THE EFFECTS OF SUBSIDIES ON URBAN MASS TRANSIT SYSTEMS: SOME TAIWAN EXPERIENCE

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1. INTRODUCTION

Subsidies to urban mass transit systems have long been controversial and become an important as well as troublesome problems for policymakers around the world. Furthermore, governments are increasingly reluctant or unable to subsidize these rapidly increasingly deficits. Thus, the existence and effects of subsidies on urban public transport systems will be a critical issue for the transit industry.

There have been many attempts to focus on the investigations of the effects of subsidies on costs, productivity and service levels by multiple regression analysis in recent years. However, the subsidies, costs, service quality, travel demand and fares are all somewhat interdependent. To deal with these interrelationships, this research attempts to establish a two-stage least squares (2 SLS) and a three-stage least squares (3 SLS) simultaneous equations models in addition to a ordinary least squares (OLS) method.

This article examines the extent to which subsidies have effected the costs, frequency, wage rates, fares and other interactions among those operating variables. It also reviews regional aggregate trends in transit operating ratios and subsidies. Next, simultaneous-equations models were established with different variable compositions on a pooled time-series and cross-sections sample of three bus transit systems in Taiwan. From the model estimation results, some conclusions and policy implications are made for implementations in the subsidy program that would lead to a more efficient use of transport resources and also improve service quality for the riders.

2. TRENDS IN OPERATING RATIOS

Operating revenue is primarily revenue produced through fares data collected by the transit system. Other operating revenue sources include advertising in and on vehicles and stations, charter operating, interest on cash and investments and rental of facilities. Operating costs comprise those expense items which vary with the quantities of transit service offered, namely, salaries, wages and fringe benefits, fuel, supplies, insurance, vehicle license fees and taxes, advertising and promotion, tire rentals, etc. Vehicle depreciation is sometimes included, sometimes listed as a capital cost. Generally speaking, operating ratio can be defined as operating revenue/operation cost to represent the basic indicator of the transit agency's financial profitability. The indicator may also be computed for individual modes or routes but some expenses are often difficult to determine precisely enough for this purpose.

Table 1 shows the trend of operating ratio for 34 Taiwan bus transit companies in 1985. Approximately half number of these bus systems have an operating ratio of less than one. Furthermore, trends in the ratio seem to be universally around one. It appears that public subsidies in some form is a general and continuing requirement under present circumstances. However, governments are increasingly reluctant or unable to subsidize the privately-owned transit companies. Therefore in Taiwan, the publicy-operated bus transit authorities (i.e. Taipei, Kaohsiung and Keelung) can only obtain the subsidies to absord these rapidly increasingly deficits in the last decade.

3. TRENDS IN TRANSIT SUBSIDIES

Transit subsidies (shown in Table 2) to government-operated bus transit authorities in Taiwan has increased rapidly from 1978 to 1982 and then gradually diminish over the next 6 years, with the exception of Kaohsiung city where its bus operating areas and routes greatly expanded in that period and more subsidies are needed.

The possible results or issues of these trends are as follows. First, these dedicated funds have forced municipal bus transit authorities to eliminate highly unprofitable services and reduce their frequency of some uneconomical routes. Second, whether the design of transit subsidy programs in Taiwan would therefore encourage the efficient use of subsidy funds. Third, whether the increased subsidies could be traslated into lower fares or additional service. Subsequent sections of the article examine the extent to which they have affected the bus transit operations.

4. ECONOMETRIC MODELS

There is quite a number of searches focusing on the investigations of the effects of subsidies on costs, labor productivity and other important transit operations by empolying multiple regression analysis (Anderson (1983), Berchman (1980), Bly, et al (1980), Pucher, et al (1983), etc.). However, the subsidies, costs, service levels, travel demand and fares are all somewhat interdependent. To deal with these interrelationships, this research tries to establish the simultaneous-equations econometric models to investigate the effects of transit subsidies. The analysis here is limited to three government-operated urban bus authorities in Taiwan, because the other privately-owned bus systems yield few available data and no subsidies to them.

The data base for the models consisted of a pooled time-series and cross-sections sample of three bus transit systems from 1979 to 1987. The systems were selected primarily because data were available for them. The necessary transit data were assembled from three sources: (1) mandatory financial and operating reports submitted by bus transit systems to the municipal government; (2) regular financial and operating reports filed

Table 1. Operating Ratios of 34 Taiwan Bus Transit Companies in 1985

Bus Company or Authority	Operating Ratio (other operating revenue included)	Operating Ratio (other operating revenue excluded)	Bus Company	Operating Ratio (other operating revenue included)	Operating Ratio (other operating revenue excluded)
Kee-Lung	1.021	1.014	Jyuh-Yeh	1.148	1.142
	* 0.865	0.865	Tai-Chong	1.033	1.025
San-Churng	1.002	0.990	Ren-Yoou	0.934	0.923
Shoou-Du	0.960	0.947	Chang-Hua	1.010	0.951
Tai-Pei	1.102	1.097	Yuarn-Lirn	1.084	1.072
	* 0.866	0.866	Nan-Tou	0.987	0.979
Haai-Shan	1.076	1.071	Tai-Hsi	0.985	0.981
Tam-Shui	1.001	0.997	Chia-I	0.939	0.904
Shin-Diahn	0.949	0.940	Hsin-Yin	1.000	0.988
Shin-Her	1.030	1.030	Shier-Cherng	1.004	1.003
Jyy-Nan	1.003	0.998	Shing-Nan	0.990	0.983
Tao-Yuan	1.229	1.203	Tai-Nan	0.901	0.897
Jung-Li	0.779	0.778	Ping-Tung	1.072	1.060
Hsin-Chu	1.130	1.087	Kao-Hsiung	1.061	1.046
Miao-Li	1.028	0.983		* 0.726	0.726
Hua-Lien	1.088	1.080	Diing-Dung	0.944	0.940
Feng-Yang	1.087	1.075	Dah-Yoou	1.112	1.113

*: for publicy-operated bus transit authority, otherwise the operating ratios are for privately-owned bus companies.

Table 2. Trends in Transit Subsidies in Taiwan by Municipal Government, 1978-1987

Year	NT$ Million	NT$ Million	NT$ Million
	Taipei	Kaohsiung	Keelung
1978	190.0	1.94	-
1979	500.0	3.49	18.37
1980	500.0	5.57	15.93
1981	300.0	13.22	14.89
1982	250.0	114.87	16.66
1983	54.1	167.21	14.30
1984	180.0	192.92	24.43
1985	0	181.34	12.00
1986	223.3	162.36	10.00
1987	330.0	137.71	10.00
Total	2527.4	981.08	136.58

by member systems with the Taiwan Bus Association; (3) supplemental, unpublished information obtained by the author from all the systems.

In the simultaneous-equations models, the travel demand, operating cost per vehicle-kilometer, labor wages, total amount of vehicle frequency and average price were chosen as the dependent variables respectively in the simultaneous-equations model. Also, a number of factors were hypothesized to influence each other. The models were specified as follows:

1. Travel demand equation:
   LNDEMAND = f(LNPRICE, VKM, AUTORATE, POPUL)
2. Cost equation:
   ACOST = f(AWAGE, PRODY, OIL, FLEET, ASUB, DUMMY 1, DUMMY 2)
3. Wage equation:
   AWAGE = f(PRODY, AINCOME, ASUB, DUMMY 1, DUMMY 2)
4. Frequency equation:
   FRE = f(LNDEMAND, FLEET, ACOST 2, ASUB, DUMMY 1, DUMMY 2)
5. Price (fare) equation:
   LNPRICE = f(ACOST 3, ASUB, DUMMY 1, DUMMY 2)

Definitions and descriptive statistics for each of variables are shown in Table 3. The relationships between these equations and several of the explanatory variables are rather obvious. However, the unavailability of several important operating data of bus transit systems limits the choice of independent variables, therefore, other important variables (e.g., the ratio of peak-hour buses in service to off-peak, management, and average year of buses in fleet, etc.) cannot be incorporated into the models.

5. MODEL ESTIMATION RESULTS

The simultaneous-equations models with different variable composition were estimated by using ordinary least squares (OLS), two-stage least squares (2 SLS) and three-stage least squares (3 SLS), respectively. The results were shown in Table 4~8. As expected, the coefficients and signs of independent variables are quite consistent by using these three methods.

The first equation of the estimated demand model is reported in Table 4. The fare elasticity of demand (-0.24 ~ -0.35) can be obtained from this equation. The coefficient for the auto ownerships is negative and statistically significant, this indicats that the increase in auto ownerships apparently affects the bus transit ridership. Also, the escalation of level-of-service (i.e. the number of vehicle-kilometers increases) and population will increase the demand of bus systems.

The estimated effect of transit wage rates on costs is positive and insignificant, whereas the impacts of transit subsidies and labor productivity are negative and insignificant. However, this represents bus transit subsidies in Taiwan more or less have its positive effects in reducing vehicle operating costs, which may improve the transit performance in the long run.

Of greatest interest for this result, is the estimates of the relationship between the frequency and subsidy variables. The estimated effect of transit subsidies on frequency is negative and significant, indicating the increase of government funds to the publicly-owned bus companies in Taiwan will deterioate their level of service (i.e. the amount of frequency decreases). This maybe because that the rising deficits and increasing costs of labor, energy and transit operations have caused many bus managers to cutout the amount of frequency for uneconomical routes so as to relieve the fiscal problems. This also suggests that the regulatory measures and monitoring systems should be taken along with the subsidy program in order to prevent the decline of transit service quality.

Moreover, the difference in costs, wages, service levels, fares between bus systems were examined by using regional dummy variables. It was found that no any significant deviation in operations existed among those systems although they are operated in different regions.

Finally, the important effect of subsidies from the estimated fare equation supports that the existence of subsidies could maintain the low-fare policy in Taiwan. Indeed, it might be expected that subsidies affect costs through their impacts on transit wages and labor productivity by encouraging higher wages as well as higher productivity, and thereby reducing the total operating costs for transit agencies. The effect of transit subsidies on labor wages (positive impacts) and other variables can also be obtained from the estimated simultoneous-equations model. However, it was noted earlier, because of data limitations, no all satisfactory instrumental variables could be incorporated in the equations that might permit more meaningful and satisfactory results from this reasearch.

6. CONCLUSIONS AND POLICY IMPLICATIONS

The preceding analysis suggests that transit subsidies in Taiwan, probably has its positive effects in reducing vehicle operating cost, which

Table 3 Variable Definitions and units

Variable Name	Definition	unit
LNDEMAND	logarithm of annual passenger demand	persons (x10,000)
LNPRICE	Logarithm of average bus fare	NT$/person
AUTORATE	ownership of motorcycles and automobiles	vehicles/person
VKM	annual number of vehicle-kilometers travelled	vehicle-kilometers
POPUL	population	persons
ACOST	cost per vehicle-kilometer	NT$/vehicle-kilometer
ACOST 2	cost per vehicle departure	NT$/vehicle
ACOST 3	cost per passenger	NT$/passenger
AWAGE	average annual wages per employee	NT$/employee (x10,000)
PRODY	productivity per employee	kilometers/person (x10,000)
FLEET	number of buses in fleet	buses
ASUB	subsidies per vehicle-kilometer	NT$/vehicle-kilometers
AINCOM	average annual income of local residents	$/person
FRE	total amount of vehicle frequency in a year	Buses/year (x10,000)
DUMMY 1	1 = Taipei; 0 = otherwise	none
DUMMY 2	1 = Kaohsiung; 0 = otherwise	none
OIL	oil price	NT$/liter

Table 4 Estimation Results of Demand Equation

Model	Variable	Coefficient	t Statistic
OSL	LNDEMAND		
	LNPRICE	-0.24035	-2.2212
	VKM	0.35911 E-08	1.0668
	AUTORATE	-0.63309	-2.4620
	POPUL	0.11329 E-05	8.3347
	CONSTANT	8.1249	52.692
	R^2 = 0.9852		n = 27
2 SLS	Variable	Coefficient	t Statistic
	LNDEMAND		
	LNPRICE	-0.24739	-2.1638
	VKM	0.27639 E-08	1.1603
	AUTORATE	-0.70414	-3.3218
	POPUL	0.11765 E-05	11.823
	CONSTANT	8.1343	53.241
	R^2 = 0.9968		n = 27
3 SLS	Variable	Coefficient	t Statistic
	LNDEMAND		
	LNPRICE	-0.35412	-3.5358
	VKM	0.47637 E-08	2.2959
	AUTORATE	-0.52192	-2.7993
	POPUL	0.10916 E-05	12.583
	CONSTANT	8.2744	61.367
	R^2 = 0.9966		n = 27

Table 5 Estimation Results of Cost Equation

Model	Variable	Coefficient	t Statistic
OSL	ACOST		
	AWAGE	0.29329 E-04	1.6009
	PRODY	-0.40220 E-03	-1.4402
	ASUB	-0.16685 E-04	-1.6042
	FLEET	0.17988 E-07	0.34836
	OIL	0.20750 E-02	1.3577
	CONSTANT	0.20291 E-02	8.8311
	R^2 = 0.8049		n = 27
2 SLS	Variable	Coefficient	t Statistic
	ACOST		
	AWAGE	0.39609 E-04	3.8308
	PRODY	-0.51525 E-03	-3.1475
	ASUB	-0.15190 E-04	1.6448
	FLEET	0.16560 E-07	0.79772E-01
	OIL	0.17563 E-04	-1.7255
	DUMMY 1	-0.79973 E-04	-0.28101
	DUMMY 2	-0.14133 E-03	-1.4891
	CONSTANT	0.21224 E-02	13.293
	R^2 = 0.7231		n = 27
3 SLS	Variable	Coefficient	t Statistic
	ACOST		
	AWAGE	0.46247 E-04	4.8883
	PRODY	-0.61082 E-03	-4.0646
	ASUB	-0.13500 E-04	-1.6235
	FLEET	0.28229 E-07	0.14980
	OIL	0.19623 E-04	2.0233
	DUMMY 1	-0.10652 E-03	-0.41124
	DUMMY 2	-0.4953 E-03	-1.7039
	CONSTANT	0.21246 E-02	14.199
	R^2 = 0.7030		n = 27

Table 6 Estimation Results of Wage Equation

Model	Variable	Coefficient	t Statistic
OSL	AWAGE		
	PRODY	8.6393	3.9183
	AINCOME	0.13914 E-03	4.1758
	ASUB	0.10015	1.2593
	CONSTANT	-5.5182	-2.5665
	R^2 = 0.9575		n = 27
2 SLS	Variable	Coefficient	t Statistic
	AWAGE		
	PRODY	8.2705	4.749
	AINCOME	0.17392 E-03	4.0291
	ASUB	0.16045	1.3340
	DUMMY 1	-0.19796	-0.23595
	DUMMY 2	0.69935	0.99154
	CONSTANT	-7.7113	-4.6605
	R^2 = 0.9328		n = 27
3 SLS	Variable	Coefficient	t Statistic
	AWAGE		
	PRODY	8.0602	5.1734
	AINCOME	0.17608 E-03	4.5939
	ASUB	0.15345	1.3316
	DUMMY 1	-0.21437	-0.26656
	DUMMY 2	0.78259	1.1237
	CONSTANT	-7.5154	-4.7085
	R^2 = 0.9327		n = 27

Table 7 Estimation Results of Frequency Equation

	Variable	Coefficient	t Statistic
OSL	FRE		
	LNDEMAND	136.68	3.8831
	ACOST 2	-0.84728	-15.490
	FLEET	0.41043	6.3922
	ASUB	-7.4069	-2.1159
	CONSTANT	-903.25	-3.3129
	R^2 = 0.9910		n = 27
2 SLS	Variable	Coefficient	t Statistic
	FRE		
	LNDEMAND	215.85	1.2730
	ACOST 2	-0.75881	-2.9930
	FLEET	0.38665	6.4446
	ASUB	-7.5250	-2.3420
	DUMMY 1	-160.36	-0.43916
	DUMMY 2	-84.599	-0.62142
	CONSTANT	-1553.8	-1.1415
	R^2 = 0.9957		n = 27
3 SLS	Variable	Coefficient	t Statistic
	FRE		
	LNDEMAND	308.01	1.9473
	ACOST 2	-0.67415	-2.8692
	FLEET	0.36676	6.5034
	ASUB	-8.2790	-2.6711
	DUMMY 1	-360.82	-1.0644
	DUMMY 2	-176.49	-1.4095
	CONSTANT	-2308.8	-1.8200
	R^2 = 0.9956		n = 27

Table 8 Estimation Results of Fare Equation

Model	Variable	Coefficient	t statistic
OSL	LNPRICE		
	ACOST 3	0.13194 E-04	9.2955
	ASUB	-0.37813 E-01	-5.3654
	CONSTANT	0.87498	9.7890
	R^2 = 0.8705		n = 27
2 SLS	Variable	Coefficient	t statistic
	LNPRICE		
	ACOST 3	0.16888 E-04	9.4880
	ASUB	-0.29820 E-01	-4.9041
	DUMMY 1	0.30995 E-01	0.84307
	DUMMY 2	-0.99749 E-01	-1.9943
	CONSTANT	0.68409	7.0154
	R^2 = 0.8995		n = 27
3 SLS	Variable	Coefficient	t statistic
	LNPRICE		
	ACOST 3	0.16048 E-04	9.8921
	ASUB	-0.3189 E-01	-5.7045
	DUMMY 1	0.28859 E-01	0.78860
	DUMMY 2	-0.78783 E-01	-1.7089
	CONSTANT	0.72984	8.2026
	R^2 = 0.8984		n = 27

may improve the transit performance in the long run.

The results also indicate that the increase of government funds to the publicly-owned bus transit companies will lead to service cutbacks. These results, therefore,suggest that transit operations should be regulated and monitored more carefully and that transit subsidy program should be improved to be related explicitly to those systems that raise labor productivity, attract new riders, or enhance the quality of their service.

On the other hand, the Central Government in Taiwan, R.O.C., is now seriously considering taking the policy of deregulation and reorganization of the bus industry. Therefore, transit subsidies might gradually diminish than in recent years. This would push the publicly-owned transit operators to achieve more optimal use of resources and thereby hopefully to reduce the total costs. This should also be helpful in leading to a more effective urban transport policy and in improving service quality for the transit passengers.

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