Public transportation Service Monitoring Using Transit Card System and User Satisfaction Assessment Using On-line Survey in Korea

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Abstract: Public Transportation Investigation aims to develop and manage public transport data in a systematic and effective manner, which can be a reference for local governments and related organizations to establish their public transport related plans. With new approaches adopted in 2012 investigation, the results were reliably improved and offered various findings compared to those in 2011. In this paper, the results of indicators or items representing the characteristics of the public transport through transit card data and on-line survey are shown and the specific causes are interpreted. Finally, suggestion for policy-making of the available level on the government and municipalities are also made.

Keywords: Public Transportation Investigation, Transit Card Data, On-line Survey, public transportation indicators

1. INTRODUCTION

Public Transportation Investigation has been carried out throughout the nationwide every year since 2006 by article sixteen of 「Act on the Support and Promotion of Utilization of Mass Transit System」 & article 4 of Enforcement Rule. Public Transportation Investigation aims to develop and manage public transport data in a systematic and effective manner, which can be a reference for local governments and related organizations to establish their public transport related plans. Its survey range can be classified into 5 division, 9 indicators, 13 items and 37 detailed investigations and the methodologies are divided into literature survey, observational research, interview survey and mailing survey by the detailed investigations. Specific details are given in Table 1. Also, in table 2, the investigation tried to improve the reliability and objectivity of the results by expanding from 68 local governments, 578 bus lines, 14,380 face to face samples in 2008 to 106 local governments, 1,764 bus lines and 69,000 on/off line interview samples in 2012.

Unlike so far in 2011, the 2012 investigation was used the transit card data and employed the on-line survey, thereby the results were reliably improved and the various findings can be offered.

This project is to produce the results of indicators or items which can represent the characteristics of the public transportation through transit card data and on-line survey, to interpret the specific cause, and to suggest policy-making of the available level on the government and municipalities. And also, this paper suggests the mandatory requirement for the long-term development.

Our paper is organized as follows; Section 2 reviews domestic traffic survey projects and compare the methodologies improvement for the Public Transportation Investigation in 2011 & 2012. In section 3, we figure out the results, interpretation and suggest policy-making of the available level. Finally, Conclusions and further improvement needs are in section 4.

Table 1. Public Transportation Investigation provision

Divisions	Indicators	Items	Detailed investigations
1. Socioeconomic index related to public transportation	Socioeconomic indicators	a. Outlier	- Population -Car registration -Accident related to transit -Area -GDP -Road coverage index -Railway overview
2. Management condition for owner	Operation indicators	a. Transit owner outlier	-Transit owner(intercity bus, intra-city bus, subway) general status quo
		b. Transit owner operation	-Travel distance per mode-year, Stops per line, Bus ownership, Headway per line-day, Driving distance, Density etc.
	Financial indicators	a. Transit owner management	-Management status quo -income, expenditure, operation cost, central financial aid, etc.
3. Transit mode and facility	Supply indicators	a. Transit mode	-Transit fare system -Transit mode status by regional group -Transit operation status by regional group -Special transportation service offering status -non-profit bus line operation
		b. Transit facilities	-Transit stops by regional group -Exclusive bus line operation -BIS/BMS operation -Garage installation status(, area) -Transit Mall installation & planning -Advanced transit system(BRT) operation & planning
4. Transit utility condition	Passengers traffic indicators	a. Transit sharing rate	-Transit volume by mode -Transit sharing rate
	Utility rate indicators	a. Transit utility rate	-Transit utility status(frequency, distance) -Transit expenditure -The number of boarding/alighting by line, stop -Transit card system and status etc.
		b. Transit vs. passenger car comparison	-Bus vs. Passenger car travel time & cost survey by regional group
	Mobility indicators	a. Transit transfer	-Transfer facilities -Transfer actual condition(type, number etc.) -Transfer ratio etc.
5. Etc.	Transportation welfare indicators	a. Public Transportation customer satisfaction	- Public Transportation customer satisfaction by mode - Public Transportation customer satisfaction by facility
	Green transportation & safety indicators	a. Traffic Accident b. Greenhouse gas emission	-Public transportation accident by regional group, line - Bus greenhouse gas emission -Transit mode & facility foreign countries

Table 2. Comparison on the spatial range for 2011 and 2012

Division		Seoul	Bu-san	Dae-gu	In-cheon	Gwang-ju	Dae-jeon	Ul-san	Gyeong-gi	Chung-buk	Chung-nam	Jeon-buk	Jeon-nam	Gyeong-buk	Gyeong-nam	Gang-won	Jeju	Total
Total	City	1	1	1	1	1	1	1	27	3	8	6	5	10	8	7	2	83
	Country	-	-	-	-	-	-	-	4	9	8	8	17	13	10	11	-	80
	Subsum	1	1	1	1	1	1	1	31	12	16	14	22	23	18	18	2	163
Subject	'11 City	1	1	1	1	1	1	1	24	2	5	5	5	9	7	4	1	69
	'11 Country	-	-	-	-	-	-	-	3	2	3	1	5	3	4	2	-	23
	'11 Subsum	1	1	1	1	1	1	1	27	4	8	6	10	12	11	6	1	92
	'12 City	1	1	1	1	1	1	1	27	3	8	6	5	10	8	7	2	83
	'12 Country	-	-	-	-	-	-	-	3	2	3	1	5	3	4	2	-	23
	'12 Subsum	1	1	1	1	1	1	1	30	5	11	7	10	13	12	9	2	106

2. NATIONWIDE TRAFFIC SURVEY PROJECTS IN KOREA

Nationwide traffic survey projects are parts of National Transportation Survey by 「National Transport System Efficiency Act」, Public Transportation Investigation by 「Act on the Support and Promotion of Utilization of Mass Transit System」, Road Traffic Survey by「Road act」, Urban Transportation Investigation by 「Urban Traffic Readjustment Promotion Act」

2.1 Domestic traffic survey projects Outlier

National Transportation Survey monitors operational service, service volume, travel behavior, transportation networks of roads, rail, port, freight and other transport-related services. Items in survey can be categorized into (1) Transportation-related statistics such as land use, socioeconomic, facilities, (2) Basic Transportation data such as personal origin-destination trip tables, Trip tables by mode, trip rate of various facilities (3) transportation network for analysis and GIS map (4) Report of National Transportation Survey and Guideline of Traffic Survey.

Data from the project can be utilized to develop effective and reliable transportation policies and to assess and evaluation transportation facilities proposed and planned. The data is more reliable and more attractive from user perspective because it provides time-series data and standardizes the various transportation related data. It also offers the reliable data coupled with GIS map and readily usable for Transportation simulation models.

Public transportation investigation by Act on the Support and Promotion of Utilization of Mass Transit System is conducted nationwide every year since 2006, the aim of which is the provision of standardized and basic dataset to various users. Policy makers and analysts can use it when they establish transportation-related policies for more efficient and attractive public transportation system.

Road traffic survey conducted every year since 1955 purports to provide basic data for design and plan of new roads and road expansion in which traffic volume and speed is summarized annually by types of road, vehicles, time. Korea Expressway Corporation surveys expressways, Korea Institute of Construction Technology does National highway, province roads and local road, municipal authority collects other classified road, respectively.

Urban transportation investigations for Seoul and six Metropolitan cities should be conducted by Urban Traffic Readjustment Promotion Act. In the investigation, traffic volume,

speed, household travel survey, city logistic and freight survey are collected by types of vehicle, direction, time on principal arterials and city expressways.

2.2 Public Transportation Investigation methodologies In 2012

Public Transportation Investigation in 2012 adopts various survey methods: (1) Literature and mail-back surveys for general statistics for present transportation systems, (2) transit card data for transit usage status, (3) On-line survey for user satisfaction survey. Since (1) is same as previous year, (2) and (3) are briefly compared to methods in 2011 in table 3.

Table 3. Comparison on the investigation method in 2011 and 2012

| Division	2012 year	2011 year
Range	Local government : 106 Transit line : 1,764	Local government : 92 Transit line : 1,542
Transit utility & operation condition	Transit card data (Weekday, Weekend, Rain day, Snowfall)	Observation survey (Weekday sampling)
Bus vs. car travel time & cost survey	Travel time & cost for bus, car, portal-site	N/A
Urban train Boarding & alighting time survey	Subway site: 111/744 (14.9%) Fixed : a heavily populated area (transfer site, stairway) - Maximum user	Subway site: 73/ 727(10%) Rotation : from first carriage to next - Average user
Public transportation customer satisfaction	Total sample : 69,000 On-line: 49,000(71%), Off-line: 20,000 (29%)	Total sample : 34,500 Off-line survey overall
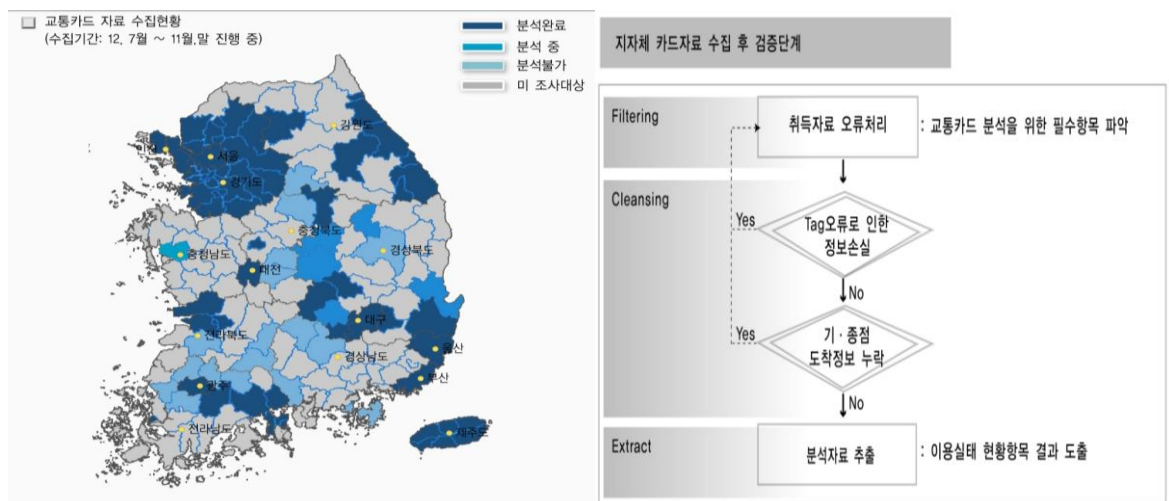
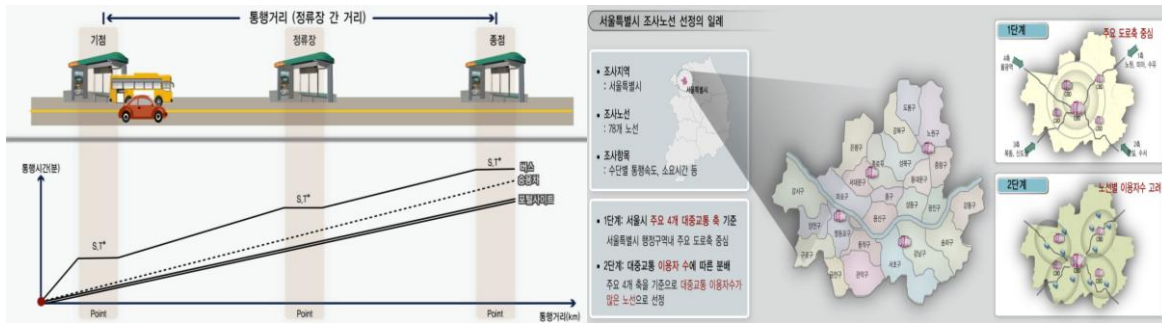Figure 1. Transit card data collection & Procedure of datum analysis

Figure 2. Concept of bus vs. car travel time & cost survey method

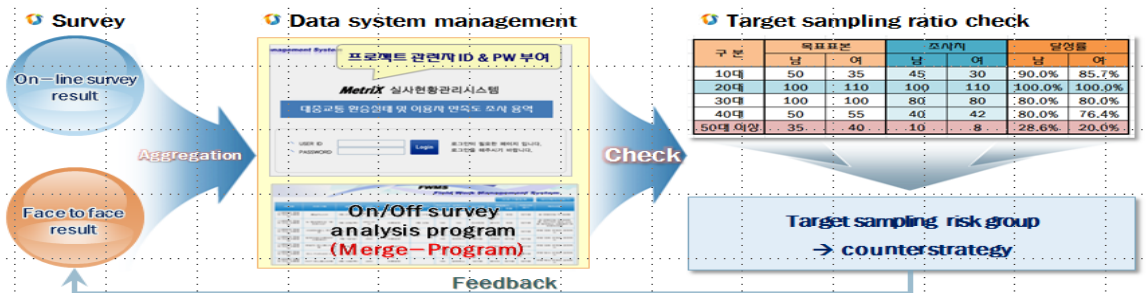Figure 3. Concept of urban train boarding & alighting time survey method

Figure 4. Concept of public transportation customer satisfaction survey method

3. Survey Results and Interpretation

3.1 Number of Bus Trips

1,764 bus lines are selected to collect data and travel characteristics are shown for weekday, weekend, rainy and snowy days by sixteen metropolitan cities and provinces. For weekdays, Seoul has 31.18% and Gyeonggi Province has 26.37%, respectively. While number of bus trips during Weekends is about 62.31% of those during Weekdays, Gyeonggi province shows 93.07% because many commuters from Gyeonggi province to Seoul have leisure trips during weekend. In addition, rain and snow do not effect significantly on bus ridership because over 90% bus ridership of normal days are shown under rain and snow conditions. However, cities having metro-lines such as in Busan, Daegu, Gwangju, and Daejeon has relatively lower bus patrons because many bus users can shift their mode to metro for their safety and punctuality.

Table 4. Number of bus trips by regional group & days

Division	Weekday		Weekend		Rain day		Snow fall		Average	
	trip	Ratio (%)	Trip	Ratio (%)	trip	Ratio (%)	trip	Ratio (%)	trip	Ratio (%)
Seoul	1,888,634	31.18	900,635	23.86	1,708,662	30.33	1,715,326	30.97	1,553,314	29.58
Busan	803,327	13.26	449,403	11.91	692,218	12.29	578,172	10.44	630,780	12.01
Daegu	343,634	5.67	196,437	5.20	331,657	5.89	275,929	4.98	286,914	5.46
Incheon	342,615	5.66	169,566	4.49	319,385	5.67	302,254	5.46	283,455	5.40
Gwangju	60,909	1.01	34,541	0.92	57,307	1.02	11,210	0.20	40,992	0.78
Daejeon	77,225	1.27	39,754	1.05	69,013	1.23	60,859	1.10	61,713	1.18
Ulsan	196,544	3.24	105,528	2.80	178,704	3.17	173,446	3.13	163,556	3.11
Gyeonggi	1,597,687	26.37	1,487,029	39.40	1,609,044	28.56	1,827,184	32.99	1,630,236	31.05
Chungbuk	108,024	1.78	51,763	1.37	100,853	1.79	80,450	1.45	85,273	1.62
Chungnam	30,715	0.51	12,579	0.33	27,479	0.49	16,797	0.30	21,893	0.42
Jeonbuk	47,136	0.78	20,315	0.54	43,488	0.77	35,070	0.63	36,502	0.70
Jeonnam	82,357	1.36	44,727	1.19	72,030	1.28	69,991	1.26	67,276	1.28
Gyeongbuk	99,493	1.64	55,453	1.47	82,864	1.47	72,055	1.30	77,466	1.48
Gyeongnam	241,545	3.99	139,714	3.70	218,696	3.88	222,045	4.01	205,500	3.91
Gangwon	77,565	1.28	36,150	0.96	67,868	1.20	54,421	0.98	59,001	1.12
Jeju	60,181	0.99	30,688	0.81	53,805	0.96	42,828	0.77	46,876	0.89
Sum	6,057,591	-	3,774,282	-	5,633,073	-	5,538,037	-	5,250,747	-
Average	378,599		235,893		352,067		346,127		-	

Skewness of number of users and lines can provide the meaningful interpretation as shown in Figure 5, 6, and 7. Asymmetry to upper-right (negative skewness) shows bus lines making a good profit with large number of patrons, positive skewness depicts deficit lines, and convex type curve shows disequilibrium between bus lines in terms of profit.
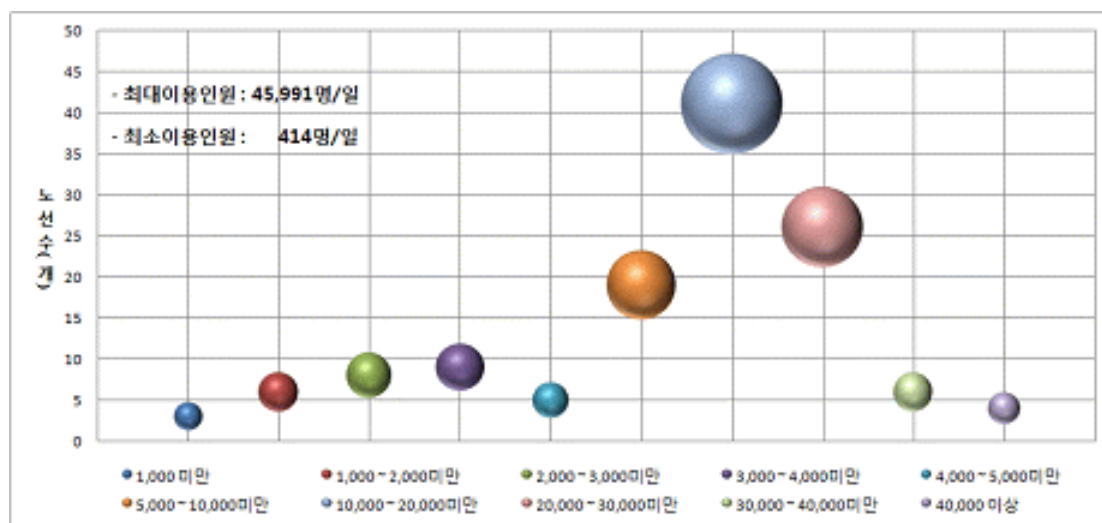

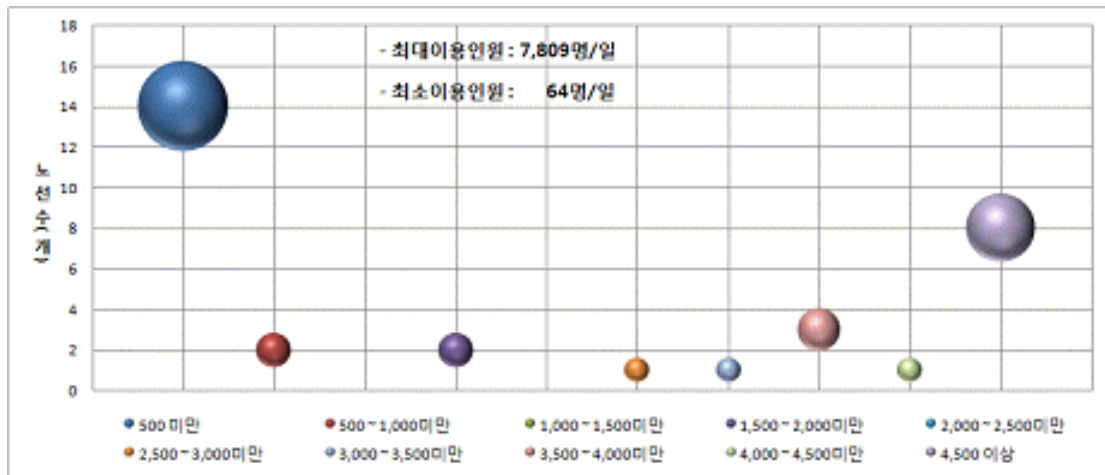Figure 5. Negatively skewed distribution such as Seoul and so on.

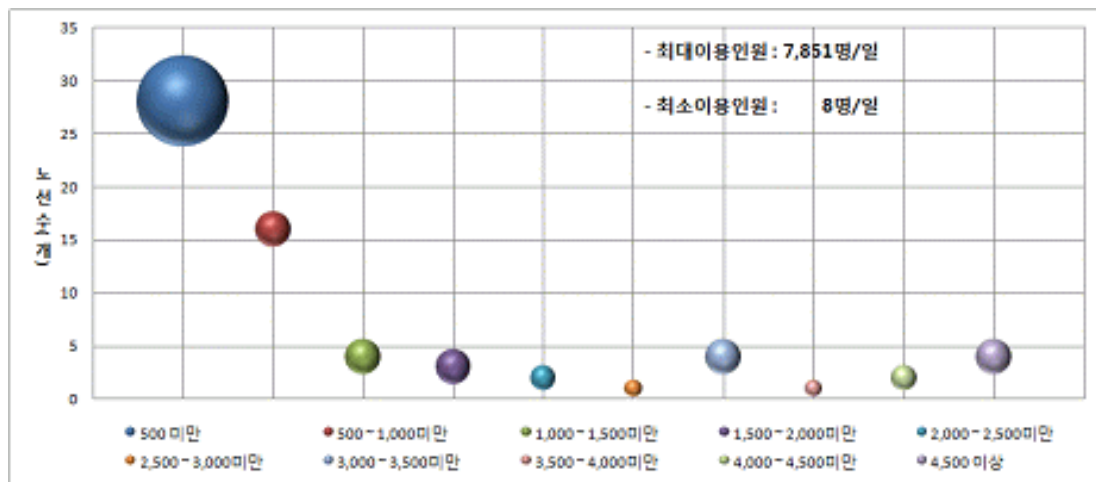Figure 6. Convex function type curve such as Daejeon and so on.

Figure 7. Positively skewed distribution such as Jeonnam and so on.

3.2 Bus transfer

Times and rate of bus transfer shows 26% and 1,514,154 respectively, which means one of four persons having experienced bus transfer. Interestingly, data for Seoul depicts 33.29% and 630,631, which are the highest rate and frequency. Capital Metropolitan area has 30.56% and 1,170,276 above average of nationwide due to Public transportation integrated discount fare system.
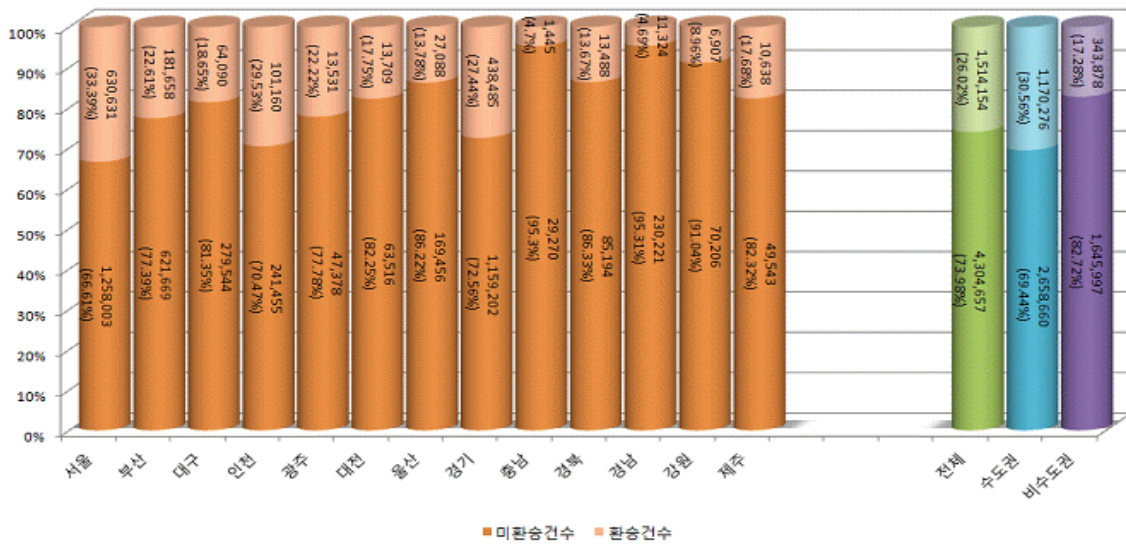
Figure 8. Results of the bus transfer/non-transfers

- Exclusion of several areas such as Chonnam and Gyungbuk due to lack of data

The number of transfer and rate of a linked trip is 1,245,070 and 82.23% for only one transfer, 15.59% for two transfers, 2.18% for more than three transfers, respectively. Hence, one and two transfers occupy about 97.8% of total trips and more than three transfers is relatively rare as shown in Figure 9.
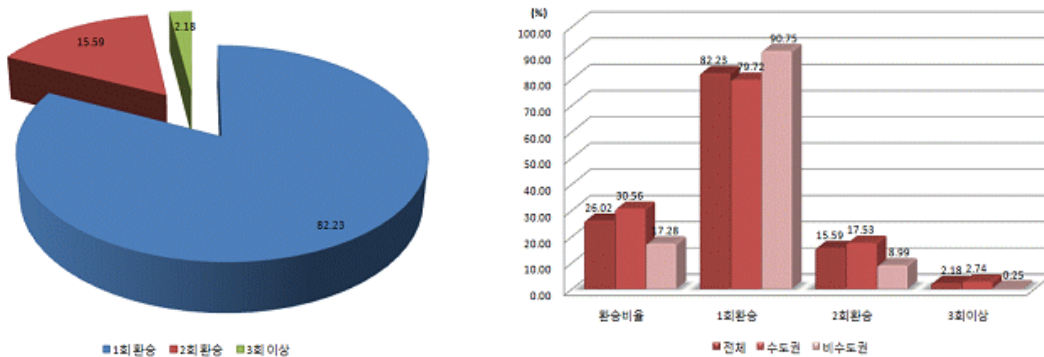

Figure 9. The number and rate of transfer

3.3 Bus fare

Average weekday bus fare per trip is ₩705 for Seoul, ₩1,087 for Chungbuk (the highest fare), and ₩591 for Busan (the lowest fare), respectively. Compared to Weekday fare, average weekend bus fare per trip is higher because more leisure trips are made during weekend, which have different trip characteristics such length, time, and destinations. The data to be interpreted is shown in Table 5.

Table 5. Average transit fare per trip by regional group

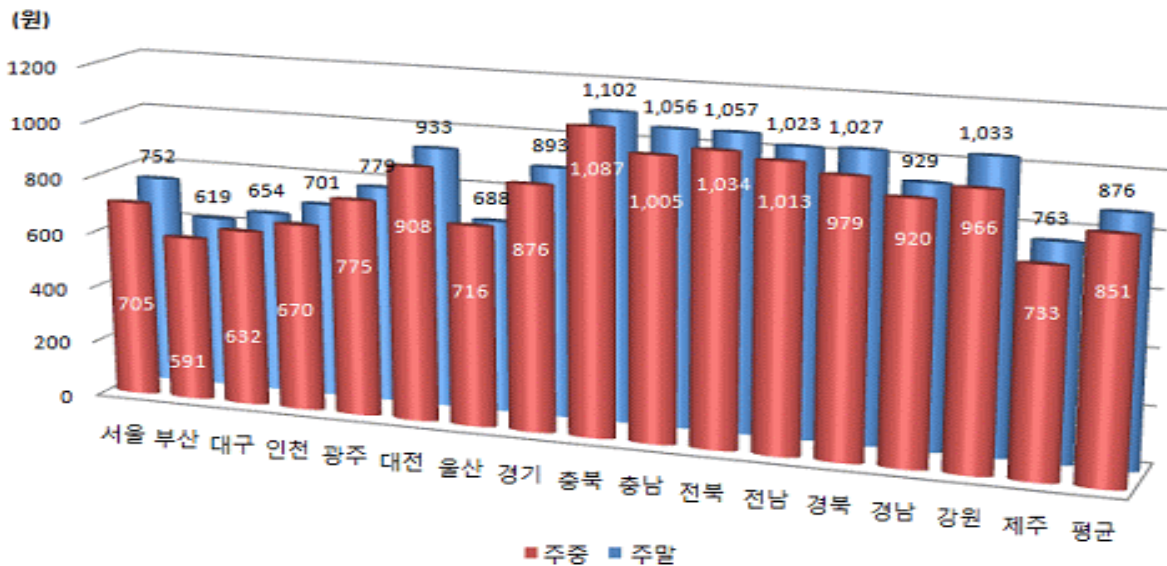| Division		Average fare per trip(₩)	
		Weekday	Weekend
Metropolitan city	Seoul	705	752
Megalopolis	Busan	591	619
	Daegu	632	654
	Incheon	670	701
	Gwangju	775	779
	Daejeon	908	933
	Ulsan	716	688
Province	Gyeonggi	876	893
	Chungbuk	1,087	1,102
	Chungnam	1,005	1,056
	Jeonbuk	1,034	1,057
	Jeonnam	1,013	1,023
	Gyeongbuk	979	1,027
	Gyeongnam	920	929
	Gangwon	966	1,033
	Jeju	733	763
Average		851	876

Figure 10. Average transit fare per trip by regional group

While with an integrated discount fare the annual average bus fare is about ₩530,520, without the fare system is ₩692,760, which is about reduction of ₩162,240 and 24.33%, respectively. Similarly, with and without discount fare are ₩320,200 and ₩519,140 for Seoul, respectively, which are the largest reduction rate in the country. The monetary saving is a part of welfare policies through the transportation system, which should be applied to every region over the country in near future coupled with other welfare policies.

Table 6. Results of cost saving for transfer

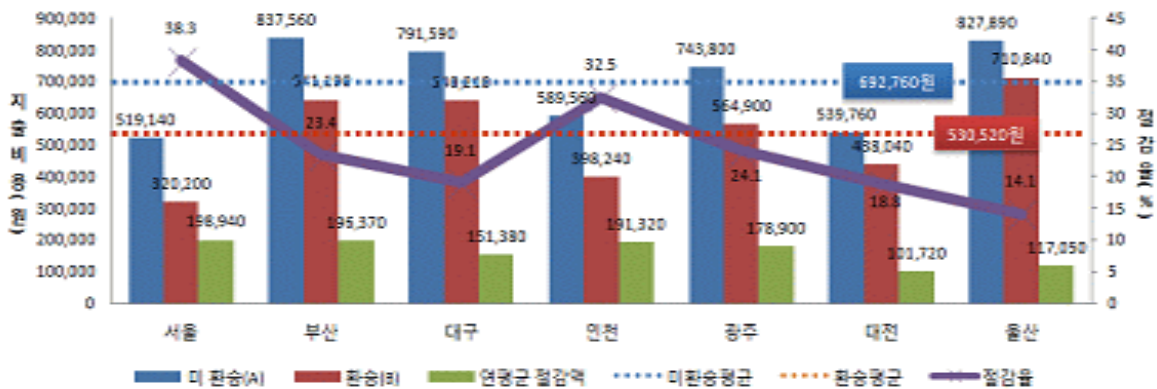| Division		Average annual bus fare(₩)		Annually cost saving (B-A)	Saving rate (%)
		Non-transfer(A)	Transfer(B)		
Metropolitan city	Seoul	519,138	320,202	198,936	38.3
Megalopolis	Busan	837,560	641,187	196,373	23.4
	Daegu	791,587	640,210	151,377	19.1
	Incheon	589,561	398,243	191,318	32.5
	Gwangju	743,803	564,901	178,902	24.1
	Daejeon	539,763	438,041	101,722	18.8
	Ulsan	827,885	710,839	117,046	14.1

Figure 11. Results of the cost saving for transfer

3.4 Comparison of Bus and Car service

Travel speeds of car and bus are compared for the selected 208 bus lines in this survey. Ratio to the travel speed of bus and car is 0.86. However, excepting for boarding and alighting time and clearance time for bus, the rate should be changed to 1.04, which indicates the higher travel speed of bus. The rate for Seoul is 1.39, which is the highest value and Busan, Incheon, Gwangju and Ulsan also show rates over one. Furthermore, travel cost of bus is much cheaper that car, which make user travel cost saving ranges of which are from 37% to 46%.
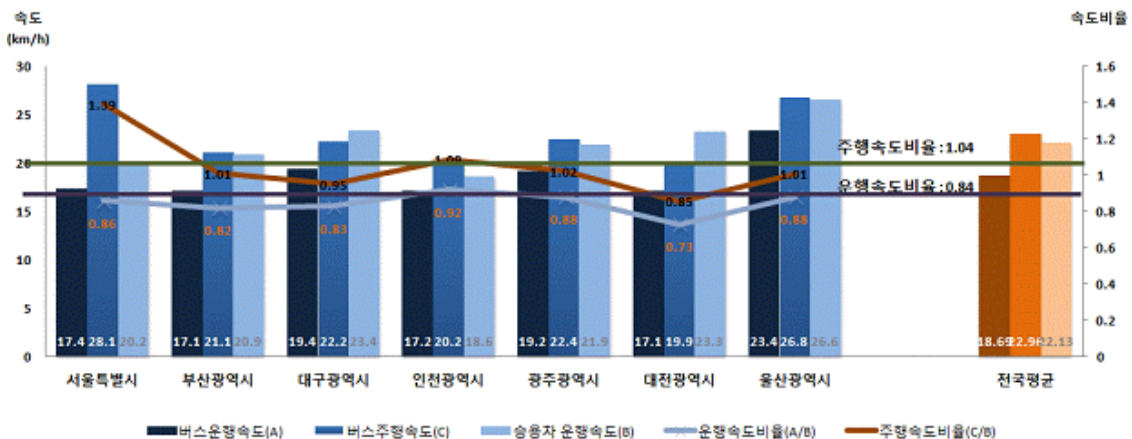

Figure 11. Results of bus vs. passenger car travel time & cost

Table 7. Results of bus vs. passenger car travel time & cost

Division	Bus		Passenger car	Ratio		Items(won)	Bus	Passenger car	Rate (%)
	Travel speed(A)	Operation speed(C)	Travel speed (B)	A/B	C/B				
Seoul	17.4	28.1	20.2	0.86	1.39	Travel Time	11,046	18,471	40.2
						Travel Cost	1,333	4,489	70.3
						Sum	12,379	22,960	46.1
Busan	17.1	21.1	20.9	0.82	1.01	Travel Time	12,154	18,936	35.8
						Travel Cost	1,238	3,996	69.0
						Sum	13,392	22,932	41.6
Daegu	19.4	22.2	23.4	0.83	0.95	Travel Time	17,626	28,032	37.1
						Travel Cost	2,043	6,656	69.3
						Sum	19,669	34,688	43.3
Incheon	17.2	20.2	18.6	0.92	1.09	Travel Time	10,688	17,912	40.3
						Travel Cost	1,218	4,268	71.5
						Sum	11,906	22,180	46.3
Gwangju	19.2	22.4	21.9	0.88	1.02	Travel Time	15,001	25,611	41.4
						Travel Cost	1,706	5,577	69.4
						Sum	16,707	31,188	46.4
Daejeon	17.1	19.9	23.3	0.73	0.85	Travel Time	12,597	17,943	29.8
						Travel Cost	1,371	4,376	68.7
						Sum	13,968	22,319	37.4
Ulsan	23.4	26.8	26.6	0.88	1.01	Travel Time	14,404	23,283	38.1
						Travel Cost	1,744	6,021	71.0
						Sum	16,148	29,304	44.9
Average	18.69	22.96	22.13	0.84	1.04	Travel Time	13,359	21,455	37.7
						Travel Cost	1,522	5,055	69.9
						Sum	14,881	26,510	43.9

3.5 Transit User satisfaction

Transit user satisfaction survey shows above 4.0 of 7.0 likert scores. User satisfaction is 4.76, satisfaction compared to expectation is 4.46 and satisfaction for transit facilities is 4.44, respectively. Generally, user satisfaction for transit service is fairly good and acceptable. In terms of user satisfaction, Seoul shows the highest score and Jeonbuk has the lowest value.
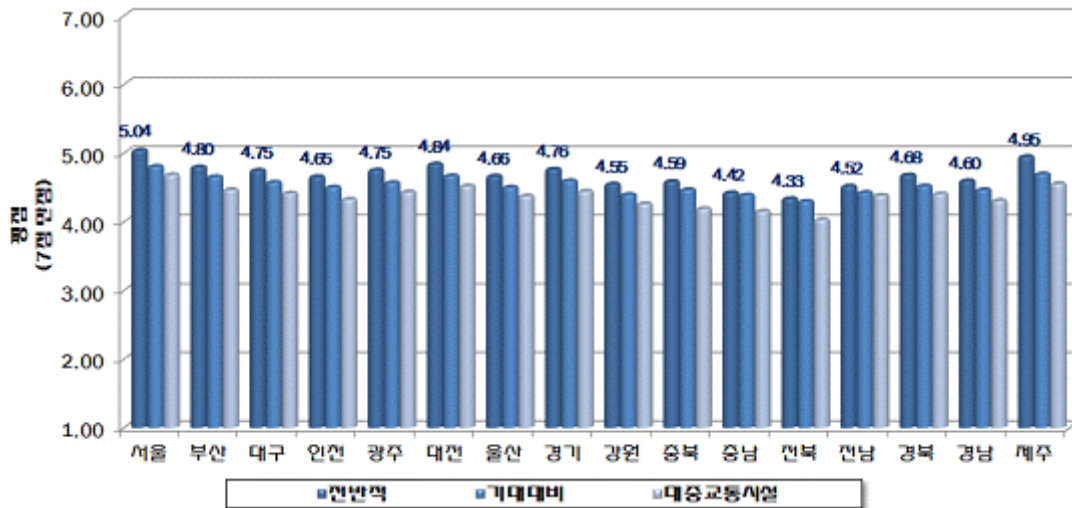
Figure 12. Results of the general satisfaction by regional group
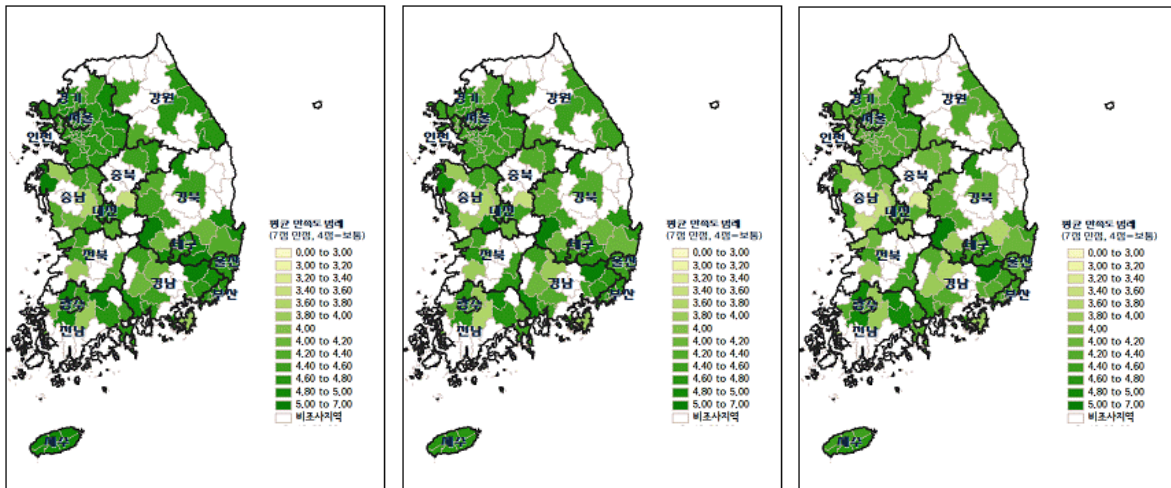

Figure 13. Results of overall confirm/disconfirm & transit facility satisfaction

4. Conclusions and further improvement needs

Public Transportation Investigation aims to develop and manage public transport data in a systematic and effective manner, and thereby providing them as reference for local governments and related organizations to establish their public transport basic plan. Whereas the presented findings were derived through observational research and field survey until 2011, the results were reliably improved and offered various findings by taking advantage of the transit card data and on-line survey in 2012.

Number of bus trips, transfer, fare, travel speed of bus and car, and user satisfaction are surveyed in this study. Based on the data, various interpretations can be made, which can be a milestone in establishing transit-related polices such as bus-exclusive lane, integrated discount system, bus information systems. However, several aspects should be taken into account and the problems should be tackled in next survey. (1) Different local authorities use

different Transit systems in term of acquisition, modification and provision. The difference should be understood clearly, (2) The province and local governments without transit card system should be dealt with fairly and equally in provision of the basic data set. (3) Collaboration of the different and various datasets should be achieved to have synergic effect.

REFERENCES

Ministry of Land, Infrastructure and Transport (2009), *The 1st nationwide transportation survey planning (2009~2013)*, Republic of KOREA.

National Information for Law and Act, http://www.law.go.kr, "National Transport System Efficiency Act", "Act on the Support and Promotion of Utilization of Mass Transit System", "Road act", "Urban Traffic Readjustment Promotion Act".

Ministry of Land, Infrastructure and Transport (2011), Public Transportation Investigation, Republic of KOREA.

Ministry of Land, Infrastructure and Transport (2012), Public Transportation Investigation, Republic of KOREA.