shows the modal split in 2012 and 2013 per district, where the size of the pie-chart corresponds to the district's population size. The modal share of public transport has increased most substantially in the eastern and north–eastern districts of Lasnamäe (from 55 to 61 %), Pirita (41–48 %) and Põhja–Tallinn (56–68 %) as well as the southern district of Nõmme (43–68 %).

Accessibility and equity

One of the main policy objectives is to improve travel accessibility for disadvantaged groups by improving travel affordability. The FFPT led to a noticeable decrease in the

Fig. 2 Mode split in 2012 (*inner-ring*) and 2013 (*outer-ring*)

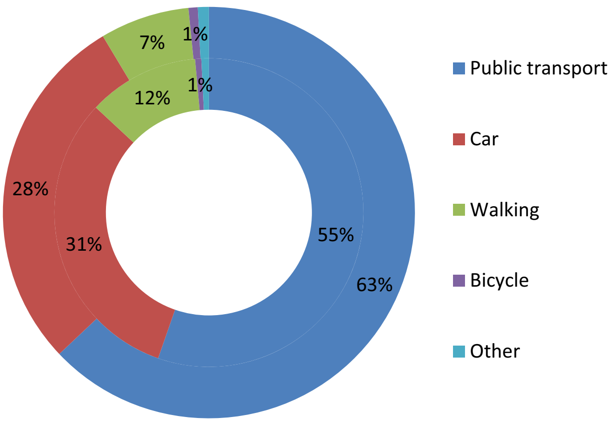

Table 2 Modal split by user group

	Fall 2012					Fall 2013					Increase in PT share (%)
	PT	Car	Walk	Bike	Oth.	PT	Car	Walk	Bike	Oth.	
Total	55	32	12	1	1	63	29	7	1	1	14
Gender (%)											
Men	43	44	11	1	1	49	41	7	1	1	14
Women	43	22	13	1	1	71	20	8	0	1	11
Age group (%)											
15–19 years old	66	9	23	0	1	80	7	13	0	0	21
20–29 years old	58	32	9	1	0	62	26	9	2	1	7
30–39 years old	42	49	8	0	0	44	48	7	1	0	5
40–49 years old	43	41	15	1	0	50	39	10	0	1	16
50–59 years old	54	36	8	0	1	59	33	3	1	0	9
60–74 years old	64	22	13	1	1	76	18	5	0	0	19
75 years old or older	71	1	19	1	2	82	10	6	0	3	15
Net monthly income (%)											
Up to 300 €	5	12	21	0	2	82	12	5	0	0	26
301–400 €	63	25	11	1	1	72	20	6	0	1	14
401–650 €	59	34	8	0	0	58	31	8	2	1	−2
651–1000 €	39	52	7	1	1	42	50	6	1	2	8
1000 €+	39	59	2	0	0	31	50	18	0	2	−21
No answer	49	36	13	1	1	59	31	9	0	0	20
Primary occupation											
Working	48	43	8	1	0	54	38	7	1	1	13
Pensioner	69	12	16	1	2	81	11	6	0	2	17
Home/parental leave	39	39	22	0	0	47	34	19	0	0	21
Student	73	9	18	0	1	76	11	13	0	0	4
Unemployed	53	24	20	2	2	70	15	9	3	3	32
Car available per household (%)											
None	79	1	17	1	1	88	1	8	1	1	11
1 car	43	47	8	0	1	43	50	7	0	0	0
2 or more cars	22	71	6	0	0	24	69	5	1	1	9
Registered residency											
Tallinn	55	32	12	1	1	64	28	7	1	1	16
Elsewhere	52	36	11	0	1	34	50	15	0	1	−35

share of respondents that remained at home and did not perform any trip, from 18 to 13 %. Combined with the substantial increase in the modal share of public transport amongst people who are out of education and employment (i.e., pensioners, unemployed and stay-at-home partner/parental leave) reported in Table 2, these results suggest that FFPT led to a trip generation rather than substitution effect for these user groups, increasing their mobility. It is worth noting that car ownership among respondents in 2013 is lower than in 2012, 0.273, vs. 0.307, respectively.

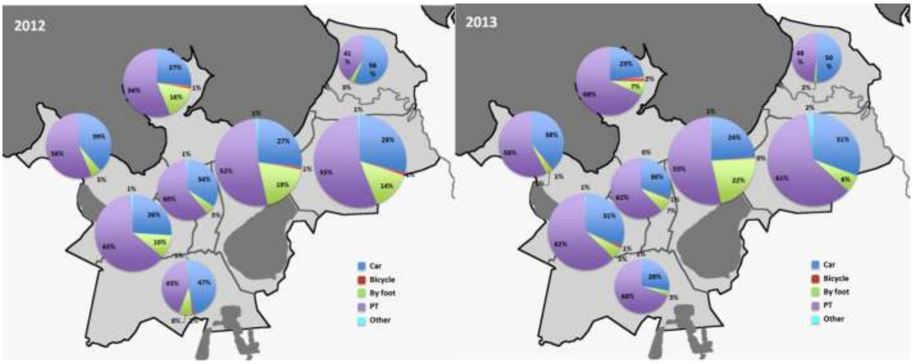

Fig. 3 Mode share by district before (*left*) and after FFPT (*right*)

Employment opportunities

An increased accessibility and mobility will help to get more people involved in more activities. In particular, it can extend the potential job and labour search zone and reduce the transportation costs associated with employment for both employees and employers. The share of respondents that report that they or a member of their household had to give up on a job opportunity in the last 2 years due to mobility-related reasons was 5 % in both survey years. The primary reasons were almost identical with 40 % mention distance and long travel time, 31 % service connectivity (transferring), whereas only 12 % pointed out the cost of travelling by public transport as the main reason. The latter may be associated with job opportunities beyond the city boundaries, where services between the city and the county can hinder accessibility. These results suggest that ticket price is a relatively marginal factor in missed employment opportunities. The main reasons for declining a job opportunity due to mobility reasons have to do instead with poor and unattractive connections. Notwithstanding, 40 % of the unemployed ($N = 32$) believe that FFPT has improved their job finding prospects compared with 31 % that do not think it has an effect and 4 % that believe it has influenced their job search negatively.

Shopping and leisure destination choice

To examine whether FFPT has an effect on mobility patterns and travel destinations, respondents were asked about their most popular areas in Tallinn for shopping and leisure activities. Figure 4 depict the most popular destinations that were reported in each year for both shopping (above) and leisure (below), as well as those areas that people said that they will visit more often when public transport will become fare-free (in 2012, left). The old city and the main commercial districts retained their prominent position as attractive shopping and leisure destinations. Almost 15 % reported that the new policy influenced their trip location choice. With FFPT, average trip length for shopping and leisure purposes has increased where a general trend that can be observed is an increase in travel to northern districts for shopping activities instead of shopping locally. Interestingly, these areas that became popular differ from those areas that were identified by travellers as areas that will become popular destinations with FFPT.

Satisfaction, attitudes and acceptability

Dissatisfaction with the cost of travelling by public transport was one of the motivations for introducing FFPT. Since travel cost was mentioned among the main causes of dissatisfaction with public transport, it is interesting to analyse the impacts of FFPT on travel satisfaction. Attitudes and the acceptability of FFPT among Tallinn residents was also investigated in the survey, in light of the prominence of this policy issue in public debate, media and politics in Estonia in general and Tallinn in particular.

Travel satisfaction

The introduction of FFPT was followed by a significant increase in the satisfaction with PT in Tallinn. The average satisfaction level increased from 3.20 to 3.35 on a 1–5 scale, primarily due to a decrease in the share of respondents that viewed the service as “poor” or “very poor” which decreased from 12.0 to 5.4 %. This change could be either caused by satisfaction with the fare–free trip and positive secondary or simultaneous effects (i.e., improvements in service supply, see Cats et al. 2014) or alternatively, be attributed to lower expectations from services that are free of charge. When asked whether public transport has changed for better or worse in the last year, 44.3 % answered that it has changed for the better in 2013, almost twice their share in 2012 (23.8 %). In both survey years, $\sim$5 % of the sample answered that it has changed for worse.

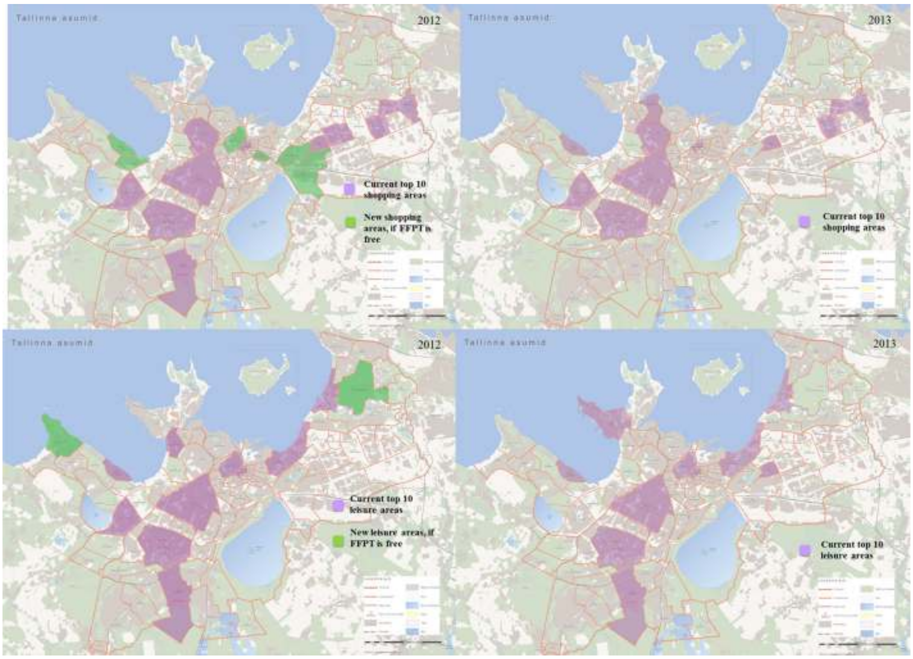

Fig. 4 Most popular shopping (*above*) and leisure (*below*) areas in Tallinn in 2012 (*left*) and 2013 (*right*). Areas that respondents in 2012 expected to become popular with the introduction of 2013 are also indicated (*left*)

When asked to list the main problem areas in Tallinn, public transport was ranked as the third best performing municipal service out of 23 services in 2013, as compared with the seventh position in 2012. Thus, the increase in travel satisfaction can be attributed to an improvement in perceived performance rather than lower user expectations. Interestingly, the least satisfied group in 2013 are non–residents of Tallinn and cyclists whereas car-users are most satisfied. Other transport–related problems such as road conditions, parking availability, walkway conditions and traffic culture were among the six top problem areas in both 2012 and 2013.

Respondents were asked to name the three main problem areas related to PT services. Figure 5 shows the share of respondents that named each problem area. The share of respondents that declared that they are satisfied and there is no particular problem area increased from 7.6 to 18.4 %. In the fall of 2012, crowding (15 %) and frequency (11 %) were the most commonly mentioned problem areas, followed by travel cost (10 %). The latter already reflects a substantial decrease in importance as compared with the 2010 survey which triggered the discussion around FFPT as a policy instrument (see Sect. "The case of Tallinn"). This shift is arguably caused by the fact the respondents already knew in the fall of 2012 that FFPT will shortly be introduced, leading to tactically voting in favour of other problem areas. Notwithstanding, travel cost was the most important problem area among the unemployed and the second most important problem among the following groups: men, non-PT users (car, walking, cyclists), workers and non-residents of Tallinn. Following the introduction of FFPT, crowding (12 %) and frequency (11 %) remained the most prominent problem areas along with vehicle cleanliness (12 %). The expansion of express services at the expense of local services presumably led to greater satisfaction with speed, albeit causing an increase in the dissatisfaction with network design.

Respondents also had the opportunity to mention other problems which did not appear in the list, of which the most common was the presence of homeless or drunk fellow-

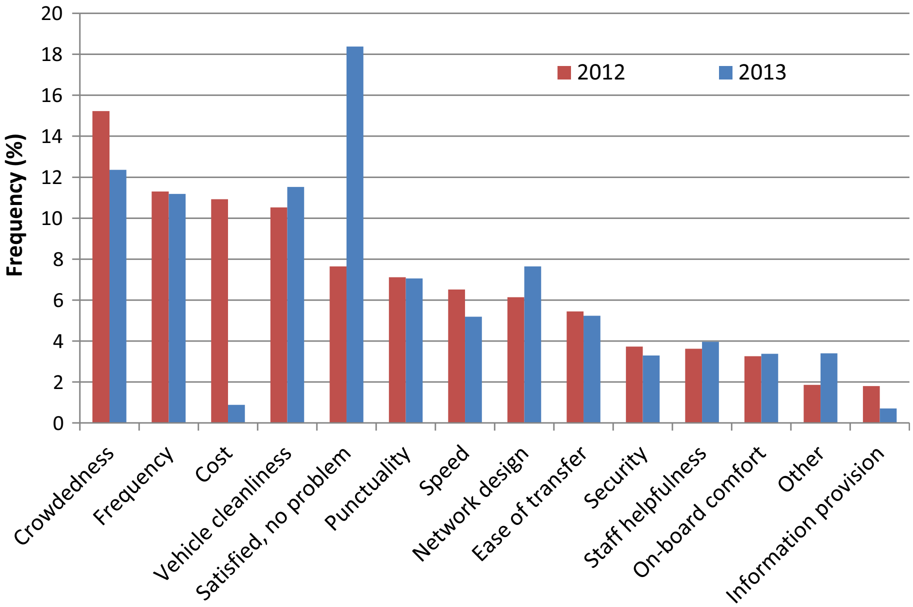

Fig. 5 Main areas of dissatisfaction with public transport in Tallinn in 2012 vs. 2013

passengers. Related complaints were made by 2.5 % of the sample in 2013, a four-fold increase compared with 2012, when PT was not barrier-free.

Attitudes and acceptability of FFPT

Respondents were interviewed in both before and after periods on their perception of FFPT impacts. Figure 6 presents the distribution of expected/assessed effects of FFPT on a 1 (very negative) to 5 (very positive) scale based on the 2012 and 2013 survey results. When asked in 2012, people reported moderately positive expectations concerning the effect that FFPT will have on Tallinn as a whole (3.30) and their own daily travel experience (3.18), and just marginally positive considering the overall traffic situation (3.09). These expectations were replaced by more positive assessments of the actual effect that FFPT had on Tallinn as a whole (3.72), the overall traffic situation (3.63) and individual travel experience (3.50). Evidently, people are significantly more positive about the FFPT effects than their earlier anticipations, most notably concerning its overall effect rather than its effect on their own mobility. These findings are in-line with the impacts of various different policy implementation in the past, including with the public acceptance towards Stockholm congestion charge system (Eliasson 2014; Börjesson et al. 2015), bicycle use in the UK (Chatterjee et al. 2013), and bus use in Japan (Fujii and Kitamura 2003). These studies concluded that once people being exposed to the system and experience the benefit by themselves, the public become much more appreciative and positive towards the given policy intervention.

Among those travellers that report an increase in public transport usage following the introduction of FFPT, i.e., 14.4 % of the entire sample, 45 % state that they did so within the first week of its introduction and additional 28 % did so within the first month. Interestingly, the empirical analysis of the ridership change 3 months after the introduction of FFPT found an increase of only 3 %, less than one quarter of the change indicated by the analysis of travel diaries. This seemingly inconsistency can be attributed to respondents

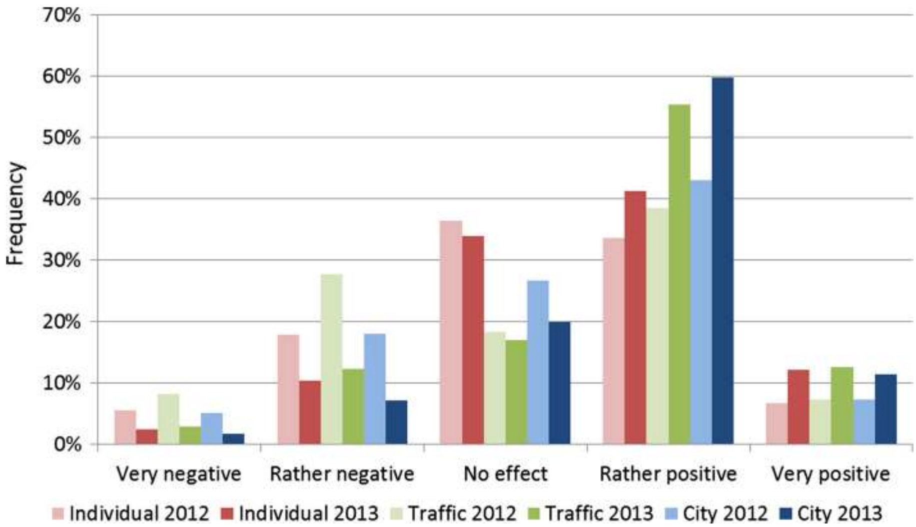

Fig. 6 Effect of FFPT on individual mobility, overall traffic situation and the city prior (2012) and following its introduction (2013)

inability to recall when did they change their travel behaviour, leading to a bias towards reporting an early adaptation.

Residency registration

As explained in Sect. "The case of Tallinn", one of the objectives of the FFPT policy is to increase local income tax collection. The policy has been successful in this regard with 11,000 new residents in 2013, ~40 % of unregistered residents based on estimates made by city officials prior to policy introduction. On average, the municipality receives 1000 euro in tax from each registered resident. Hence, the newly registered residents contribute annually approximately 11 million euro, almost equivalent to the lost income from ticket sales. Furthermore, 42 % of the respondents that were unregister in the end of 2013 answered that FFPT makes them more inclined to register themselves as Tallinn residents (48 % said it has no influence, an increase from 36 % in 2012).

Discussion and conclusion

With the idea of FFPT remaining a subject of political and policy making debate, it is important that public, professionals, decision makers and researchers will assess this instrument based on previous experience. Even though FFPT has been experimented (and abandoned) in a large number of public transport systems, there is lack of a rigorous evaluation of its consequences. This study analyses the implications of a full-fledged FFPT implementation in Tallinn using a before and after large-scale individual travel attitudes and habit survey. This policy evaluation is expected to be of interest not only to Tallinn but would also be instrumental in supporting relevant stakeholders in other cities which discuss the introduction of similar policies. By doing so, we hope to contribute to a more evidence- and knowledge-based decision making.

The study provides evidence that the modal shift objective from car to public transport has been achieved. Almost a year after the introduction of FFPT, public transport usage increased by 14 %. The patronage increased by 24 % due to an increase in the average public transport length. The effect of FFPT on ridership is substantially lower than those reported in previous studies (Sect. "Full-fledged FFPT") due to the good level of service provision, high public transport usage and low public transport fees that existed already prior to the FFPT.

The increase in public transport modal usage indicates that the initial ridership increase of 3 % in the 3 months following the introduction of FFPT that was reported by Cats et al. (2014) based on the empirical analysis of automated passenger counts, continued in a similar pace in the months leading to the survey. These findings concurrence the results of the meta-analysis by Holmgren (2007) that long-term fare elasticity is higher than the short-term elasticity. Our finding confirms the early indications in Cats et al. (2014) concerning a considerable shift from walking to public transport in 2013, with a 40 % decrease in the share of walking trips while the distance of the average walking trip remains unchanged. It is noteworthy that while the share of car users decreased by 5 %, the average distance travelled by car increased resulting with a 31 % increase in total vehicle-km. This is explained by the increase in daily travel distance, i.e., from 7.98 to 9.07 km per person, a 13 % increase, driven by changes in shopping and leisure destination choices. In summary, the modal shift from car to public transport was accompanied by an undesired shift from walking to public transport and an increase in car traffic.

There is mixed evidence concerning whether FFPT improved mobility and accessibility of low-income and unemployed residents. FFPT led to a trip generation effect among these user groups and the respective market share of public transport increased by more than 20 %. However, there is no indication that employment opportunities improved as a result of this policy. Satisfaction with public transport and popular support in FFPT increased during the study period.

The third objective of the FFPT was achieved as it led to an increase in the number of inhabitants registered in Tallinn. This objective is unique to the local taxation and domestic migration circumstances. It is also critical for ensuring the financial viability and sustainability of this policy instrument as the additional income from tax collection allows the City of Tallinn to cover the costs associated with fully subsidizing the public transport operational costs. The newly registered residents induces also a lost to other municipalities where they were formerly registered which benefited from the misalignment between place of residence and place of registration. Given the relative importance of Tallinn in Estonia (33 % of the population and 50 % of the GDP), these changes cause redistribution effects that may increase regional disparity at the national level.

The long-term effects of a FFPT still remain to be assessed and will allow determining whether the results attained in the analysis period are sustained. A cost-benefit analysis of the FFPT policy should also encompass wider economic benefits such as labour market effects and location choice. The next step of this study will be to further investigate individual travel patterns by performing a detailed multivariate analysis of before and after travel diaries to identify the role of individual attributes such as trip purpose, travel attitudes and socio-demographic attributes on changes in travel behaviour.

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