Determinants of Bus Transit Ridership : The case of Seoul

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1. Introduction

The population of Seoul, the capital of Korea, was 3 million in 1963 when Korea stepped on the road to develop her economy. Since then, Seoul has experienced rapid population growth; at last count the population of Seoul had reached 10 million in 1996. In addition, much more rapidly achieved passing-demand resulted in an excess demand for transportation and congestion. Since the 1980's, rapidly increasing private auto ownership and use, have deepened the transportation problems such as road traffic congestion, parking, etc. Seoul's transportation situation is often expressed as a "transportation hell". The government's policies to counter these problems have been road supply expansion, constraint on private auto ownership by various ownership taxes, and supply of improved public transportation--especially increasing the subway service supply through subway construction.

Road supply expansion has been a difficult and high-cost measure since Seoul is one of the highest land price region in the world. This results from severely restricted land availability due to geographical features and the government's rigid green belt policy. The constraints on private auto ownership with various taxes were overcome by rising income and reducing the real costs of owning and using cars since the 1980's. In fact, between 1980 and 1996, while real per capita income increased about three fold, private auto ownership increased over fourteen fold. So it is most efficient for the government to depend on the subway and bus service to absorb the increasing demand for private car use.

Increasing the supply of subway service through new subway construction has steadily increased the subway ridership since 1974. But the bus ridership has consistently declined since 1983. This may mean that increasing the service of the subway absorbed the demand not for private car use but for bus use. Decline in bus ridership resulted in financial problems of the bus companies and a decline in public transit(bus and subway) ridership. In fact, the transit ridership has declined since 1991 by 1.9 annual percent rate. So it will be very useful to analyze the factors that determine bus transit ridership. In particular, it is very important to separate out the effects of bus fare and service, subway service, private car ownership and other variables beyond the government's control such as real income, suburbanization, etc.

The primary objective of this paper is analysis of the factors that determine ridership change of buses in Seoul. In particular, it will analyze those factors that caused the bus ridership decline since 1983. The implications of such analysis will be useful to evaluate the existing policies and coordinate the policies to increase or sustain the public transit ridership.

These analyses are based on statistical analyses of trends in Seoul's annual per capita bus ridership, fares and service levels, per capita income, gasoline price, etc.

The rest of this paper is composed of 4 sections. Section 2 overviews the trends of bus ridership, fare, service and other factors which can affect bus ridership. Section 3 describes

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the modelling changes in per capita bus ridership and data which were used in model estimation. Section 4 presents and discusses the estimation results for the model. Section 5 summarizes the findings and provides policy implications.

2. An Overview of Seoul's Bus Transit Situations

2.1. Bus Services

Like other major cities in developing countries, buses are the dominant mode of passenger transportation in Seoul. Although growing private auto use and the rapid expansion of subway networks have resulted in declining bus use, 34.9 percent of all trips were made by bus in 1996. The city's bus services are owned and operated by private companies. But routes, fares, and service quality have been strictly regulated by the government.

In 1996, bus companies operated a total of 438 routes, in which 282 routes were city-bus routes with 6,211 regular buses and 156 were seat-bus routes with 2,446 seat-buses.

2.2. Ridership

Figure 1 shows the changes in Seoul's bus ridership and population between 1971 and 1996. Ridership is measured by the annual number of passenger boardings.[2]

Seoul's population increased from 5.9 million to 10.5 million during 1971-96. The annual population growth rate for the same period was 2.6 percent, in which it grew continuously until 1992, but slightly declined during 1993-96 largely because many people moved to newly-constructed towns outside Seoul. But the number of daily trips has increased steadily and more rapidly than the population from 5.4 million to 28.2 million during 1970-1996 by a 6.6 percent annual rate(Table 1).

Despite the steady and rapid increases in trips, annual bus transit ridership increased until 1983 but decreased consistently by 4.5 percent since 1983. As figure 1 shows, Seoul's annual bus transit ridership increased form 1.3 billion to 3.2 billion during 1971-1983, but decreased to 1.8 billion in 1996. The declining trend is more obvious if the effect of population growth in Seoul is eliminated. During 1971-1983, per capita bus ridership increased from 214 to 352, but decreased to 169 in 1996 as shown in figure 2.

Table 1. Population and Daily Trips in Seoul 1970-1996 (Unit: 1000)

	1970	1981	1985	1992	1994	1996	Annual growth rate(%)
Population	5,525	8,676	9,646	10,976	10,779	10,460	2.6
Daily trips	5,411	16,608	16,831	25,715	26,440	28,220	6.6

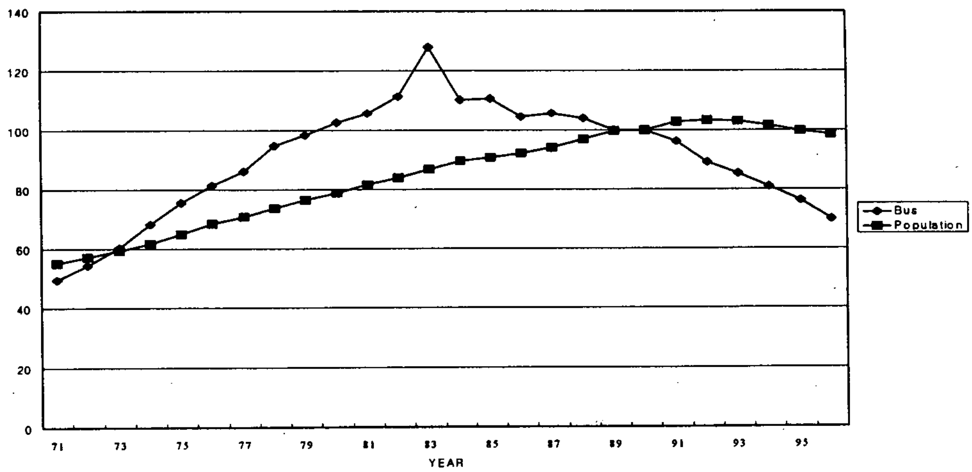
Source: 1) Seoul Statistical Year Book, Every year.
2) Transportation White Paper of Seoul, 1994.

The decline of bus transit ridership can be explained by the rapid increases in private car

2. According to the custom in the transit industry, ridership is measured by the number of "linked" trips rather than by the number of passenger boardings. But the consistent data on the number of linked trips are not available.

ownership and use, and suburbanization with increasing income, the decreases in bus service which resulted from rapidly growing traffic congestion, shift of bus users to subway and auto use, the increases in bus fare, and the decreases in bus services.

Figure 1. Trends of Bus Transit Ridership and Population(1990=100)

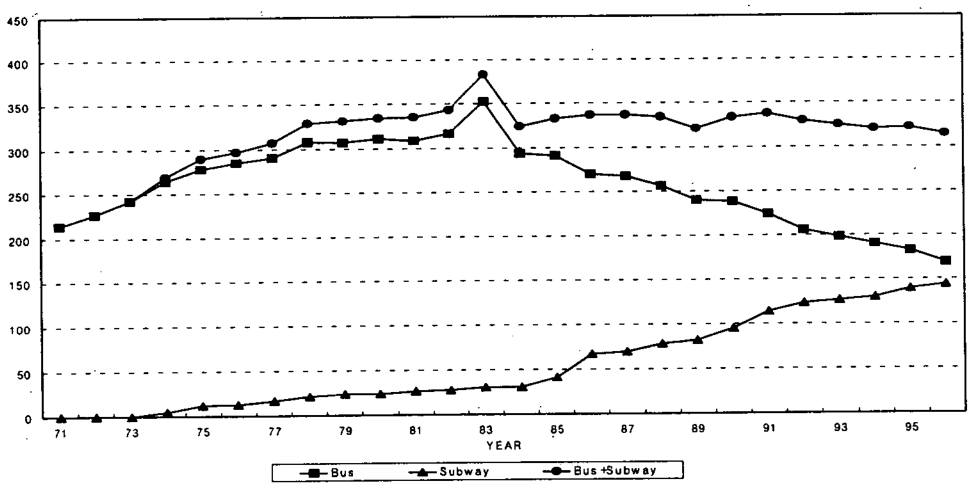


2.3. Fare and Services

As discussed earlier, fares are strictly regulated by the government, especially the department which is responsible for management of the general price level.

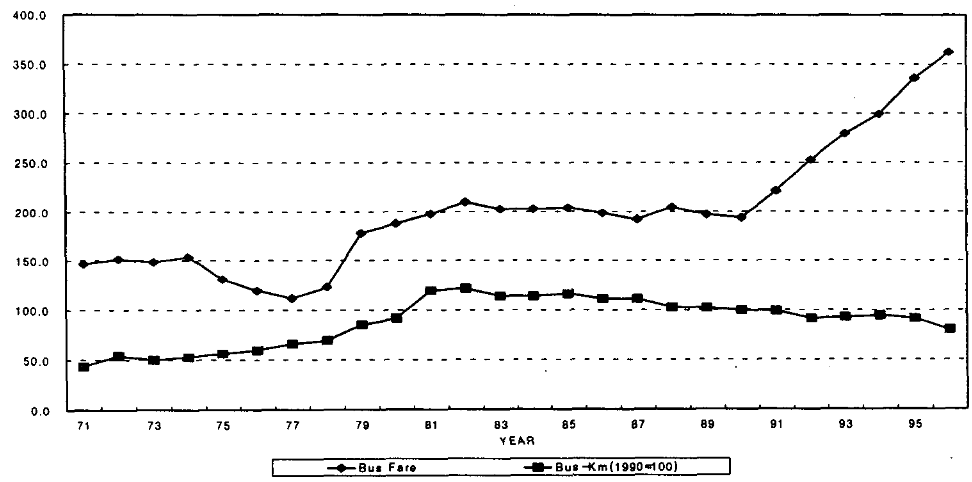
Figure 3 shows the changes in the weighted average bus fare of city-bus and seat-bus by number of registered buses. It increased by only 3.2 percent annual rate during 1971-1982 but decreased during 1982-90, and then increased by a 10.9 percent annual rate. The strict regulation of fares is one of the main reasons for bus companies' deteriorating financial condition.[3]

Figure 2. Trends of Per Capita Transit Ridership



3. According to the data of Bus Owner's Association, the ratio of operating deficit for operating revenue per bus was 20 percent in 1989, 34.7 percent in 1992, and 30.0 percent in 1993. The financial conditions of bus companies have been deteriorating rapidly.

Figure 3. Trends of Real Bus Fare and Vehicle-Km



In fact, the rapid increase in real bus fares since 1990 can be explained by the government's admittance of an increase to relieve the financial difficulty of bus companies.

The service variable is usually measured by the number of vehicle-km operated. Bus-km increased by 9.9% annual rate until 1982 largely because of the increasing number of routes and buses operated.(Figure 3) In fact, the number of registered buses steadily increased from 4,271 in 1971 to 8,657 in 1996. The number of routes increased from 270 in 1980 to 448 in 1990, and slightly decreased to 438 in 1995. But bus-km declined during 1982-1992 by 2.8% annual rate largely because of decreases in operating distance per bus due to deteriorating road traffic congestion which resulted from an increasing number of autos. In fact, in the case of city-buses, the daily operating distance per bus decreased from 388km in 1981 to 257km in 1992 and in the case of seat-buses, it decreased from 370km to 299km. But after 1992, due to the expansion of exclusive curb-side bus lanes, commercial bus speed increased and so did the bus-km.

As discussed, bus-km is closely related with bus speed. Actually congestion in Seoul reduced bus commercial speed even more seriously than it did auto speeds. Statistical analysis suggested that bus commercial speeds are a fraction of auto speeds and decrease faster than auto speeds when the latter decrease.(Liu,1994, p.6)

If auto ownership in Seoul continues to increase at 5 to 8 percent per year, which is highly possible because of the current policies that encourage domestic auto ownership, it is predicted that Seoul's traffic volumes will increase by 50 percent by the year 2000, and 90 percent of all existing intersections with traffic signals will be over-saturated.(Won, 1994, p.13)

Growing congestion reduces bus commercial speeds and service reliability and therefore discourages public transit use and encourages use of private cars. On the other hand, the decrease in bus commercial speeds will increase bus operating costs.

In response to the declining ridership and rising real costs of bus services, Seoul's private bus companies would have to demand that the government raise fares to cover their rising costs. Higher fares and lower services will further discourage bus use and encourage greater use of private cars. This vicious cycle will eventually force private bus companies out of business if no corrective actions are taken to alleviate congestion and protect the bus's operating environment.(Liu, 1994, p.6)

Exclusive bus lanes which began to be implemented in 1984, can be a solution for this problem. In 1994, Seoul's government implemented 89km exclusive bus lanes on 15 arterial roads. They are enforced in both morning and afternoon peak hours. Seoul's government plans to expand them to 226km lanes on 54 arterial roads. The effects of Seoul's exclusive bus lanes reveal that the average bus's commercial speed on these facilities increased 105 percent for city-buses and 103% for seat-buses(City of Seoul 1995). But the effects of exclusive curb-side bus lanes are increasingly limited as the level of road congestion becomes greater.(Liu, 1994)

2.4. Subway Expansion

Seoul's subway systems, which consisted of four lines of 220km in 1996, carried 4.1 million passengers per day, and 34.1 percent of the city's daily total person trips in 1996. Since the opening of Line 1 in 1974, the subway ridership has increased from 31.8 million to 1.5 billion by a 19.2 percent annual rate up to 1996. These increases are attributable to the construction of new subway lines, increased train-km and a government policy of maintaining low subway fares. In fact, the route-km increased from 7.8km to 218.4km and the train-km from 0.2 million to 220.6 million during 1974-1996. Real subway base fare increased by only 2.8 percent annual rate between 1974 and 1996.

The subway expansion has affected the bus ridership adversely. As the subway service increases, the adverse effect may increase.

2.5. Auto Ownership

Seoul's number of registered autos has increased from 67,275 to 2.2 million between 1971 and 1996 by a 14.9 percent annual rate. The annual growth rate of number of private car ownership for the same period is 18.8 percent, that is, the share of private cars among all autos has steadily increased.

The rapid increase of automobiles is the main reason for traffic congestion. As discussed earlier, the main cause of the rapid increase in automobiles is the increase in private car ownership. And deteriorating traffic congestion results in a fatal decrease in bus commercial speed and an increase in operating speed.

The fast increase in private car ownership is largely attributable to rising income and partly to the government's policy of encouraging domestic car use. The following regression equation shows that each percent increase of real per capita income(Y) leads to an increase in the per capita private car ownership(CAR) by 2.5 percent (t-statistics are shown in parentheses).

$$\ln(CAR) = -40.7 + 2.5*\ln(Y)$$
$$(-27.0) \quad (24.7)$$

The gasoline price, which is the main item in the private car operating cost, can affect car ownership and use. That is, the increases in gasoline price can discourage one from owning or using a private car by increasing car operating cost. In fact, real gasoline price per liter increased by a 15.0 percent annual rate during 1971-83, but since 1983 it has decreased by a 8.5 percent annual rate. The decrease in gasoline price can encourage the use of private cars.

3. Model and the Data

What are the causes of bus transit ridership change? And what are the causes of bus ridership decline since 1983? The answers for this question can be obtained from the statistical analysis with a multiple regression model. The model used in this analysis is based on the following basic functional form:

$$R = a + b_1B + b_2X + b_3C$$

where R is the per capita annual number of passenger boardings, B is the bus fares and services(bus-km, bus commercial speed, headway, punctuality, comfort, and etc.), the X is the demographic and income variables, the C is the variables which are related to competition with other modes, the a is the constant, and the b's are the estimated coefficients.

The period of this statistical analysis is between 1971 and 1996 when it is possible to get consistent data about bus ridership, fare, service, etc. The dependent variable is the per capita bus ridership which can isolate the effects of population growth.

The factors which determine the per capita bus ridership are categorized into three groups. The first one is the group of variables which are directly related to bus ridership, that is, bus fares and services. Bus fares are measured by real city-bus fares(in 1990 constant price) while bus services are measured by bus-km or bus commercial speed offered, whose data are available. The data of bus-km are calculated with average operating distance per bus-day and the number of buses.

Five equations are estimated for the purpose of this paper. All equations include the bus fare and bus service(bus-km) which are directly related to the bus ridership. Models 1-3 have demographic and income variable, and gasoline price. Model 4 is set by substituting subway service variable(subway train-km) for income variable. Model 5 has speed variable(bus speed). By adding the variable bus commercial speed we can analyze the effects of deteriorating traffic congestion on bus ridership(model 5). But there are missing data in bus commercial speed, so those are estimated by interpolation method by assuming that the annual growth rates are equal between the years the data are missing.[4]

Other factors of per capita bus ridership are demographic and income variables(models 1-3). Income is measured by per capita real gross regional domestic product in 1990 constant price.

By substituting per capita private car ownership for income, the effects of the changes in car ownership and use can be analyzed(model 2). Actually, since the income changes are closely related to car ownership, simply adding the car ownership variable results in the multicolinearity problem. Other demographic variables are employment and suburbanization. But adding the employment variable to the model did not give plausible results. Suburbanization is measured by the ratio of the population of CBD(Central Business District: Chongro-Gu and Jung-Gu) for that of Seoul.

It will be useful for the model to include the cost and service quality offered by buses' principal competitors, the subway and the auto. Data on the train-km of the subway are available. Adding the train-km variable enables us to analyze the effects of rising subway service on bus ridership(model 4).

Gasoline prices are believed to be an important factor for auto use. Increases in real gasoline price would increase the relative cost of auto use, thus encourage auto users to shift

4. The years the data are missing are the years between 1971 and 1980, and 1982, 1983, 1984, 1986, and 1987.

to public transit such as bus and subway. The gasoline prices are measured by real price per liter in 1990 constant price.

In statistical analysis, all regression equations are log-log functions, where both dependent and independent variables are transformed into natural logarithms. So the coefficients estimated can be interpreted as constant elasticities. Serial correlation could be adequately alleviated with first-order auto regressive estimation.

Actually, the five models estimated presented the most plausible results. The results of the statistical analyses of these five models are quite reasonable and consistent with similar models estimated for other cities.[5]

4. Causes of Bus Ridership Change

Table 2 shows the estimated coefficients of the five models. The coefficients can be interpreted as constant elasticity because of the log-log functional form of the equations. All estimated coefficients are statistically significant from zero in 5 percent significance level.

For convenience of explanation, I divided the analysis into two periods, Period 1 (1971-1983) in which the per capita bus ridership was rising and Period 2 (1983-1996) in which it was declining. And also the whole analyzing period during 1971-1996 will be called as the Whole Period.

4.1. Effects of Fare and Services

4.1.1. Fare

Each percentage increase in the real bus fare is predicted to reduce the per capita bus ridership by 0.25 percent to 0.32 percent. It is the third most strongly associated variable with per capita bus ridership. The effects of fares on per capita bus ridership that a 146.4 percent increase in real fares in the Whole Period would have decreased per capita bus ridership by 20.2 percent to 25.1 percent.

During Period 1, the real fare increased by only 37.9 percent reduced per capita bus ridership by only 7.7 percent to 9.8 percent. Actual real bus fare during Period 2 increased by 78.6 percent, and this increase resulted in the reduction of per capita bus ridership by 13.5 percent to 16.9 percent.

4.1.2. Services

The increase of one percent in bus service mileage appears to have increased per capita ridership by 0.25 percent to 0.48 percent, which would imply that the 85.3 percent increase in bus mileage during the Whole Period increased per capita bus ridership by only 16.7 percent to 22.6 percent. This estimate assumes that the mileage increase during the period stimulated the ridership increase and not vice versa. This assumption is plausible because the government regulated even the bus mileage by regulating the number of buses, the routes, the allocation of buses, etc.

During Period 1, the actual bus mileage increased by 163.1 percent, so it is estimated to increase per capita bus ridership by 27.4 percent to 45.0 percent. But in Period 2, the 29.6

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5. There are similar studies in other cities, for instance, John F. Kain, "Cost Effective Alternatives to Atlanta's Costly Rail Rapid Transit System, " and Zhi Liu(1993), Jose A. Gomez-Ibanez et al.(1994).

percent actual decline in bus mileage largely because of deteriorating road congestion reduced the per capita ridership by 8.4 percent to 15.5 percent.

The decline in bus commercial speed reflected well the deteriorating road congestion. By the estimates, each decrease in bus commercial speed reduced per capita bus ridership by 0.51 percent. This estimate is the most strongly associated variable with per capita bus ridership. During Period 1, the actual bus commercial speed reduction by 20.1 percent decreased the per capita bus ridership by 10.6 percent. The 16.5 percent decline in bus speed during Period 2 decreased the per capita ridership by 8.6 percent.

4.1.3. Combined Effects of Fares and Services

During Period 1, the per capita ridership changes resulting from fare and service changes increased by 11.1 percent to 32.8 percent. The increase in per capita bus ridership through the improvement of bus service was bigger than the decline caused by real bus fare increase. But in Period 2, the combined effects are the decrease of per capita bus ridership by 22.1 percent to 32.4 percent. That is to say, in Period 2, both the bus mileage and real bus fare had adverse effects on per capita bus ridership.

Table 2. Estimates of Regression Models for Seoul's Per Capita Bus Transit Ridership Change

Independent Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	2.97 (2.57)	-0.76 (-0.41)	-0.29 (-0.17)	-1.89 (-1.02)	-1.97 (-0.99)
Bus fares and services					
Real city-bus fare (log)	-0.28 (-3.80)	-0.27 (-3.54)	-0.25 (-3.30)	-0.32 (-5.55)	-0.32 (-5.19)
Bus-km (log)	0.25 (2.93)	0.32 (3.22)	0.33 (3.35)	0.48 (3.72)	0.33 (3.45)
Bus commercial speed (log)					0.50 (3.31)
Demographic and Income					
Per capita real income (log)	-0.15 (-2.89)				
Per capita private car ownership(log)		-0.08 (-2.95)			
Suburbanization(log)			0.27 (3.08)		
Competition with other modes					
Subway service: train-km(log)				-0.08 (-3.18)	
Real gasoline price(log)	0.16 (3.77)	0.14 (2.83)	0.16 (3.75)	0.12 (2.00)	0.14 (3.30)
Adjusted R-squared	0.93	0.93	0.93	0.94	0.93
RHO	0.11	0.10	0.08	-0.04	0.07
D-W Statistic	1.99	1.93	1.95	2.04	1.92

(t-statistics are listed in parentheses)

4.2. Effects of Demographic and Income Variables

4.2.1. Income Growth and Suburbanization

Income growth affects per capita ridership adversely as a whole. Each percentage increase in real per capita income is predicted to reduce per capita bus ridership by 0.15 percent annual rate. This elasticity is not big compared with other cities.

Since real per capita income grew by 521.3 percent during the Whole Period(1971-1996), per capita bus ridership would have dropped by 24.0 percent during the same period from the effects of income growth alone. Relatively large per capita ridership loss attributable to income growth occurred in Period 2(1983-96).

In Model 3, which includes suburbanization instead of income, per capita bus ridership is estimated to decline by 0.27 percent per year due to the effect of each percent suburbanization. This elasticity implied a per capita bus ridership loss of 28.0 percent during the Whole Period, 16.8 percent loss in Period 1, and 13.4 percent loss during Period 2.

4.2.2. Auto Ownership

The elasticity of per capita bus ridership for per capita private car ownership is estimated at -0.08, which means that when the per capita private car ownership increases by 1 percent, the per capita bus ridership declines by 0.08 percent. So the actual 4,075.0 percent increase in per capita private car ownership during the Whole Period implies that the per capita bus ridership declines by 25.8 percent during the same period. In Period 1, the actual increase in per capita private car ownership by 395.5 percent is estimated to imply a ridership loss of 12.0 percent, and during Period 2, the 742.6 percent growth of per capita car ownership means the decline of bus ridership by 15.7 percent.

4.2.3. Combined Effects of Demographic and Income Variables

Over the period of 1971 to 1996, the combined effects of demographic and income changes reduced per capita bus ridership by 24.0 percent to 28.0 percent. This means that demographic and income changes which government and bus companies can not control reduced the per capita bus ridership by those percent. Actually the magnitude of those effects to bus ridership was relatively big in the effects of three categorized groups of factors. That is to say, the government or bus companies can not control relatively big part of per capita ridership change. For Period 1 and Period 2, the portion which the government can not control is relatively big, either.

These results imply that it may be very difficult for the bus companies to sustain their ridership in the future even if they reduce fares and expand services.

4.3. Effects of the Competition with Subway and Auto

4.3.1. Subway

The estimates show that one percent increase of subway service(subway train-km) reduces the per capita bus ridership by 0.08 percent. During the Whole Period(1971-96), the 6,882.4 percent growth of subway train-km resulted in the reduction of per capita bus ridership by 28.8 percent. In Period 1, the per capita bus ridership declined by 19.0 percent due to the effects of 1,294.9 percent growth in train-km. During Period 2, the actual subway train-km increased by 400.6 percent and this implies the decline of per capita bus ridership by 12.1 percent.

The sensitivity of per capita bus ridership to subway train-km is small, but the actual effects of subway train-km growth on the per capita bus ridership is quite big simply because the actual increase in subway train-km was very big. This means that the government's public transportation policy which relied on new subway construction attracted bus riders.

The amount of subway service' adverse effect to bus ridership will be larger and larger as the subway service increase with the second and third phase subway project completion.

4.3.2. Automobile Operating Cost

Each percent increase in real gasoline price which is an important factor in auto use, is estimated to increase the per capita bus ridership by encouraging auto users to shift to buses by 0.12 percent to 0.16 percent. This elasticity implied that the actual increase in real gasoline price by 67.3 percent during the Whole Period(1971-96) is estimated to increase the per capita bus ridership by 6.4 percent to 8.6 percent during the same period. During Period 1, the real gasoline price increased by 432.7 percent largely because of the Oil Shock. This increase result in the increase of the per capita bus ridership by 22.2 percent to 30.7 percent. But during Period 2(1983-96), the gasoline price declined by 68.6 percent. This means the decline of per capita bus ridership by 13.0 percent to 16.9 percent.

In Period 1, the huge increase in real gasoline price restricted auto use and encouraged bus use. But the decrease in real gasoline price in Period 2(1983-96) encouraged the bus users to shift to auto use.

The favorable effects of gasoline price increase to bus ridership support that the high gasoline price policy such as fuel tax can increase the bus ridership.

4.3.3. Effects of Competition

In Period 1, bus ridership decline by construction of new subway lines was offset by the real gasoline price increase. In particular, during Period 2(1983-96), the decline of real gasoline price encouraged the decrease of per capita bus ridership by subway service improvement. The combined effects of subway service improvement and real gasoline price decline were large. That is to say, the big part of per capita bus ridership decline in Period 2(1983-96) was due to the competition with subway and autos.

Table 3. Etimated Sources of Seoul's Per Capita Bus Transit Ridership Change: 1971-1996

Variables	Percent change	Estimated percentage ridership response				
		Model 1	Model 2	Model 3	Model 4	Model 5
1971-1996						
Total per capita bus ridership change	-20.7	-25.2	-23.9	-23.5	-23.7	-19.0
Bus fares and services		-9.4	-4.5	-2.2	0.7	-25.0
Real city-bus fare	+146.4	-22.3	-21.6	-20.2	-25.1	-25.1
Bus-km	+85.3	+16.7	+21.8	+22.6	+34.5	+22.6
Bus commercial speed	-33.3					-18.3
Demographic and Income		-24.0	-25.8	-28.0		
Per capita real income	+521.3	-24.0				
Per capita car ownership	+4075.0		-25.8			
Suburbanization	-70.3			-28.0		
Competition with other mode		+8.6	+7.5	+8.6	-24.3	+8.0
Subway train-km	+6882.4				-28.8	
Real gasoline price	+67.3	+8.6	+7.5	+8.6	+6.4	+8.0
1971-1983						
Total bus ridership change	+64.8	+33.6	+38.9	+38.1	+42.1	+42.6
Bus fares and services		+16.4	+24.9	+27.0	+43.5	+11.0
Real city-bus fare	+37.9	-8.6	-8.3	-7.7	-9.8	-9.8
Bus-km	+163.1	+27.4	+36.3	+37.6	+59.1	+37.6
Bus commercial speed	-20.1					-10.6
Demographic and Income		-12.1	-12.0	-16.8		
Per capita real income	+137.0	-12.1				
Per capita car ownership	+395.5		-12.0			
Suburbanization	-49.4			-16.8		
Competition with other mode		+30.7	+26.4	+30.7	-1.0	+28.5
Subway train-km	+1294.9				-19.0	
Real gasoline price	+432.7	+30.7	+26.4	+30.7	+22.2	+28.5
1983-1996						
Total bus ridership change	-51.9	-44.0	-45.2	-44.6	-46.3	-43.2
Bus fares and services		-22.1	-23.6	-23.0	-29.8	-32.4
Real city-bus fare	+78.6	-15.0	-14.5	-13.5	-16.9	-16.9
Bus-km	-29.6	-8.4	-10.6	-10.9	-15.5	-10.9
Bus commercial speed	-16.5					-8.6
Demographic and Income		-13.5	-15.7	-13.4		
Per capita real income	+162.2	-13.5				
Per capita car ownership	+742.6		-15.7			
Suburbanization	-41.4			-13.4		
Competition with other mode		-16.9	-15.0	-16.9	-23.5	-15.9
Subway train-km	+400.6				-12.1	
Real gasoline price	-68.6	-16.9	-15.0	-16.9	-13.0	-15.9

Notes: Combined effects of several variables are not the sum of the individual effects since the equations are log-log functions.

5. Implications and Conclusion

This paper has examined the causes of per capita bus transit ridership for the period of 1971-96. Using time series data, this paper provides the estimates of multiple regression models to separate out the effects of demographic and income variables and competition with subway and autos from those of bus fares and services.

Several results are worth emphasizing. First, bus ridership is the most sensitive to bus fares and services, but the actual effects of bus fares and services are relatively small largely because the actual amount of change in the variables such as income, subway service and auto operating cost was large.

Second, the increase in bus ridership in the 1970's was largely due to bus service expansion, and rising gasoline price offset the decrease effects of income growth, subway service expansion and real bus fare increase. But after 1983, all variables adversely affected the bus ridership.

Third, the reversal of bus transit ridership declines during 1983-96 is largely attributable to income growth, competition with subway and autos, and the increase in real bus fare. The degree of effects is almost equal.

Fourth, the effects of demographic and income changes beyond the government or bus companies' control are relatively large. This means that it may be very difficult for the bus companies to sustain or recover their ridership even if there is a corrective policy.

Fifth, the policy alternatives to sustain bus ridership can be gasoline price increase through policy such as fuel tax, which can discourage auto use and encourage transit use. Of course, in the present situation, with the low quality of bus service including lower speed, this may encourage subway use. So it is more efficient to implement a supporting policy which can improve the buses' commercial speed. In fact, the implementation of exclusive bus lanes showed good results. According to the estimation results, the bus ridership is estimated to increase greatly as the bus speed increases. But it is said that the exclusive bus lanes become nearly impossible to enforce when road traffic congestion becomes very serious. So in the long run, the introduction of congestion pricing[6] will be a good and efficient policy tool.

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