

# Public Transport Pricing Policy – Empirical Evidence from a Fare-Free Scheme in Tallinn, Estonia

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Paper submitted for presentation at the 93rd Annual Meeting of the Transportation Research Board, Washington, D.C., January 2014 and publication in the Transportation Research Record, Journal of the Transportation Research Board

Word Count: ca. 6,000 words + 2 Tables + 2 Figures = ca. 7,000 words

**Keywords:** Public Transport, Pricing, Ridership, Elasticity

## Abstract

Cities worldwide are looking for new policies to attract travellers to shift from car to public transport. Policies focused on reducing public transport fares are aimed to improve social inclusion and trigger a modal shift. The City of Tallinn, the capital of Estonia, has recently introduces a free-fare public transport (FFPT) in an effort to improve accessibility and mobility for its residents. The case of Tallinn is a full-scale real-world experiment that provides a unique opportunity to investigate the impacts of FFPT policy. This paper presents a macro-level empirical evaluation of FFPT impacts on service performance, passenger demand and accessibility for various travellers groups. In contrast to previous studies, the influence of FFPT on passenger demand was estimated while controlling for supply changes. The results indicate that the FFPT measure accounts for an increase of 1.2% in passenger demand with the remaining increase attributed to extensions made in the network of public transport priority lanes and increased service frequency. The relatively small effect could be attributed to the previous price level and public transport share as well as the short-term impact. The evidence-based policy evaluation is instrumental in supporting policy makers and facilitating the design of public transport pricing strategies.

## 1. INTRODUCTION

Public transportation provides people with mobility and access to employment, community resources, medical care, and recreational opportunities, especially among those who have no other choice [1]. Ensuring its effective and efficient provision is a priority of many governments and a key to provide a better accessibility in urban areas. Accessibility in this case refers to the ease of reaching various destinations as measured by service availability, speed and affordability. Measures to improve public transport accessibility could hence consist of infrastructure investments, increasing supply outputs or the introduction of public transport pricing schemes.

Public transport is often considered as both public good and market product. Public transport pricing schemes may reflect this spectrum by charging a market price, the full operational cost or providing it for free. Public financing is an important and sometimes the primary contributor to the cost structure of public transport systems across Europe and North America. Transport pricing policies are often discussed in the public debate with strong links to the attitudes towards freedom, fairness as well as personal norms [2,3]. The term FFPT is used here rather than ‘free public transport’, since public financing would have to compensate for the lost fare income and fully subsidize the service.

FFPT is also a potential measure to promote a modal shift towards public transport. The increase demand to public transport services may even trigger the well-known ‘Mohring effect’ [4]. This effect refers to the desired vicious cycle where a service improvement that reduces the disutility associated with traveling such as shorter waiting times or travel times or indeed lower fare, would lead to a higher demand that will result in a need to increase the supply and improve the priority given to public transport which will further improve the service and will further increase the demand and so forth. Since the economics of public transport are characterized by the economics of scale, the marginal benefit from increasing service supply exceeds the marginal cost and therefore increases the social welfare.

Transport economics often argue that the fundamental problem in the prices associated with travelling is that travelling by car is under-priced and this should be addressed by internalizing car externalities [5]. Studies that analysed how sensitive people are to various price changes found that more people would shift from car to public transport if the price of the former is increased rather than if the latter is reduced to the same extent. This suggests that strategies focused on increasing the cost of travelling by car might be more effective in achieving the modal shift objective. FFPT could be therefore considered to be a second-best pricing scheme in this respect. Moreover, it is argued that people tend to underappreciate things that they get for free. The absence of a direct cost attached to the consumption of a public good may even lead in some cases to its over-utilization. In the context of public transport this implies riding public transport instead of walking or cycling which is clearly not the purpose of a sustainable transport solution. Another risk is that it may lead to fewer investments in public transport in the long run due to the lack of direct income gathering.

The City of Tallinn, the capital of Estonia, introduced a FFPT scheme for all its residents on all public transport services that are operated by city-run operators, since January 2013. Public transport services in Tallinn are provided by a municipally-owned company. Tallinn with 425,000 inhabitants is currently the largest city in the world that provides a full-scale FFPT service to all residents. The main objectives of this policy are: promoting modal shift from private car to public transport; increasing the mobility of unemployed and low income groups and; stimulating the registration of inhabitants as a residents of Tallinn and hence increase the municipal income tax [6].

The case of Tallinn is a full-scale real-world experiment that provides a unique opportunity to investigate the impacts of FFPT policy. This study presents a macro-level empirical evaluation of FFPT impacts on service performance, passenger demand and

accessibility for various travellers groups. The introduction of FFPT was often accompanied in previous studies by an increase in service supply and hence the effects of the two measures could not be easily distinguished. The influence of FFPT on passenger demand was estimated in this paper by accounting explicitly for supply changes. The evidence-based policy evaluation is instrumental in supporting policy makers and facilitating the design of public transport pricing strategies.

The remainder of the paper is organized as follows: the following section provides a literature review concerning the effects of fares on public transport demand, arguments in favour and against public transport and results from previous FFPT programs. Section 3 describes the case of Tallinn and the data analysis related to this study. The results of the supply performance and passenger demand analysis are presented in Section 4. The paper concludes with remarks concerning the generality of the results and suggests directions for future studies.

## **2. LITERATURE REVIEW**

### **2.1 The effect of fares on public transport demand**

The identification and analysis of the main determinants of demand to public transport services has been a subject of extensive research. In particular, numerous studies have analysed the elasticity and cross-elasticity of public transport fares. Several studies conducted a meta-analysis of fare elasticity [7,8,9]. 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 [9]. Paulley et al. [8] examined how fare elasticities depend on transport mode, type of area, analysis horizon, type of fare change, current fare levels as well as the specific local circumstances. Moreover, elasticities were derived using various methods including stated and revealed preference surveys, before and after studies and time series analysis. Individual choice models resulted with higher price elasticities than those obtained from aggregate demand analysis [7]. Chen et al. [10] argued that because of the different assumptions underlying micro- and macro-level studies, behavioural results of the former could not be directly applied at the aggregate level. In a discussion on the limitations of public transport elastic studies, Hensher [11] highlighted that it should always be preferred to use primary data for evaluating the effects of policy changes.

Fare elasticity depends on the magnitude, sign and time-span of the fare change. Chen et al. [10] found that fare elasticity is strongly asymmetric – passenger demand decreases in response to an increase in price but the estimate associated with price fall is insignificant. Holmgren [9] concluded the long-run fare elasticity was found significantly higher (in absolute terms) than the static or short-run elasticity. In addition, supply 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 [12,13].

The elasticity of public transport demand with respect to level of service variables was found systematically higher compared with the fare elasticity [8,9,13]. The elasticity of passenger waiting time – which is pre-dominantly determined by service frequency - was on average estimated as -0.64. In-vehicle travel time elasticities were estimated in the range of -0.4 to -0.6. Elastic with respect to service supply as measured by total vehicle-kilometres has an average value of 0.72, considerably higher than the fare elasticity. Furthermore, the cross-elasticity with respect to the cost of car is similar or higher than the direct fare elasticity.

## **2.2 Fare-free public transport arguments**

Even though the results from previous studies suggest that reduced fare levels are probably a second best pricing strategy compared with car disincentives, pull strategies are more popular than push policies in the public debate realm [3]. The key arguments in favour of FFPT include improving social inclusion and attracting people to public transport and hence reducing car traffic externalities and road infrastructure investments. FFPT could potentially induce a fundamental demand change that could not be assessed through fare elasticities. Behavioural studies indicate that when facing the alternative of free consumption, people do not act according to the standard cost-benefit analysis and appear to perceive it as an additional benefit beyond the actual cost reduction [14].

The introduction of FFPT could also save related costs and improve operational efficiency. The public transport agency saves fare collection and control costs and can capitalize on public transport economies of scale when extending system supply. In case of an on-board payment validation, FFPT is expected to result with shorter dwell time at stops due to smoother boarding may result in higher commercial speeds and even fleet operations savings. The introduction of FFPT is sometimes also motivated by nontangible arguments such as promoting a barrier-free and equal public space.

The main argument against FFPT claim that this is a second-best pricing scheme as car travel is under-priced. Auto disincentives such as parking and road pricing or gasoline price might be a more effective measure for triggering modal shift from car to public transport as than transit fare incentives will [13,15]. In order to bring about an equivalent impact, a larger public transport fare reduction would be required depending on the extent to which the cross-elasticity dominates the direct elasticity. Moreover, a differential fare scheme could have attracted demand to underutilized segments of the public transport service avoiding supply increase in the peak hour where the marginal operational cost is the highest.

Other arguments include the potential risk that in the case of short-distance trips it may become a substitute to walking and cycling rather than car trips which may counteract the environmental and well-being benefits [16]. The lack of an independent income source for public transport funding may also pose a threat as it could lead to fewer investments in public transport in the long run. A fully subsidizes public transport service could also potentially reduce the operational efficiency. An under-priced service might also generate non-productive trips and even vandalism [17].

The introduction of FFPT is a costly measure that could have been invested instead in improving the level of service. The evaluation of FFPT has to consider also the opportunity cost of an alternative investment. From a macroeconomic point of view, income inequality would be better addressed through adjustments to income tax schemes. Furthermore, it is not clear that the market distortions that exist due to pricing reasons are larger than distortions caused by taxation which covers public funding.

## **2.3 Previous and on-going fare-free public transport programs**

Few small European cities introduced a FFPT policy since the late 90s. FFPT schemes were introduced in Hasselt (c.a. 75,000 inhabitants), Belgium; Templin (15,000), Germany and; Aubagne and nearby municipalities (100,000 in total), France in 1996, 1997 and 2009, respectively. All these programs were introduced together with substantial additions to the network supply and were followed by a dramatic increase in ridership. However, only a relatively small substitution effect (10-20%) was caused by a modal shift from car to public transport in [17,18]. In the case of Aubagne, the introduction of FFPT was motivated by the fact that user fares accounted for only 9% of the public transport system budget to start with.

In Templin, the vast majority of this increase reported to be among children and youth that led to an increasing problem of vandalism.

There are few other cases of FFPT policies directed toward specific user groups such as students, youth or off-peak riders. A limited-scale FFPT pilot study was carried out on the Leiden-The Hauge corridor, Holland during the year of 2004 [18]. It was concluded that the scale of the pilot was insufficient to address its objective and allow a significant congestion reduction. A FFPT policy was introduced in 2004 for students admitted to Flemish universities in Brussels, Belgium [19,20]. Similarly, all students in Holland are eligible to FFPT in the entire country since 1991 [18]. Both programs reported the generation of new trips as well as a substitution effect for active transport modes. An analysis based on interviews and focus groups of the health impacts of a FFPT program for youth in London, UK, was performed by Jones et al [16]. They reported mixed results concerning the level of activity, likelihood of injury, and cases of assaults.

While previous implementations of FFPT shed light on the anticipated impacts of such a policy measure, there is lack of a systematic analysis which limits the validity and prevents the quantification of FFPT. McCollom and Pratt [12] concluded from a review of over 20 FFPT programs that most of the reported results are anecdotal. A comprehensive analysis would be valuable for assessing the impacts of this policy measure to assist planners and policy makers. The case of Tallinn provides a valuable opportunity to evaluate empirically the impact of a full-scale pricing policy change.

### **3. CASE STUDY**

#### **3.1 The case of Tallinn**

The public transport system in Tallinn consists of trams, trolley buses and ordinary buses. The share of public transport trips decreased dramatically during the last two decades since Estonia restored its independence. The current mode split is still favourable towards public transport with a market share of 40% followed by walking (30%) and private car (26%). During the same period, the motorization rate has more than doubled up to 425 cars per 1,000 residents in 2012.

Before FFPT was introduced in Tallinn, the farebox recovery rate – the proportion of public transport operational costs that was covered through ticket sales – was 33%. The cost of a single ticket and a monthly card were 1 and 20 euros, respectively. The cost of a monthly card corresponds to approximately 2.5% of the average monthly disposable income after tax. The additional subsidy amounts to an annual cost of 12 million euros. Note that public transport fares were already reduced by 40% for Tallinn residents on 2003. Moreover, 36% of the passengers are already exempted from paying public transport fare based on their socio-economic or occupational profiles. Additional 24% are entitled for special discounts.

Public transport fares were identified as a primary problem area in Tallinn. On an annual municipal public transport satisfaction survey from 2010, 49% of the respondents were most unsatisfied with public transport fares followed by crowding (29%) and frequency (21%). This led the City of Tallinn to propose a FFPT policy on a popular referendum where it was supported by 75% of the voters with a participation rate of 20%. Following the referendum, the city council approved the measure [6]. The FFPT measure was preceded by supply changes which aimed to increase the system capacity in order to accommodate the induced demand.

#### **3.2 Data analysis**

The evaluation of FFPT in Tallinn consisted of the analysis of extensive automatic vehicle location (AVL) and automatic passenger counts (APC) data. The Transport Department of the

City of Tallinn circulates vehicle positioning and passenger counting equipment over the service lines throughout the year in order to cover the entire network and allow year-over-year comparisons. Data is therefore available for a subset of the trips for all lines. The disaggregate data contains the arrival and departure times as well as the number of boarding, alighting and on-board passengers for each stop visit.

The evaluation of FFPT consisted of a before-after analysis of AVL and APC data. The 'before' period refers to fall 2011-spring 2012, while the 'after' period refers to the period directly after the introduction of FFPT, January-April 2013. The intermediate period of fall 2012 constitutes a distinguished analysis period due to the implementation of several service improvement measures. The network of dedicated public transport lanes was extended from 17.4 km to 28 km prior to the introduction of FFPT. In addition, frequency changes took place throughout the analysis period. The overall increase in the number of vehicle runs for the sub-network is 8.2% when comparing before and after periods.

The AVL and APC equipment circulation implied that only about half of the lines were sampled during the first quartile of 2013, following the introduction of FFPT. A subset of the public transport lines was selected for evaluation based on data availability constraints, demand levels and spatial and modal coverage concerns. The sub-network for analysis consists of 22 lines – 3 tramlines, 12 bus lines and 7 trolley lines - which carry 64% of the total ridership. On average data from 300 weekday trips was available for each line which facilitated the analysis of performance and ridership measures. The number of APC and AVL data records that was used in this analysis amounts to almost 150,000 stop visits.

## **4. RESULTS**

### **4.1 Descriptive analysis**

The introduction of FFPT in Tallinn had implications on three key service quality aspects – waiting time, in-vehicle time and crowding. These changes are the result of the accompanying supply changes – frequency and priority lanes - rather than the FFPT policy per-se and would hence be explicitly distinguished in the demand analysis in Section 4.2.

Changes in public transport speed could arise from the direct impact of the extension of priority lanes or due to a secondary impact due to modal shift away from car which will result with less traffic congestion. The overall average speed remained at the same level of 19.14 km/hour throughout the analysis period. However, an analysis at the link level reveals significant spatial variations. Figure 1 presents the average speed of each network link for buses and trams for both before and after periods. As expected, speeds are lower in the centre of the city and higher in the periphery and along major arterials. There is a noticeable increase in average link speed in the city centre in the after period, particularly where priority lanes were introduced.

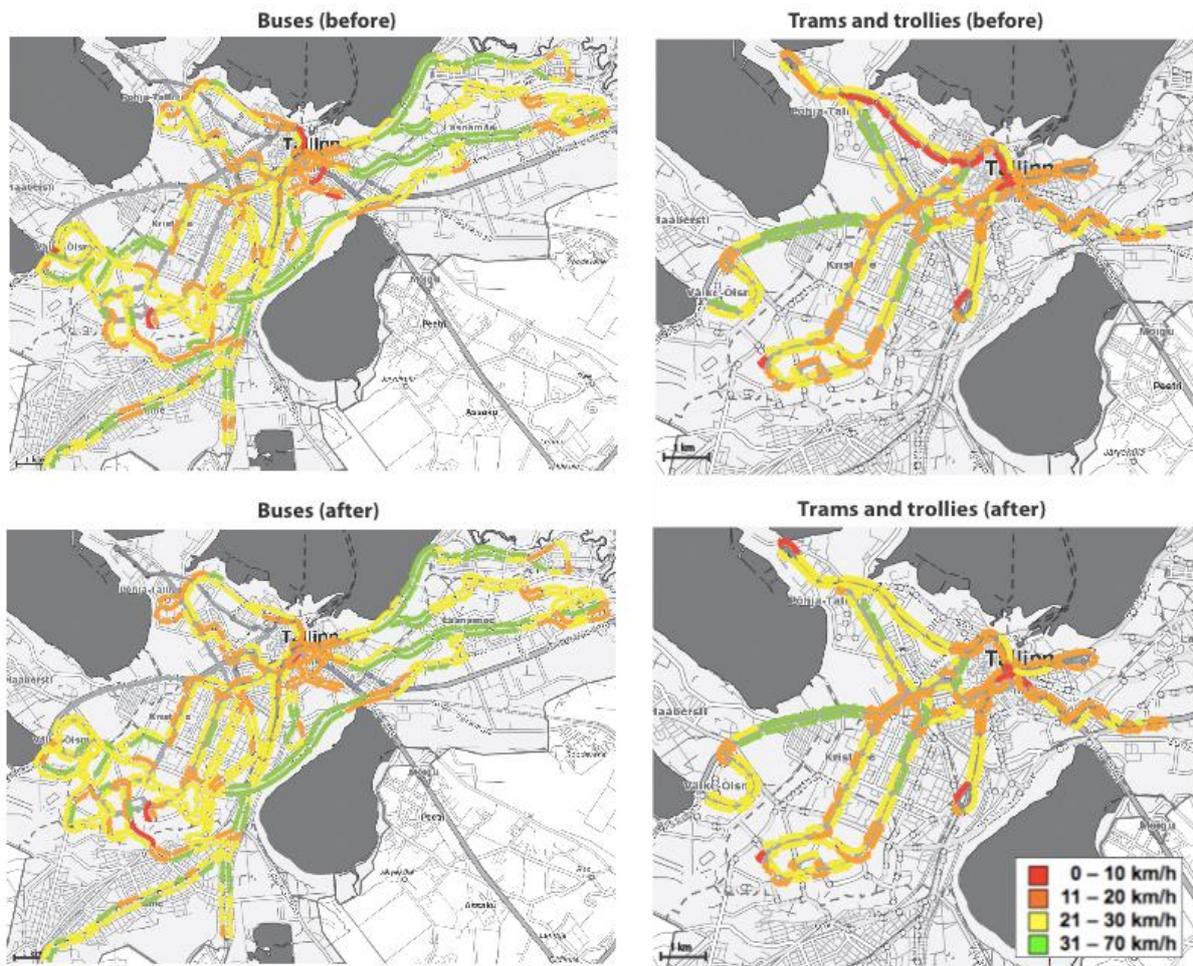


Figure 1 – Average travel speeds for buses (left) and trams and trolley buses (right) before (above) and after (below)

A before-after comparison of the total number of boarding passengers reveals an increase of 3% in passenger demand. The corresponding increase in total passenger-kilometres was 2.5%. Figure 2 presents the geographical distribution of changes in demand levels at the district level. The central district of Keskklinn which accounts for the lion share of the demand (40%) experienced an increase of 3.4%. The highest increase of more than 10% occurred in the north-eastern district of Lasnamäe which is the most populous and dense district and characterized by higher unemployment rates and a predominantly Russian speaking population.

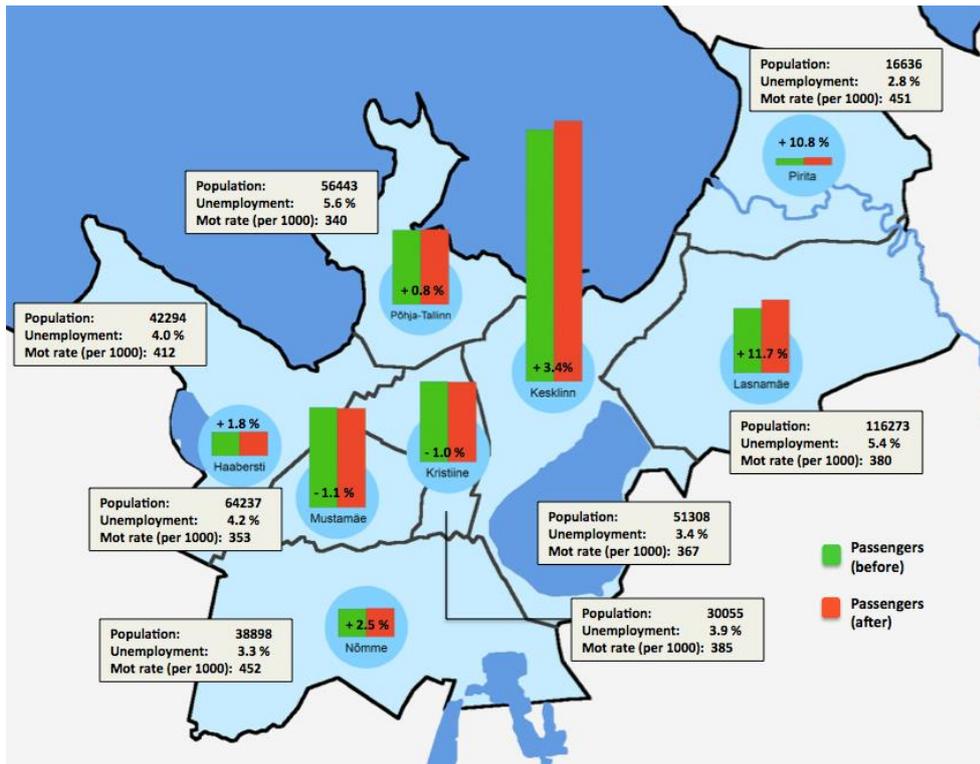


Figure 2 – Background information and ridership changes in Tallinn’s districts

The overall capacity increased by 9.6% which exceeded the increase in passenger demand. The FFPT scheme therefore does not induce any further capacity needs. Passengers are hence expected to experience less crowding compared with the before case. This figure has also been confirmed by calculating the vehicle load utilization which is twice as high for buses and trollies as for trams.

The average trip length could be derived from the total number of boarding and passenger-kilometres metrics. The average trip length decreased from 2.72 km in the before period to 2.40 km during the after period, a reduction of 11.8%. This result suggests a modal shift from soft modes and in particular walking to public transport, following the introduction of FFPT. Part of this shift is presumably attributed to non-regular passengers that previously used single tickets and may be more inclined to transfer after the introduction of FFPT.

#### 4.2 Multivariate Analysis

As shown on Section 4.1, the FFPT policy has made impacts to the ridership and the overall network performance of the public transport services. However, it is very difficult to infer the impacts of the policy, given all other external and internal variability surrounding the system. Therefore, multivariate analysis is used to measure the impacts of the policies after all other socio-demographic, land use, infrastructure conditions and temporal characteristics have been controlled. A series of multiple linear regression models for public transport demand model were estimated in order to quantify the impact of FFPT and supply changes. Various multiple linear regression models were specified and estimated at the individual stop-level. Each single APC record was supplemented with three sets of independent variables that were compiled to facilitate model development:

- Temporal indicators - time-of-day periods, day of the week and month-specific indicators. In addition, a dummy variable for 2013 corresponds to the FFPT condition.

- Supply variables – mode-specific dummies, the availability of a priority lane, interchange dummy, service frequency and the number of stops available in the respective district.
- Residents’ socioeconomic attributes, at zone level – population size and density, share of age groups, unemployment rate, share of education levels, real-estate prices, motorization rate, distance from the city centre, density of various land-uses and the number of stops – all of them at the respective district level, which were extracted from the central and municipal bureaus of statistics.

Model selection was based on a backward estimation approach by iteratively reducing the number of variables. The estimated model is not developed for forecasting purposes and is therefore not evaluated based on the R-square values. Instead, alternative models are evaluated by the inclusion of variables that are found significant explanatory factors of the number of boarding passengers. This process obtained the following model:

$$D_{s,k} = \beta_0 + \beta_1 \cdot FFPT_k + \beta_2 \cdot PMpeak_k + \beta_3 \cdot PLane_{s,k} + \beta_4 \cdot F_k + \beta_5 \cdot I_s + \beta_6 \cdot B_k + \beta_7 \cdot T_k + \beta_8 \cdot NrStops_s + \beta_9 \cdot E65_s + \beta_{10} \cdot UE_s + \beta_{11} \cdot RE_s + \beta_{12} \cdot M_s + \varepsilon_{s,k} \quad (1)$$

Where the dependent variable,  $D_{s,k}$ , is passenger demand at stop  $s$  for vehicle trip  $k$  as measured in terms of boarding passengers.  $\beta_s$  are the estimated coefficients and  $\varepsilon_{k,s}$  is the error term. Table 1 provides a list of all the independent variables that are included in this model in the same order as they appear in Eq. 1. Note that all the socio-economic variables were specified as interaction variables with  $FFPT_k$  in order to capture how the impact of FFPT varies with socio-economic variables rather than their general influence to passenger demand. The level of data availability or relevancy is indicated along with whether the variable is time-dependent or regarded as constant throughout the analysis period. Transport mode specific dummies are time-dependent as one of the main trolley lines was converted to an ordinary bus line during the analysis period. Other variables were excluded from the model, mainly due to high multi-correlation between the variables.

**TABLE 1 Description of Independent Variables**

	Variable name	Description	Time-dependent
Temporal	Free-fare public transport (2013)	Dummy variable for FFPT (2013)	Yes
	PM peak period	Dummy variable for trips on PM peak period (16:30-18:30)	Yes
Supply	Priority	Dummy variable for the presence of a priority lane adjacent to the stop	Yes
	Frequency	The number of vehicle departures per hour	Yes
	Bus mode	Dummy variable for bus	Yes
	Trolley mode	Dummy variable for trolley bus	Yes
	Interchange	Dummy variable for an interchange between lines	No
	Number of stop	The number of public transport stops in the respective district (2012)	No
socio	Share of elderly	Share of people who are 65 years or older in the respective district (2012)	No

Unemployment	Registered unemployment rate in the respective district (2011)	No
Real estate price	Price of residential m2 in hundred euros in the respective district (2012)	No
Motorisation rate	Number of cars per 1000 residents in the respective district (2012)	No

Table 2 presents the estimated values of the coefficient and the corresponding t-statistic in parentheses for three models: accounting only for the introduction of FFPT (Model 1); accounting for service variables and supply changes (Model 2) and; incorporating socio-economic and service coverage variables at the district level (Model 3). All of the estimated coefficients of the explanatory variables are significant at the 99% level. The coefficients are interpreted as the change in the average number of boarding passengers at a single stop for a single vehicle trip associated with a unit change in the explanatory variable.

**TABLE 2 Number of Boarding Passengers per Stop Model**

<b>Variables</b>	<b>Model 1</b>	<b>Model 2</b>	<b>Model 3</b>
Constant	4.880 (270.094)	3.632 (23.222)	-0.390 (-0.536)
FFPT	1.207 (30.638)	0.859 (21.382)	0.940 (23.314)
PM peak period	---	0.971 (17.581)	0.967 (17.608)
Priority lane	---	4.069 (43.630)	3.284 (33.115)
Frequency	---	0.211 (19.850)	0.228 (20.049)
Bus	---	-1.739 (21.255)	-0.968 (-11.426)
Trolley	---	-1.706 (-24.790)	-1.073 (-13.918)
Interchange	---	0.657 (16.822)	0.531 (13.186)
Number of stops	---	---	0.005 (9.128)
Share of elderly	---	---	0.114 (12.295)
Unemployment	---	---	0.268 (9.238)
Real-estate price	---	---	0.266 (22.972)
Motorization rate	---	---	-0.009 (-10.106)
Observations (N)	149,514	149,514	149,514
R-squared	0.006	0.040	0.051
Adjusted R-squared	0.006	0.040	0.051

Model 1 is a naïve model which reflects the overall demand change following the introduction of FFPT. The model indicates an increase of 1.2 passengers per stop and trip which is an average increase of 7,128 passenger trips or 2.8% at the network level when comparing before and after periods. Attributing all changes in demand to FFPT results with an overestimation of the FFPT effect compared with more elaborated models that account for supply variables.

Models 2 and 3 include temporal and supply variables. In particular, it accounts for supply changes which took place throughout the analysis period. The presence of a priority lane next to the stop caused a substantial increase in the number of boarding passengers at this stop. This demand increase is presumably related both to downstream in-vehicle time savings and public space design changes. Unsurprisingly, service frequency is an important determinant of passenger demand. Higher frequency is associated not only with overall higher demand but also with increased demand per vehicle. An increase of 1% in service frequency would yield a 0.44-0.47% increase in passenger demand. This range of elasticity is in agreement with the values reported in the literature [8].

The specification of models 2 and 3 allow decomposing the demand change following the FFPT introduction to the direct FFPT effect and supply changes impact. FFPT per-se led to an increase of 1.2% in passenger demand, which is approximately 42% of the impact estimated by the naïve model. The rest of the increase is attributed to greater priority lanes network and increased service frequency.

As could be expected, interchange stops which offer connections to other lines including express lines and the afternoon peak period are characterized by higher demand levels. Bus and trolley coefficients are significantly negative suggesting that given everything else being the same, tram lines attract more passengers. However, this result depends on the current network design of the various transport modes.

While similar signs and magnitudes are obtained for temporal and supply variables, the inclusion of district attributes in Model 3 allows investigating how the impact of FFPT varied spatially as a function of socioeconomic variables. The increase in passenger demand at the stop level is positively correlated with the number of stops located within the district boundaries, the share of the elderly population, unemployment rate, average real-estate prices, and negatively correlated with motorization rate. The results hence suggest that areas that are characterized by higher shares of older or unemployed residents and lower share of car ownership increased their demand more compared with other areas, everything else being equal. These groups are expected to be more sensitive to fare changes and benefit from greater accessibility to potential activities due to reduced transport costs. However, the aggregate level of analysis does not allow drawing conclusions at the individual traveller level. Real-estate prices were used as proxies for income levels because the latter were not available at the district level. The result is in line with previous studies that have shown that elasticity goes up with income, presumably because higher income travellers are less captive public transport users and hence respond stronger to fare changes.

## **5. CONCLUSION**

The impacts of a free-fare public transport policy in Tallinn, Estonia were evaluated empirically based on a before-after comparison and a public transport demand model analysis. Passenger demand increased by 3% following the introduction of FFPT. An analysis of supply variables reveals that the FFPT measure accounts for an increase of 1.2% in passenger demand with the remaining increase attributed to extensions made in the network of public transport priority lanes and increased service frequency. Districts with high shares of elderly

and unemployed and low motorization rates were associated with higher increase in passenger demand when public transport became fare-free.

The analysis of modal shift impacts of FFPT requires distinguishing between generation effects and substitution effects. The former refers to trips that are now carried out by public transport that otherwise would not occur, while the latter refers to trips that without FFPT were done by some other mode and switched to public transport modes. Generation effects can thus indicate greater mobility and access to opportunities but could also be the result of unnecessary trips. Substitution effects represent mode choice changes with the most desired effect been that of public transport substituting car trips. In the case of Tallinn, the average trip length decreased by 10% which indicates that FFPT has resulted with a substitution effect from soft mode. There are no indications from speed changes of a modal shift from car. Further analysis requires the analysis of traffic counts.

The impact of FFPT on passenger demand in the case of Tallinn is considerably lower than the corresponding figures reported by previous FFPT programs. The relatively small increase in passenger demand following the introduction of FFPT in Tallinn could be attributed to one or more of the following factors:

- Public transport fare was relatively low to start with and many user groups had an exemption before the introduction of full-scale FFPT
- Public transport share was relatively high (40%) to start with compared with previous cities that have implemented a FFPT policy
- The introduction of FFPT had to rebound a two decades long negative trend in the share of public transport

The prospects of FFPT would most likely depend on the existing share of tickets revenues in financing system operations costs and the cost of alternative travel modes - in particular, the private car – compared with the current fare level. In addition to the above caveats concerning the generality of results, the results reported in this study reflect the immediate impact of FFPT while previous studies have considered the mid to long term impacts of such programs. Paulley et al. (2006) found in their meta-analysis that fare elasticities increase over time since the change of fare take place.

Previous studies did not account for supply changes and hence do not distinguish the supply effect from the FFPT effect. Even though the analysis presented in this study accounts for supply changes, it might be argued that there is a lag relationship between supply change and travel demand which is manifested at a later period. Chen et al. [10] found that changes in service levels influence ridership in the same month and four months later. The same study found that demand is influenced by public transport fare with zero and ten months lag. A future study on how ridership trends evolve in Tallinn will allow accounting for potentially lagged effects and establishing the long-term impacts of FFPT. Furthermore, the analysis of FFPT impacts for various socioeconomic groups was limited to the district level. One of the main policy objectives is to improve accessibility for low-mobility and disadvantaged groups which require a more detailed analysis of changes in travel patterns for different user groups. A series of before-after questionnaires and travel diaries will facilitate the estimation of generation and substitution effects of the FFPT policy as well as changes in mobility patterns by socio-economic groups.

## **ACKNOWLEDGEMENT**

The authors thank The City of Tallinn and Tallinn Development and Training Centre, specifically Allan Alaküla, Udo Ots, Raul Rannaveer and Anu Rentel for providing ridership and fare information for this study.

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