# The calculation of frequency elasticity with considering its instinct characteristic

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## 1. Introduction

Bus service demand generally rises when bus service quality attractively increases achieving viable and reasonable standard. There are many important aspects to be considered in the increasing bus service demand include the changes of bus service elements and characteristics of ridership factors. A set of elements elasticity can be used to measure and to evaluate the demand of bus services so that the opportunities for bus service demand improvements can be readily identified.

Suwardo et al. (2010) studied evaluated the change in ridership factors and to assess the bus service demand sensitivity with respect to ridership factors change. Through calculating the elasticity of factors, he concluded that frequency change is likely most preferable recommendation than the change in capacity due to the opportunity of raising load factor in future time.

There are many researches on the frequency elasticity. However, there are less studies about how to calculate the elasticity. Most of the elasticity value was got from data statistics (CHEUNG et al.1985. WALLIS,2004). The purpose of the study is to build a model to calculate the frequency elasticity with considering the trend of public transport and other factors through taking Arao public transport as an example.

## 2. Building the model

Although there is a close relationship between the frequency and public transport demand, there exists the instinct trend of the public transport and other factors. They also influence the demand. But, that trend is almost ignored when calculating demand forecast. $A(x)$represents the total influence factors. Eq(1) shows the total public transport demand. $X=\{x_k\}(k=1\cdots n)$ represents that there are $n$ factors influencing the public transport demand $x_k(k=1\cdots n)$, as shown Eq(3).

$$C'=A(x)\cdot C \tag{1}$$

$$lnC'=lnA(x)+lnC \tag{2}$$

$$lnA(x)=\mu_1\cdot lnx_1+\cdots+\mu_n\cdot lnx_n \tag{3}$$

## 3. Analysis and Calculation

This paper takes the public transport in Arao as an example to analyze. Due to the popularity of private cars, the operation situation is sharply deteriorated. In order to change the situation, transit privatization began in 2004. As a result, the amount of subsidies fell, and meanwhile the number of patronage decreased a lot. In order to improve the service level and increase patronages, the local government respectively reorganized the bus network in 2008 and 2009. In the process of reorganizing the bus network, the frequency of bus lines had been changed, and the ticket price still invariable.

The factors of last year may influence the demand in the next year, as Eq(4) shown. In the case, we respectively knew the demand of before year and after year. $A(x_{i(t-1)})$ is the factors index that affects the demand in the next year. In the factors, the local population and number of private cars also may affect the demand besides effect factors of public transport. Therefore, the effect factors are determined by public transport, number of population and private cars. In the factors of public transport, they not only include frequency and inherent trend as we said before. We also consider the influence which the adding or cancelling lines may affect on the demand. In each reorganization of the network in Arao, some bus lines are added and some bus lines are cancelling. The changed bus lines may affect the demand in the next year. It is the factor of public transport that must be needed to be considered. Eq.(6) presents the effect factors.

$$N_{it}=A(x_{i(t-1)})*N_{i(t-1)} \tag{4}$$

$$\ln N_{it} = \ln A\left(x_{i(t-1)}\right) + \ln N_{i(t-1)} \quad (5)$$

$$\ln A\left(x_{i(t-1)}\right) = \mu_p \ln x_{p(t-1)} + \mu_{car} \ln x_{car(t-1)} + (\mu_{bus} + \eta_{bus} * \delta_{i(t-1)} + \varepsilon_{bus} * f_{i(t-1)}) \ln N_{i(t-1)} \quad (6)$$

$N_{it}$ : the number of passengers of line $i$ in $t$ year; $A\left(x_{i(t-1)}\right)$: the index that affecting number of passengers of line $i$ in $t-1$ year; $N_{i(t-1)}$ : the number of passengers of line $i$ in $t-1$ year; $\mu_p$ : the influence coefficient of population; $x_{p(t-1)}$ : the population in $t-1$ year; $\mu_{car}$ : the influence coefficient of car; $x_{car(t-1)}$ : the number of private cars in $t-1$ year; $\mu_{bus}$ : the inherent influence coefficient of bus; $\eta_{bus}$ : the influence coefficient of cancelling or adding lines; $\delta_{i(t-1)}$ : passengers of line $i$ that were influenced by cancelling or adding lines in $t-1$ year; $\varepsilon_{bus}$ : the elasticity of frequency; $f_{i(t-1)}$ : the changed frequency of line $i$ in $t-1$ year.

We used the public transport data and the number of population and private cars from 2005 to 2010 and used SPSS to calibrate parameters. The result is shown as Table1.

Table1 the estimation results

| Variant | Parameter | t-value |
|---|---|---|
| constant | 1.121 | 0.619 |
| influence coefficient of car | -0.331 | -0.513 |
| inherent coefficient of bus | -0.064 | -2.361 |
| coefficient of changed lines | 7.50E-006 | 5.698 |
| elasticity of frequency | 0.349 | 6.688 |

When calibration parameter, the variant of population was exclude by the software. The reason may be that the number of population has less influence on the demand. This is due to the low population growth rate. In 2005, the population of Arao is 56,420, and the growth rate is -0.3%. There is scarcely population change in Arao. Therefore, the parameter of number of population was excluded by the software.

The parameter of the number of private cars is negative. It means that people would like to take private cars as the trip mode when they have it. The parameter of inherent coefficient of bus is negative. It means that the inherent trend of public transport is the demand of the bus would decrease year by year. It hints that people would have more choose as the society develops. The parameter value of coefficient of changed lines is little. That means the change of bus lines may cause influence on the demand. But the effect can be ignored.

The parameter of the frequency is positive. It means that when the government and bus operators take measures to improve the frequency to shorten the waiting time of passengers, people would like to choose the bus. Currie& Wallis(2008) concluded that the average elasticity is 0.35. Paulley et al. (2004) concluded the frequency elasticity of England and said the elasticity of bus demand with respect to vehicle km is approximately 0.4 in the short run. Therefore, the frequency elasticity of Arao is reasonable.

## 4. Conclude

The existing method about calculating elasticity is calculating ratio of the relative change in the quantity demanded to the relative change in service level. This paper proposed a model to calculate the frequency elasticity with considering the instinct trend of public transport. Through referring the frequency elasticity value of other researches, the elasticity of our paper is reasonable.

## Reference

Suwardo, Madzlan Napiah, Ibrahim Kamaruddin.(2010). Ridership factors change and bus service demand sensitivity assessment of the fixed-route bus service for short-term action plan, *Journal of Civil & Environmental Engineering*, vol. 10, p1-10.

Cheung, Y. H. F., Krose, E. P. & Jansen, J. A. L. (1985) The effect of frequency changes in regional bus services on patronage in The Netherlands. PTRC Summer Annual Meeting.University of Sussex, England.

Wallis, I. (2004) Review of passenger transport demand elasticities. Wellington, Transfund.

服部 徹(2006)：自由化と電気事業の効率化に関する実証分析－潜在的競争圧力の効果を中心として－, 産業組織研究会.

Currie G, Wallis I.(2008) Effective ways to grow urban bus markets-A synthesis of evidence, *Journal of Transport Geography,* vol. 16, p419-429.

Paulley, N, Mackett, R,Preston, J,Wardman, M,Titheridge, H,White, P.(2004). Factors affecting the demand for public transport. *Proceedings of the European transport conference*.