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Hedonic pricing models for metropolitan bus services

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Abstract

Conventional studies on the pricing of bus services use the cost structure to explain bus fares. In this paper, a hedonic pricing model for bus services in Hong Kong is estimated. The contributions of cost and market factors are uncovered. It is found that the cost factors dominate the determination of bus fares. In contrast to our expectation, bus fares do not react to competition faced by bus companies. Moreover, except the three cross-harbour tunnels, the bus fare has no direct relationship with the tolls of other tunnels. Our model serves well as a reference tool for bus companies to set market-acceptable bus fares.

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1. Introduction

The determination of bus fares in a metropolitan city has long been analyzed in the field of transportation economics since the pioneering works of Turvey and Mohring (1975) and Jansson (1979). More recent related studies include Chiang and Chen (2005), Jorgensen and Preston (2003) and Dargay and Hanly (2002). Conventional studies use the cost structure to explain bus fares (Shaw-Er *et al*., 2005; Jorgensen and Preston, 2003). In this paper, we approach the problem by estimating a hedonic pricing model of bus services. The hedonic pricing method was introduced by Court (1939) and further developed by Lancaster (1966) and Rosen (1974). The model has a good number of empirical applications, such as the determination of housing prices (Bourassa and Peng, 1999**;** Adair *et al*., 1996; Bloomquist and Worley, 1981; Freeman, 1979; Witte *et al*., 1979) and prices of auctioned license plates (Chong and Du, 2008). The willingness to pay for the bus service depends on a number of factors, including the duration of the route, the number of bus stops and the waiting time. The fare also varies with the cost of fuel and the capacity of the buses. A long-distance bus is expected to charge a higher fare than a short-distance one. Routes passing through pay highways, tunnels or bridges should also charge a higher fare (Tabuchi, 1993). The fare of an air-conditioned bus should also be higher than that of a non air-conditioned bus. To investigate the effect of these factors, this article estimates a hedonic pricing model for bus services in Hong Kong. The case of Hong Kong is studied for two reasons. First, Hong Kong is one of the densest cities in the world, and there is a high demand for bus services. Therefore, a fair setting of bus fares affects the livelihood of millions of people. Second, since the city has a good number of bus routes and the data are well available, a large and clean data set can be obtained for our analysis. Our results show that the fare is highly related to the operation cost of a bus route. Surprisingly, we find that factors such as the tunnel fee and competition faced by bus companies do not affect the bus fare. The remaining of the paper is organized as follows: Section 2 presents the model and the data. Section 3 reports the estimation results and Section 4 concludes our findings.

2. Data and the Model

The main part of our data set is obtained from the website of the Kowloon Motor Bus (KMB), http://www.kmb.com.hk, which contains the information of 120 different bus routes. For each route *t*, we define:

$FARE_t$ = the bus fare of the route (HK dollars);
$TIME_t$ = the travel time between two terminals of the route (minutes);
$DISTANCE_t$ = the distance between two terminals of the route (km);
$STOP_t$ = the number of bus stops along the route;
$WAITING_t$ = the expected waiting time (minutes);
SUB_t = the number of substitutes for the route, including railways, minibuses, which can take the passengers to their destinations within a 10-minute walking distance.

The followings are binary variables:

N_t = 1 if the route is an overnight route, and 0 otherwise;
$ABERDEEN_t$ = 1 if the bus passes through Aberdeen Tunnel, and 0 otherwise;
$CROSS_t$ = 1 if the bus passes through Cross Harbour Tunnel, and 0 otherwise;
$EASTERN_t$ = 1 if the bus passes through Eastern Harbour Tunnel, and 0 otherwise;
$LIONROCK_t$ = 1 if the bus passes through Lion Rock Tunnel, and 0 otherwise;
$SHINGMUN_t$ = 1 if the bus passes through Shing Mun Tunnel, and 0 otherwise;
$TAILAM_t$ = 1 if the bus passes through Tai Lam Tunnel, and 0 otherwise;
$CAIRN_t$ = 1 if the bus passes through Tate's Cairn Tunnel, and 0 otherwise;
$TSEUNG_t$ = 1 if the bus passes through Tseung Kwan O Tunnel, and 0 otherwise;
$WESTERN_t$ = 1 if the bus passes through Western Harbour Crossing and 0 otherwise;
$LANTAU_t$ = 1 if the bus passes through Lantau Link, and 0 otherwise;
$AIRCON_t$ = 1 if the bus is air-conditioned, and 0 otherwise;
$DOUBLE_t$ = 1 if the bus is double-deck, and 0 otherwise.

The values of the variables $FARE_t$, N_t, $ABERDEEN_t$, $CROSS_t$, $EASTERN_t$, $LIONROCK_t$, $SHINGMUN_t$, $TAILAM_t$, $CAIRN_t$, $TSEUNG_t$, $WESTERN_t$, $LANTAU_t$, $DISTANCE_t$, $STOP_t$, $WAITING_t$, $AIRCON_t$, $DOUBLE_t$ are obtained from the website of KMB directly. SUB_t is the number of other transportation means, including minibuses and the two railways, MTR and KCR, which can take the passengers from the same origin to the same destination within a 10-minute walking distance. $WAITING_t$ is the expected waiting time as stated in the bus schedule. We estimate the following hedonic pricing model:

$$FARE_t = \beta_0 + \beta_1 TIME_t + \beta_2 N_t + \beta_3 ABERDEEN_t + \beta_4 CROSS_t + \beta_5 EASTERN_t + \beta_6 LIONROCK_t + \beta_7 SHINGMUN_t + \beta_8 TAILAM_t + \beta_9 CAIRN_t$$

$+ \beta_{10}$ TSEUNG$_t$ $+ \beta_{11}$ WESTERN$_t$ $+ \beta_{12}$ LANTAU$_t$ $+ \beta_{13}$ DISTANCE$_t$
$+ \beta_{14}$ SUB$_t$ $+ \beta_{15}$ STOP$_t$ $+ \beta_{16}$ WAITING$_t$ $+ \beta_{17}$ AIRCON$_t$
$+ \beta_{18}$ DOUBLE$_t$ $+ u_t$

$t = 1, 2, \ldots, 120.$

For routes that cross tunnels or bridges, extra fees will be charged. The journey time (TIME$_t$), the distance of the route (DISTANCE$_t$) and whether the bus is air-conditioned (AIRCON$_t$) will also affect the operation cost of a bus route. These variables are expected to have a positive impact on bus fares. Because of a lower passenger flow, we anticipate a higher fare for the overnight routes. In addition, since double-deck buses (DOUBLE$_t$) have a lower cost per passenger, their fares should be lower than the fares of single-deck buses. Besides the cost factors, we also include the market factors. The number of direct substitutes (SUB$_t$) to the routes reflects the competition faced by the bus company. The higher the number of substitutes is, the keener the competition facing the bus company. We therefore anticipate that the competition will lower bus fares. For the same journey distance, the more the number of stops (STOP$_t$) on the bus path, the longer the journey will take. Since commuters prefer a faster means of transportation, a negative relationship between STOP$_t$ and the fare is expected.

3. Estimation Results

The estimation results are reported in Table 1. Note from Table 1 that the full model has a very high R^2 of 0.8883. To obtain a simpler model, we drop the most insignificant variables one at a time until the best model is obtained. The final model is:

$\hat{FARE}_t =$ .7278 + 4.9579 N$_t$ + 4.0760 CROSS$_t$ + 4.6829 EASTERN$_t$ + 2.0664 LIONROCK$_t$ + 2.8975 SHINGMUN$_t$ + 4.4756 CAIRN$_t$ + 6.8043 WESTERN$_t$ + .2447 DISTANCE$_t$ - .0454 STOP$_t$ + .0503 WAITING$_t$ + 1.4464 AIRCON$_t$

Seven variables are removed from the final model. The variables TIME$_t$ and DOUBLE$_t$ are dropped. The variable SUB$_t$ is also deleted, which implies that the number of direct transportation substitutes for a bus route does not affect the bus fare. The variables LANTAU$_t$, TAILAM$_t$, ABERDEEN$_t$ and TSEUNG$_t$ are also insignificant.

The final model includes eleven regressors, all of which highly explain the bus fare. The fares of buses crossing the three congested harbour tunnels are significantly more expensive. The estimated coefficients of Cross Harbour Tunnel (CROSS$_t$), the Eastern

Harbour Tunnel ($EASTERN_t$) and the Western Harbour Crossing ($WESTERN_t$) are significantly positive. However, this is not the case for buses crossing other less congested tunnels. In Table 2, the tunnels highlighted are found to be insignificant in our pricing model. Both the dummy variables for the tunnel with the cheapest toll (Tseung Kwan O Tunnel) and the one with a high toll (Tai Lam Tunnel) are dropped. Thus, no direct relationship between the tunnel fee and bus fare can be observed. Our results are in line with Tabuchi (1993), who examines the optimality and efficiency of several railroad fare and road toll regimes. It is found that the road tolls are effective especially in the case of heavy road congestion.

The journey distance, whether the buses are air-conditioned, and whether they operate overnight also have significant impacts on the bus fare. On the other hand, the number of bus stops has a negative relationship with the fare. The coefficient of $WAITING_t$ is found to be positive. A bus route with a longer waiting time is a refection of the lack of passengers. According to the agreement with the Hong Kong government to provide bus services to people living in the remote areas, bus companies still need to operate these unprofitable routes. As the demand for these routes is less elastic, a higher price can be charged.

4. Conclusion

This paper investigates factors affecting the bus fares in Hong Kong. Conventional studies of bus fares focus on the overall fare level and the cost structure of bus companies. We provide the first attempt to estimate the hedonic pricing model for individual bus route. The results show that the fare is highly affected by the operation cost of a bus route. Except the three cross-harbour tunnels, the bus fare has no direct relationship with the tolls of other tunnels which are less congested. Our model serves well as a reference for bus companies to set sustainable fares for new routes. Moreover, it can be used to identify the under- and over-priced routes. Due to the limitation of the data, our model does not consider the income level of passengers at different districts. One way to further improve the model is to include the average income of the residents in the district where the terminal of a certain bus route is located. In high-income districts, such as the Peak and the southern Hong Kong Island, residents can afford a higher bus fare. Further, for routes whose terminals are tourist spots such as the Ocean Park or Disneyland, a higher fare can also be charged.

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Table 1: Estimation Results: Dependent Variable = FARE

Variables		**Full Model**	***t*-ratio**		**Final Model**	***t*-ratio**
CONSTANT		1.1620	.5192		.7278	1.2697
TIME		.0026	.0890			
N		5.0679	7.3762		4.9579	9.3227
ABERDEEN		.8719	.8265			
CROSS		3.7362	5.2323		4.0760	6.8698
EASTERN		3.5380	2.6991		4.6829	4.9929
LIONROCK		1.9554	2.4864		2.0664	2.7690
SHINGMUN		2.8294	1.7732		2.8975	1.9849
TAILAM		.4358	.4712			
CAIRN		5.6780	2.9032		4.4756	2.6398
TSEUNG		2.3275	1.1840			
WESTERN		6.7315	6.0155		6.8043	6.5870
LANTAU		.1925	.1814			
DISTANCE		.2327	5.8026		.2447	13.47
SUB		-.0883	-.3133			
STOP		-.0427	-1.5179		-.0454	-2.4487
WAITING		.0521	1.6476		.0503	1.7055
AIRCON		1.4285	2.6995		1.4464	2.8209
DOUBLE		-.2109	-.1006			
R Squared		.8883			.8859	
Adjusted *R* Squared		.8683			.8743	

Table 2: Tunnel Tolls for Public Buses in Hong Kong

1.	**Aberdeen Tunnel** **Causeway Bay <-> Aberdeen**	**HK$5**
2.	Airport Tunnel Central Kowloon <-> Kwun Tong	Free
3.	Cheung Tsing Tunnel West Kowloon <-> Lantau & Northwestern New Territories	Free
4.	Cross Harbour Tunnel Wanchai <-> Hung Hom	HK$10
5.	Eastern Harbour Tunnel Quarry Bay <->Lam Tin	HK$50
6.	Lion Rock Tunnel North Kowloon <-> Sha Tin & Northeastern New Territories	HK$8
7.	Shing Mun Tunnel Tsuen Wan <-> Sha Tin	HK$5
8.	**Tai Lam Tunnel** **Ma On Shan <-> Sham Tseng**	**HK$60**
9.	Tate's Cairn Tunnel North Kowloon <-> Sha Tin	HK$20
10.	**Tseung Kwan O Tunnel** **Kwun Tong <-> Tseung Kwan O New Town**	**HK$3**
11.	Western Harbour Crossing Sheung Wan <->Western Kowloon	HK$70

Bridge Tolls

1.	Tsing Kau Bridge Tai Lam Tunnel <-> Tsing Yi Section of Route 3	Free
2.	**Lantau Link** **Northeast Lantau <-> Ma Wan at Kap Shui Mun** **Ma Wan <->Tsing Yi**	**HK$40**

Source: http://www.kcm.com.hk/tunnelfee.htm