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Changes in Commuting Patterns and Determinants of Commuting Time : Seven Korean Cities

통근·통학 유형과 통근시간 결정요인의 변화: 7대 광역시를 중심으로

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Ⅰ. Introduction

Since the Korean War, the Korean economy has grown exponentially. As a result, Korean cities grew dramatically which caused congestion. For example, Seoul became a mega-city with a population of approximately 10 million in 2000. The net density[1]) is about 27,695 persons per square kilometer, which is 71,730 persons per square mile in 2000. Consequently, the diseconomies from the cities' crowdness have been a critical issue. For example, population decentralization policy such as the relocation of the Capital city or various government functions became a hot issue. Kim(2005) simulated the commuting time cost reduction of the five percent population decentralization(about 532,000) from Seoul by relocating governments outside of Seoul, which is about 0.57 billion dollars in annual terms.

The purpose of this paper is to analyze the changes in Korean commuting over the last 20 years in two ways. The changes in commuting pattern are first scrutinized and then changes in determinants of commuting time are estimated by using the Korean Census Data 1980, 1990, 1995, 2000 and public use micro Census Data 1995, 2000.

First, it is important to describe changes in commuting patterns that have taken place. There are many important changes in commuting patterns including inner commuting, reverse commuting, excess commuting rate, and commuting mode. The most impressive change is in the excess commuting rate[2]), which means that the commuters moved closer to their working ward as cities became more congested with increased population. For the excess commuting rate(ECR), the minimum commuting time(MCT) is calculated by using a mathematical linear programming model. Actual commuting time(ACT) less minimum commuting time (MCT) is defined as the excess commuting rate. The excess commuting rate was improved from 1995 to 2000 in all seven large cities in Korea. For example, the rate in Seoul dropped from 30% to 22% and that in Busan decreased from 34% to 27%. The actual total commuting time cost based on the average hourly income in Seoul was 5.1 billion dollars and 984 dollars in per capita terms in 2000. As the commuting time cost rose, urban sprawl increased in Seoul and Busan as evidenced by the emergence of multiple central business districts(CBD) and the increase in reverse commuting. Second, commuting mode has changed significantly. More than 60 percent of commuters used buses as their commuting transportation method, while

1) Net density is the population divided by the residential area which is 374.55 km^2(or 144.61 $mile^2$).

2) Excess commuting Rate is defined as $ECR = \frac{ACT - MCT}{MCT}$

less than 10 percent of commuters used private automobiles or taxis in 1980. Unfortunately, subway transportation was not built during that time period. However, in 2000, the commuting mode was more diversified to mainly three transportation methods: bus, subway, and automobile. In Seoul, the percentages of those commuting modes are 29%, 29%, and 24% respectively.

Second, changes in commuting time determinants are analyzed. Among the many research papers on the determinants of commuting time, Lee and McDonald(2003) empirically analyzed the individual determinants of commuting time and distance for commuters into Seoul. Findings were not different from the previous research depicting that higher income workers, home-owners, highly educated workers, and older male workers usually show longer commutes. Lee and McDonald used the 2% public using sample Korean Population and Housing Census in 1995. In this paper, the same data set was used with the addition of 2000 data. From the 2000 data set, the effect of information technology was uniquely analyzed, which seemed ambiguous. The frequencies of personal computer use and internet use increased commuting time in some cities and decreased commuting time in others, while mobile phone users seemed to have longer commuting time in all cities. However, unfortunately the effect of information technology on commuting time is not clear due to the lack of data. On the other hand, there is significant relationship between departing time and commuting time. In some sense, commuters who have to commute long distance leave home earlier than the others and may have more time and opportunity to use a mobile telephone.

II. Literature Review

In this section, two topics are explored: One is about the excess commuting or wasteful commuting and the other is about the determinants of commuting time.

There is a large amount of literature on “wasteful commuting”. Hamilton(1982), a pioneer in measuring excess commuting with a mono-centric model, calculated the minimum required commuting distance, which is about one-eighth of actual commuting distance:

$$\frac{1}{P}\int_0^{\bar{x}} xP(x)dx - \frac{1}{J}\int_0^{\bar{x}} xJ(x)dx$$

<1>

where P(x) and J(x) are population and the number of jobs at the distance x from the CBD. The difference between the population density gradient and job density gradient play a key role in this monocentric model. Later, White(1990) extended Hamilton’s mono-centric to include the poly-centric model. She demonstrated the manner in which "increasing the number of sub centers could reduce commuting." In other words, the poly sub centers could lessen congestion compared to the mono-center by decentralizing population and job. According to Thurston and Yezer(1991), actual commute is about twice that of efficient commute when the commuters' heterogeneity was taken into account. Also, they pointed out that actual commuting is not entirely radial. While the models so far still deal with commuting distance to the CBD, Small and Song(1992) introduced the zonal pattern with commuting flow rather than the polycentric pattern. In their model, the total commuting cost is minimized with respect to the commuting flows given different constant marginal transportation costs between depart point to destination. The strength of this zonal pattern model is that every cross commute is considered, because specific mono-centric or poly-centric assumptions are not necessary. Kim(1993) considered the number of workers in a household, because multiple-workers household is more constrained in commuting cost minimization. However, this paper did not consider multiple-worker households, because there might be no excess commuting rate concept when all kinds of constrains such as children's school district and amenities are taken into account.

Second, there are many papers on the determinants of commuting. First of all, Madden (1981) and White(1986) tried to explain the gender difference in commuting and found that women commutes are shorter than men in general. Especially, White pointed out that urban economists fixed job location at the center of a city and figured out the resident location choice, while labor economists fixed resident location and figured out job location choice based on wage, housing price and commuting time to work. However, in general, in her reduced form of commuting time estimation, none of resident location and job location is fixed. In addition, commuting time was regressed by taste and demographic factors but not income or housing price, because of the endogeneity. According to her household head commuting time estimation, there are quite different patterns. That is male householdhead commuting patterns changes significantly by the demographic factors such as second workers or young children. Turner and Niemeier(1997) interpreted this as the relationship between household responsibility and commuting time. Salomon(1985) explained the commuting patterns with information technology. In this literature of the effect of information technology on commuting time, the main issue is whether information technology is substitute or complement to commuting. In the mean time, Giuliano(1998) approached this theory differently. He defined information technology by specific working status, working industrial categories and commuting mode. For example, if a person is working in the informational technology industry as a staff, then he was classified as an information technology user.

In this research, these determinants of commuting differences are examined greater detail with Korean large cities' data. Most recently, Lee and McDonald(2003) analyzed commuting patterns empirically in Seoul, Korea with 1995 census data, which showed the difference in commuting time varies with gender, house ownership, occupation, working industry, moving history, age, working status, marriage status, number of workers, etc. This paper extends and updates that work and also considers how information technology usage relates with commuting time. For example, the relationship of mobile phone usage, personal computer and internet use frequencies to commuting time is tested. In addition, depart timeand number of children are added as determinants of commuting time.

III. Data

In order to see changes in commuting patterns, in and out tabulations of commuting flow data from resident place to working place is necessary, which were obtained from the Korean Population and Housing Census in 1980, 1990, 1995, and 2000 for all seven Korean cities. In and out tabulations of commuters in seven cities in 1995 and 2000 shows the number of commuters and average commuting time in minute from *i*th row ward(gu or gun[3]) to *j*th column ward is represented by and t_{ij} respectively. In other words, X_{ij} means the number of commuters living in *i*th gu but commuting to *j*th gu. Commuters defined in Korean Census are the workers and students over age 12. Unfortunately, worker only flow data is unavailable. Average commuting time, t_{ij}, from a resident gu i to each commuting gu j was obtained from the two percent public use Population and Housing Census sample data in 1995 and 2000. Geographic data on population, commuting mode, and transportation in frastructural variables such as road length and subway length are from the Korean Transportation Institute. For the commuting cost calculation, average wages and working hours in each city from the Ministry of Labor were used.

For the changes in determinants of commuting time, the two percent public use Population and Housing Census sample data in 1995 and 2000 were used. The 2000 data set has more variables measuring information technology usage like the frequencies of personal computer use and Internet use as well as an ownership dummy variable for mobile phone or beeper.

3) gu and gun are administrative Districts in cities and rural area respectively in Korea just like a county in USA.

<Table 1> Summary Table for Korean Cities Commuting Pattern

	Seoul				Busan			
	1980	1990	1995	2000	1980	1990	1995	2000
Population	8364379	10612577	10231217	9895217	3159766	3798113	3814325	3662884
Commuter	3271459	5036030	5440851	5242357	1197006	1704820	1926141	1786058
Worker	2035031	3403428	3729163	3729276	773411	1122404	1278488	1226241
Student	1236428	1632602	1711688	1513081	423595	582416	647653	559817
Reverse Commute Rate	5%	7%	10%	11%	2%	4%	6%	7%
Inner Commute Rate	44%	43%	46%	52%	55%	50%	52%	53%
In/Out Commute Rate	0.95	1.06	1.08	1.10	0.99	0.98	0.97	0.96
CBD	CN,CH	CN,CH,YS	CN,CH,YS	CN,CH,YS	CH	CH	CH	CH, KS
		YDP,KN	YDP,KN	YDP,KN				KS
Subway(km) in 2003				287				71
Road(km) in 2001				7935				2553
Commuting Mode								
Bus	62%	46%	36%	29%	61%	59%	49%	46%
Automobile	3%	12%	20%	24%	2%	8%	18%	26%
Subway	3%	14%	18%	29%	0%	4%	5%	9%
Walk, Bike, etc	32%	29%	27%	18%	37%	29%	28%	19%
Congestion Cost($ billion)			3.96	4.17			2.03	2.35
Commuting Time(min)			37.41	37.55			33.73	33.37
Commuting Time Cost($billion)			6.22	5.10			1.24	1.24
Per capita Cost($)			1154.20	984.39			641.90	696.35
Excess Commuting Rate			30%	22%			32%	27%

	Daegu			Incheon		
	1990	1995	2000	1990	1995	2000
Population	2229040	2449420	2480578	1817919	2308188	2475139
Commuter	972999	1208889	1189624	794279	1138707	1237667
Worker	604848	789220	806826	577469	835284	913164
Student	368151	419669	382798	216810	303423	324503
Reverse Commute Rate	10%	9%	10%	19%	18%	21%
Inner Commute Rate	43%	54%	60%	48%	52%	59%
In/Out Commute Rate	0.94	0.94	0.93	0.92	0.93	0.89
CBD	CH	CH	CH	CH	CH	CH
Subway(km) in 2003			26			22
Road(km) in 2001			2113			2297
Commuting Mode						
Bus	61%	47%	39%	55%	42%	32%
Automobile	11%	27%	37%	10%	25%	36%
Subway	0%	0%	3%	9%	8%	11%
Walk,Bike,etc	28%	27%	22%	26%	25%	21%
Congestion Cost($billion)		0.43	0.69		0.99	1.15
Commuting Time(min)		33.83	31.00		36.64	36.58
Commuting Time Cost($billion)		0.98	0.73		1.09	1.00
Per capita Cost($)		817.96	617.39		958.87	816.10
Excess Commuting Rate		19%	11%		28%	16%

	Gwangju			Daejeon			Ulsan
	1990	1995	2000	1990	1995	2000	2000
Population	1139003	1257636	1352797	1049578	1272121	1368207	1014428
Commuter	487637	629754	657846	450603	628438	674369	496598
Worker	261960	385905	430180	266154	403343	448283	362480
Student	225677	243849	227666	184449	225095	226086	134118
Reverse Commute Rate	6%	8%	8%	6%	8%	8%	4%
Inner Commute Rate	50%	56%	67%	53%	57%	69%	71%
In/Out Commute Rate	1.00	0.96	0.96	0.97	0.94	0.95	1.00
CBD	DO	DO	DO	YS		YS	CH
Subway (km) in 2003							
Road (km) in 2001			1857			2076	2569
Commuting Mode							
Bus	67%	51%	43%	55%	43%	36%	37%
Automobile	8%	24%	35%	11%	28%	41%	38%
Subway	0%	0%	0%	0%	0%	1%	0%
Walk,Bike,etc	26%	25%	21%	34%	28%	23%	25%
Congestion Cost($billion)		0.22	0.63		0.68	0.62	0.25
Commuting Time(min)		29.42	29.62		27.10	28.02	27.01
Commuting Time Cost ($billion)		0.44	0.41		0.35	0.32	0.19
Per capita Cost ($)		703.31	622.42		579.46	476.50	392.55
Excess Commuting Rate		17%	9%		15%	9%	11%

Source: Census 1980, 1990, 1995, 2000 and Public Micro Use 2% Census, Korean Transportation Institute

IV. Changes in Commuting Patterns and Cost

Information on commuting patterns in Korean large cities is shown in <Table 1>. First, the number of commuters increased over time, possibly because the labor force participation rate increased over the last twenty years. In other words, more people, especially women workers, entered the workforce.

Second, more people have moved closer to their commuting destinations over time. The number of commuters in the main diagonal represents inner commuting. The inner commute percentage of people commuting inside of their resident gu has increased in all seven cities. For example, 52 percent of commuters were commuting inside their home gu in 2000, compared to 44 percent in 1980 in Seoul.

In addition, the percentage of reverse commuting has risen in Seoul, Incheon, Busan, and Daegu. In <Table 1>, the percentage of commuters from Incheon to Gyeonggi providence or Seoul increased 18% in 1995 to 21% in 2000. Moreover, sub centers are increasing for both Seoul and Busan in 2000. Here, the sub center is defined when the in-out commuting ratio is greater than 1.5. For example, new financial sub-center in Youngdeungpo-gu(YDP) and business center in Gangnam-gu(GN) have appeared in 1990 as well as the traditional CBD, Jung-gu(JU), Jongno-gu(JN), and Yongsan gu(YS) in Seoul. Similarly, Jung-gu(JU) was the traditional CBD in Busan.

<Table 2> Variables and Definitions

Variables	Definition
Individual Characteristics (X)	
age, age2	commuter's age and square term
college	not college (0), college (1)
graduate	not graduate (0), graduate (1)
male	female (0), male (1)
Household Responsibility (R)	
hhead	not household head (0), household head (1)
marriagestatus	single or married but separated (0), married with spouse (1)
ncworkers	number of commuting workers
ncchildren	number of commuting children
housingowner	rent (0) and owner (1)
marr. male owner w/cc	married male houseowner having commuting children (1), otherwise (0)
single male renter	single male renter (1), otherwise (0)
female hhead	female household head (1), otherwise (0)
Commuting Characteristic (M)	
departtime	time to leave home as a fraction
multicommute	commute by single mode (0), commute by multiple modes (1)
bus	primary commute mode is not bus (0), bus (1)
subway	primary commute mode is not subway (0), subway (1)
auto	primary commute mode is not auto (0), auto (1)
Working Status (W)	
workingyr	working experience in current job in year
wssalary	not salaried workers (0), salaried workers (1)
wsowner	not self-employeed workers (0), self-employeed workers (1)
occmanager	not manegers (0), managers (1)
occprofessional	not professionals (0), professionals (1)
occenginepro	not professional engineers (1), professional engineers (1)
occadmin	not administrators (0), administrators (1)
occservice	not service workers (0), service workers (1)
occsales	not sales workers (0), sales workers (1)
occagri	not agricultural workers (0), agricultural workers (1)
occengineer	not engineers (0), engineers (1)
occassembler	not assemblers (0), assemblers (1)
Information Technology Usage (I)	
pcuse	once a week or less (0), everyday (1)
internetuse	once a week or less (0), everyday (1)
mobile	not having mobile phone (0), having mobile phone (1)

<Table 3> Summary of Average Commuting Time(min)

	year	Seoul	Busan	Daegu	Incheon	Gwangju	Daejeon	Ulsan
Commute Ways								
SingleCommute	1995	70.2	65.8	72.8	66.1	37.5	71.3	
	2000	34.7	30.8	28.6	32.7	27.9	27.2	24.1
Multicomute	1995	38.1	32.9	32.3	35.7	28.7	27.8	
	2000	52.3	50.2	44.8	68.3	39.8	45.1	32.7
Commuting Mode								
Bus	1995	45.2	41.0	39.7	43.2	35.2	34.3	
	2000	42.1	39.5	36.7	41.5	35.0	36.3	31.7
Subway	1995	48.8	36.5	78.8	68.4	88.6	104.1	
	2000	49.8	42.8	44.2	67.3	78.6	94.8	75.3
Auto	1995	40.5	34.7	33.2	36.2	29.4	26.5	
	2000	37.7	33.6	30.0	33.9	29.3	28.1	25.7
Walk	1995	10.5	10.4	11.7	11.2	11.5	11.0	
	2000	13.9	14.4	16.3	14.9	15.7	15.3	14.8
Depart Time								
Before 5 am	2000	29.9	27.2	27.5	29.2	21.4	24.2	20.8
5 to 6 am	2000	47.8	39.8	39.9	50.3	37.4	42.5	26.6
6 to 7 am	2000	49.0	44.8	41.4	49.4	38.0	41.3	31.8
7 to 8 am	2000	44.6	35.9	31.9	39.3	31.0	31.6	25.1
8 to 9 am	2000	32.2	26.8	25.0	27.1	25.0	23.1	21.6
After 9 am	2000	27.3	24.6	22.9	24.4	22.3	21.3	18.2

Source: Public Micro Use 2% Census

As the number of commuters to Gangseo-gu(GS) has increased since 1995, Gangseo-gu became another sub center in Busan.

Another big change is in commuting mode. As the Korean income per capita rises and cities become more congested, people use more private automobiles rather than public transit buses. The number of registered automobiles is in creasing the new subway construction and extension investment are ongoing. According to the Korean Transportation Institute, six large cities - all cities except Ulsan - will have subways. Therefore, the diversification of commuting mode is easily predicted for the future.

Next, the commuting time cost has fallen. To measure the value of commuting time, the average hourly wage rate from the Korean Labor Department was used. The dollar cost of commuting time has decreased from 6.22 billion dollars in 1995 to 5.10 billion dollars in 2000 in Seoul, because Korean currency ‘won’ has been depreciated by the Asian financial crisis. These costs could be compared with the congestion costs of each city calculated by Yoon (2003). In 2000, the congestion cost in Seoul was about 3.96 billion dollars, which is based on the average speed 27 km/h without congestion. Also, this congestion cost covered all day long not only the commuting time period. However, commuting time cost calculation took into account only morning time rather than evening time. In <Table 1>, the residents in Seoul and Incheon commuted longer and thus commuting time costs[4)] per capita are quite high compared to the other cities. In addition, the commuting time cost is a little bit underestimated, because high wage workers in general commute longer, while the average wage in each city was used for the cost of commuting time.

It is necessary to compute the excess commuting rates for each city comparison. The excess commuting rate is based on the required minimum commuting time, which minimizes the amount of inter-zonal commuting by assigning commuters to jobs within their home zone insofar as possible. Based on Small and Song (1992)'s zonal pattern analysis, the commuting time minimization problem involves solution of the following expression:

$$\min \sum_i \sum_j t_{ij} X_{ij} \; st \sum_i X_{ij} \le E_{j,} \sum_j X_{ij} \le C_{i,} \text{ and } X_{ij} \ge 0, \forall i, j X_{ij}$$

<2>

where t_{ij} is the average commuting time, X_{ij} is the number of commuters from the resident gu i to work gu j, E_j is the total number of jobs and students in gu j, and C_i is the total number of commuters in gu i. The average commuting time in <Table 3>, t_{ij}, was obtained from the 2% public use Korean Population and Housing Census, which is better than the marginal cost, C_{ij}, in Small and Song's literature, because Korean commuting mode is diversified. The estimated excess commuting rate is larger than Kim and Chung(2004)'s rate[5)] but may still be under-calculated in that a constraint keeps the same number of workers commuting to the outside of each city. In this comparison, commuting in Busan is the most "inefficient" among seven Korean cities in resident location choice to working location. The next step is to determine excess commuting time. Because Seoul is a polycentric city, the zonal pattern of commuting analysis is more appropriate.

V. Changes in the Determinants of Commuting Time

The determinants of commuting time have been related to a variety of household factors such as gender, household responsibility, race, etc. Lee

4) Commuting time cost was calculated with average hourly wage in each city from the Ministry of Labor. For example, the average annual wage and average annual working hour in Seoul are 16.68 million Korean won and 2,340 working hours respectively in 2000.

5) Kim and Chung(2004)'s Seoul excess commuting rates in 1990, 1995, and 2000 are 11.55%, 10.27%, and 11.79% respectively.

<Table 4> Regression Results of Commuting Time

	Seoul		Busan		Daegu	
	1995	2000	1995	2000	1995	2000
age	0.16	0.00	−0.11	−0.15	0.38	0.37
	(2.43)*	(0.01)	(1.11)	(1.55)	(3.10)**	(3.07)**
age2	0.00	0.00	0.00	0.00	0.00	0.00
	(1.87)	(0.94)	(1.09)	(2.10)*	(2.76)**	(1.75)
college	2.16	1.64	1.60	1.42	1.69	0.75
	(8.94)**	(6.95)**	(3.88)**	(3.68)**	(3.56)**	(1.62)
graduate	2.90	2.42	−1.41	1.71	−1.38	2.28
	(5.60)**	(5.29)**	(1.14)	(1.76)	(1.08)	(2.08)*
male	8.83	6.92	8.89	6.87	6.66	5.22
	(24.61)**	(19.45)**	(15.38)**	(11.58)**	(9.56)**	(6.91)**
hhead	−2.20	−2.35	−2.31	−2.32	−4.18	−3.13
	(5.99)**	(6.41)**	(3.84)**	(3.78)**	(5.89)**	(4.07)**
marriagestatus	−5.23	−4.03	−4.57	−3.13	−4.06	−3.40
	(15.70)**	(13.01)**	(8.62)**	(6.50)**	(6.27)**	(5.53)**
ncworkers	0.13	−0.03	−0.34	0.16	−0.66	−0.33
	(1.17)	(0.25)	(1.91)	(0.81)	(3.42)**	(1.30)
ncchildren	0.67	0.35	0.78	0.53	1.31	0.73
	(5.17)**	(2.49)*	(3.88)**	(2.34)*	(5.34)**	(2.61)**
housingowner	2.45	2.14	1.31	1.3016	1.85	1.4622
	(10.33)**	(9.48)**	(3.59)**	(3.79)**	(4.24)**	(3.47)**
marr.male owner w/cc	0.0227	1.0443	−0.5577	1.6061	0.9558	1.0045
	(0.06)	(2.73)**	(0.95)	(2.85)**	(1.34)	(1.44)
male single renter	−5.5351	−5.3583	−5.465	−3.567	−5.161	−3.0331
	(12.84)**	(12.58)**	(7.29)**	(4.64)**	(5.84)**	(3.30)**
female hhead	−1.9572	−0.6975	−0.996	1.1717	2.1078	1.4836
	(3.41)**	(1.28)	(1.03)	(1.29)	(1.87)	(1.31)
workingyr		−0.3603		−0.388		−0.2806
		(6.91)**		(4.82)**		(2.75)**
wssalary	10.1882	10.2256	7.6137	6.7388	8.5401	7.1989
	(32.71)**	(33.12)**	(14.23)**	(13.93)**	(14.06)**	(12.33)**
wsowner	−0.3843	0.2775	−0.4708	−0.8856	2.2007	0.8323
	(1.01)	(0.75)	(0.75)	(1.55)	(3.09)**	(1.23)
occmanager	−8.0427	4.8396	0.0949	1.5555	−13.0983	2.1735
	(3.75)**	(8.99)**	(0.03)	(1.88)	(4.14)**	(2.17)*
occprofessional	7.0629	3.8559	3.3143	−0.3717	2.6704	2.311
	(12.77)**	(8.01)**	(3.80)**	(0.47)	(2.47)*	(2.37)*
occenginepro	3.2158	3.5158	−1.237	−0.6142	4.0716	2.2165
	(5.98)**	(7.63)**	(1.38)	(0.81)	(3.83)**	(2.19)*
occadmin	3.4522	3.7777	0.9521	0.7696	−0.181	2.5554
	(7.65)**	(8.52)**	(1.39)	(1.21)	(0.20)	(3.06)**

occservice	5.6519	−2.2516	1.2686	−4.304	0.8387	−3.5103
	(12.63)**	(4.91)**	(1.91)	(6.40)**	(0.99)	(4.10)**
occsales	−0.4015	0.9891	−4.0971	−2.0259	−3.4812	0.2271
	(0.94)	(2.26)*	(6.58)**	(3.19)**	(4.34)**	(0.28)
occagri	13.3545	22.3052	−9.0915	−7.9242	−5.5523	−0.6928
	(7.44)**	(11.50)**	(7.92)**	(6.75)**	(4.12)**	(0.54)
occengineer	1.3078	1.5928	0.7368	1.0036	1.1109	2.6044
	(3.00)**	(3.62)**	(1.25)	(1.63)	(1.40)	(3.16)**
occassembler	−1.6938	−1.0588	−0.849	0.5298	0.5922	1.922
	(3.32)**	(2.09)**	(1.30)	(0.85)	(0.74)	(2.46)*
pcuse		0.1881		0.1213		0.0229
		(0.53)		(0.20)		(0.03)
internetuse		0.5661		0.1766		−0.6173
		(1.59)		(0.29)		(0.84)
mobile		3.9444		2.575		2.4563
		(14.84)**		(6.73)**		(4.90)**
Observations	73380	72219	25389	23943	15938	15653
R−squared	0.08	0.08	0.07	0.07	0.06	0.05

	Incheon		Gwangju		Daejeon		Ulsan
	1995	2000	1995	2000	1995	2000	2000
age	0.15	0.17	0.45	0.45	0.45	0.50	0.14
	(1.10)	(1.28)	(2.88)**	(3.13)**	(2.63)**	(2.92)**	(1.10)
age2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.87)	(0.75)	(2.12)*	(2.57)*	(2.36)*	(2.40)*	(0.11)
college	5.28	4.73	1.03	1.98	0.63	0.68	1.23
	(9.10)**	(8.79)**	(1.67)	(3.54)**	(0.96)	(1.05)	(2.35)*
graduate	8.82	0.96	−0.33	−0.18	−4.72	−2.26	−0.41
	(4.92)**	(0.64)	(0.21)	(0.14)	(3.31)**	(1.93)	(0.26)
male	9.22	6.22	3.37	2.37	2.61	4.53	2.71
	(11.55)**	(7.48)**	(3.50)**	(2.52)*	(2.52)*	(4.16)**	(3.05)**
hhead	−3.54	−1.66	−2.13	−1.14	−1.79	−2.38	−2.43
	(4.33)**	(1.94)	(2.18)*	(1.19)	(1.68)	(2.16)*	(2.69)**
marriagestatus	−5.88	−6.37	−3.84	−2.45	−4.04	−4.09	−3.39
	(8.02)**	(9.57)**	(4.43)**	(3.20)**	(4.45)**	(4.67)**	(4.76)**
ncworkers	−1.17	−0.44	−0.02	−0.28	−0.90	0.78	−0.62
	(4.84)**	(1.59)	(0.06)	(0.85)	(2.99)**	(2.07)*	(2.42)*
ncchildren	0.34	−0.50	0.89	0.91	0.65	0.50	−0.75
	(1.02)	(1.43)	(2.89)**	(2.84)**	(1.86)	(1.33)	(2.15)*
housingowner	2.96	1.2244	0.68	0.6273	0.70	0.51	0.7154
	(5.89)**	(2.53)*	(1.15)	(1.20)	(1.15)	(0.86)	(1.53)

	Incheon		Gwangju		Daejeon		Ulsan
	1995	2000	1995	2000	1995	2000	2000
marr.male owner w/cc	−1.7249	2.0736	0.8269	−0.0429	0.9156	1.5588	1.2729
	(2.07)*	(2.60)**	(0.92)	(0.05)	(0.94)	(1.64)	(1.66)
male single renter	−8.6441	−7.332	−3.3497	−1.6139	−3.3837	−4.7621	−6.8938
	(8.26)**	(6.70)**	(2.85)**	(1.37)	(2.55)*	(3.53)**	(6.72)**
female hhead	−1.4665	−1.7533	−1.7927	−0.6595	−3.1779	−0.8781	−0.9165
	(1.04)	(1.34)	(1.19)	(0.47)	(1.93)	(0.56)	(0.66)
workingyr		−0.5785		−0.1844		−0.3865	−0.6223
		(5.10)**		(1.47)		(2.68)**	(5.43)**
wssalary	10.2279	9.3708	7.3634	7.1999	6.853	7.3029	3.388
	(13.91)**	(13.70)**	(9.05)**	(10.39)**	(7.83)**	(8.88)**	(4.48)**
wsowner	0.3662	−0.5593	0.5309	−0.2694	3.3529	0.2999	−0.9157
	(0.43)	(0.69)	(0.56)	(0.33)	(3.26)**	(0.31)	(1.08)
occmanager	−5.8153	6.9164	−9.4776	3.7006	0.3676	3.7445	−0.5553
	(1.76)	(5.91)**	(2.37)*	(2.83)**	(0.13)	(2.63)**	(0.40)
occprofessional	7.6843	1.5063	0.6682	2.6935	5.8534	−0.0354	−2.0022
	(5.44)**	(1.32)	(0.47)	(2.29)*	(3.60)**	(0.03)	(1.67)
occenginepro	−1.9828	1.3803	4.9184	−0.7316	−0.1281	−1.7302	1.1141
	(1.41)	(1.32)	(3.73)**	(0.60)	(0.09)	(1.32)	(1.09)
occadmin	4.5534	2.68	1.8991	−0.5235	0.8156	−1.2466	1.1992
	(4.43)**	(2.78)**	(1.63)	(0.49)	(0.69)	(1.05)	(1.21)
occservice	4.9665	−3.7518	1.7053	−2.3336	1.1371	−2.8132	−3.7791
	(4.71)**	(3.68)**	(1.48)	(2.09)*	(0.97)	(2.29)*	(3.52)**
occsales	−0.3083	1.1685	−2.7711	−1.1012	−2.8964	−1.7138	−1.6495
	(0.31)	(1.21)	(2.55)*	(1.04)	(2.65)**	(1.47)	(1.61)
occagri	−11.2594	−7.7353	−7.0592	−2.9459	−8.2318	1.0601	−6.1309
	(7.96)**	(5.57)**	(4.76)**	(2.04)*	(4.25)**	(0.55)	(4.65)**
occengineer	4.0033	3.5687	2.8287	2.6015	2.6622	3.8508	1.5259
	(4.21)**	(3.87)**	(2.50)*	(2.34)*	(2.40)*	(3.17)**	(1.62)
occassembler	−1.8184	−1.1469	2.429	0.0784	−1.3503	−0.8452	1.8345
	(1.87)	(1.29)	(2.10)*	(0.07)	(1.11)	(0.69)	(2.00)*
pcuse		−0.4195		−0.4171		−0.0665	1.2811
		(0.54)		(0.50)		(0.07)	(1.67)
internetuse		2.8195		−0.2396		0.1131	−0.4421
		(3.49)**		(0.28)		(0.12)	(0.56)
mobile		2.323		3.0247		2.5085	1.5394
		(4.17)**		(4.70)**		(3.48)**	(2.79)**
Observations	16805	18069	7703	8455	7912	8498	6960
R-squared	0.10	0.09	0.07	0.06	0.04	0.04	0.07

Note: Dependent Variable is one way commuting time in minute.
t statistics are in the parenthesis. * significant at 5% and ** significant at 1%.
Only manager and professional are reported but all 10 occupations dummies are included in regressions.

and McDonald(2003) empirically verified many important determinants of commuting time with 1995 Korean data.

All variables and definition are in <Table 2>. In this paper, more variables were added data was also updated in 2000. Following the literature, the empirical model of commuting behavior by households is that the commuting time(T) is a function of individual characteristics(X), household responsibility(R), commuting characteristics(M), working status and occupation(W), and information technology usage(I).

$$T = f(X, R, M, W, I) = B_0 + B_1 X + B_2 R + B_3 M + B_4 W + B_5 I + \epsilon \quad <3>$$

However, commuting characteristic variables are endogenous variable and thus there might be some causality problem. In other words, individual commuters choose the departing time and commuting mode depending upon their commuting time. According to the <Table 3>, there is a big change in the average commuting time to commuting ways between 1995 and 2000. Longer commuters chose multiple commutes in 2000, while they had chosen single commute in 1995. In addition, the longest commuters left home between 6 a.m. and 7 a.m. in all 7 cities except Incheon and Daejeon, because there are many cross city commuters in both cities. Commuting mode is also a very significant factor for commuting time. Here, subway includes urban trail, too. Actually, Gwangju, Daejeon, and Ulsan do not have subway but urban trail. Therefore, there is a limit to say that longer commuting workers used subway or train as their commuting transportation, and had multiple commuting modes in 2000. However, people with longer commutes used the fastest commuting transportation method, which is subway in Seoul, Busan, Daegu, and Incheon. According to the Korean Transport Institute, the average speed of subway is over 35 km/h in Seoul. In case of train speed, other cities are much faster because trains stops are less than subways. There was a change in the effect of the multiple commuting ways in 1995 and in 2000. It is possible that workers commuting longer tried to reduce their commuting time by having multiple commuting ways in 2000.

Therefore, regression(3) was adjusted to regression(4), which excludes commuting characteristic variables but adds some interaction variables such as married male house owner having commuting children, single male renter, and female household head.

$$T = f(X, R, W, I) = B_0 + B_1 X + B_2 R + B_3 W + B_4 I + \epsilon \quad <4>$$

The individual characteristic variables in <Table 4> showed the same results as previous literature. Male workers commute longer. So do older and more educated workers. With square term of age, commuting time increases as age increases at increasing rate or decreasing rate. However, the head of household commuted significantly less, because non-head of household workers' income were relatively lower than household head's income in most cases, which means the opportunity cost of household head's commuting is greater than that of the additional worker's commuting. However, workers who are single or married but separated commuted longer, while workers who are married and live with spouse currently commuted shorter, which is somewhat counter intuitive. One possible explanation of this fact is the residential constraint, which means the housing for single workers or married but separated is limited. Again, it seemed that the coefficients of the household responsibility variables were down-biased in 1995. The number of commuting children over 12 year old affected commuting time significantly but not the number of workers, which means the children's school district constraint is more important than the second workers' constraint is. It is possible that the second workers have more chances to be hired locally and thus location restriction is not as serious as their children's higher education mostly middle school and high school. Of course, the married house owning male workers with commuting children have longer commuting time but single male renters have much shorter commuting time.

According to the regression results in <Table 4>, working status plays a role in commuting time. However, in general, more experienced workers commuted less, which might be interpreted as positive effect of job security on commuting time. Professional and salaried workers commuted longer, while workers having service occupations and self-employed workers commuted less.

Information technology usage rarely affected commuting time. Intuitively, usage of internet is supposed to increase commuting time by inducing more remote working or telecommuting. However, network infrastructure like high speed cable connection and distance mobile service like teleconferencing communication, tele-banking, or internet trading were not fully developed for distance working in 2000. In addition, the number of commuting in a week or a month should have been taken account, because information technology user may have longer commute but small number of commutes. Nevertheless, it was more likely that longer commute workers purchased mobile phones more than the others, which may not be true any more, because almost everybody including students has a mobile phone in 2006. Relatively, daily personal computer users commuted less in all seven large cities even though it is not significant.

Lastly, there were slight differences in commuting time equations across cities in information technology usage and occupation. Information technology variables are pretty consistent with the intuition that information technology could substitute longer commute, even though only mobile usage is statistically significant. In particular, information technology usage significantly affected commuting time in Seoul only. According to commuting time estimation, information technology seems to have more complement effect than substitute effect. In general, the commuting time of professionals is longer than that of the other occupations except Ulsan. This may be related with industry composition, because Ulsan is a typical city with localization economy of automobile industry.

Ⅵ. Conclusion

This paper illustrates changes of commuting in Korean cities for in commuting pattern and determinants of commuting time. The important findings in commuting pattern are that more people moved closer to the destination and spent fewer time for commuting. Indeed, the excess commuting rate has decreased over time. As a city and its economy grew, the number of registered automobiles increased and cities became more congested. As a result, diversified commuting modes including public transportation have become more common. Also, larger cities like Seoul and Busan experience urban sprawl the population density in CBD has fallen and sub-centers have appeared. According to the regression analysis of commuting determinants, most results in previous literature were verified: Clearly longer commutes exist for male workers, old workers, single or married but separated workers, salaried workers, workers with commuting children, workers leaving home earlier, subway using workers, less experienced workers, professional workers, and mobile phone use workers shorter commutes exist for head of households, daily personal computer users, and workers with single commute way. Even though citywide differential in commuting determinants are not serious, those determinants seem to vary from city to city size with different levels of transportation infrastructure.

In the future, this research could be continued in two ways. One is the urban transportation cost analysis, because commuting is only about 25% of urban travel according to White(1990). Therefore, the excess transportation rate rather than excess commuting should be considered. The other is about resident location choice analysis for commuters, because commuting costs could be substituted with some others such as better housing or amenities including education especially in Korea.

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ABSTRACT

통근 · 통학 유형과 통근시간 결정요인의 변화: 7대 광역시를 중심으로

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※ 주요단어: 통근, 초과통근, 통근시간

이 논문에서는 지난 20여 년간 7대 광역시의 통근 · 통학의 유동패턴과 통근시간의 결정요인의 변화를 통계청의 원시자료를 통하여 분석하였다.

먼저, 비록 평균 통근 · 통학시간의 변화는 미비하지만 통근 · 통학의 유동패턴을 살펴보면 거주지 구 또는 군으로 통근 · 통학하는 내부 통근 · 통학자의 수가 점차 늘어가는 추세다. 이러한 변화는 초과 통근 비율의 하락을 설명하고 있으며 서울의 경우 초과 통근 비율이 1995년에 약 30%에서 2000년에 약 22%로 줄어들었다. 또한, 지난 20여 년간 통근 · 통학수단이 다각적으로 변화하였음을 볼 수 있다. 1980년대에는 대중교통수단 중의 하나인 버스가 주요 통근 · 통학수단이었던 반면, 최근에는 주요 통근 · 통학수단이 버스, 지하철, 자가용 등으로 다변화되었다.

두 번째로 통근시간의 결정요인 변화를 살펴보았다. 개인적 특성, 가구주로서의 책임감, 직업의 종류, 그리고 컴퓨터 및 통신기기의 사용여부 등 결정요인을 고려한 회귀분석에 따르면 고학력자, 비숙련자, 남자, 근로자, 비세대주, 전문직종사자 등이 상대적으로 통근소요시간이 긴 편에 속하였다. 휴대전화 사용자의 통근시간이 상대적으로 긴 반면, 인터넷과 컴퓨터의 사용빈도는 통근시간에 어떠한 영향을 준다고 보기에는 어려운 것으로 나타났다. 그러나 통신기술과 컴퓨터 산업의 발달이 향후 통근 행태에 중요한 영향을 줄 것이 확실시 되고 있다. 결국 통근행태의 변화가 곧 거주지 및 근무지 선택 더 나아가 도시 형태에도 영향이 미친다는 점에서 이 논문의 중요성이 있다.