INFERRING THE VALUE OF WALKING TIME FROM PARKING RENT GRADIENT

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Abstract: Most of studies on the valuation of travel time ignored that travel involves different activities, such as walking, waiting, and in-vehicle activities, and that time values of these activities are different. One of important travel activities is walking, and the value of walking time can be inferred from parking rent gradient since parking rent reflects the willingness of commuters to pay for the privilege of saving walking time. But little has been on the valuation of walking time. In this paper, I infer the value of walking time from CBD parking rent gradient.

1. INTRODUCTION

Measuring the value of travel time accurately is important since travel time saving by road users is found to be the dominant economic benefit of transportation projects. Furthermore, precise knowledge of the money value of travel time is essential if transportation facilities are to be designed and priced efficiently (Mohring (1976)). The valuation of travel time is a well-established subject, and there are a great number of studies on the subject: studies of route choice, speed choice, choice of location, and choice of modes, where majority of them are mode choice studies. One problem with most of these studies is the ignorance of the fact that travel involves different activities, such as walking, waiting, and in-vehicle activities, and that time values of these activities are different. Therefore, one should not generalize the results obtained from above studies to various travel activities, and the need for the estimation of time values of these activities arises.

Only a few studies have recognized that travelers place different time values on various travel activities. Beesley (1965) and Quarmby (1967) pointed out that it may be entirely reasonable to value walking time, waiting time and in-vehicle time differently, and claimed that walking and waiting times were worth between two and three times line-haul travel time. McFadden (1974) noted that walking or waiting time is three to four times onerous than in-vehicle time, hence, time spent waiting or walking is valued more highly than time in vehicle. Mohring *et al.* (1987) estimated the value of waiting time for bus commuters. Westin and Gillen (1978) studied parking-location decision and its contribution to the modal-choice decision. In their paper, commuters choose parking location to minimize the full price of parking, i. e., the money charge for parking plus the value of the time commuters have to walk.

Lisco (1967) is the first study which suggested the possibility of inferring the value of walking time from parking rent gradient. He suggested that travelers do not attach the same value to a minute spent in transit and a minute spent walking, and that since parking rent reflects the willingness of commuters to pay for the privilege of saving walking time, the value of walking time can be inferred from the price of saving it, i. e., the value of walking time can be inferred from parking rent data. He inferred the value of walking time from parking rent data under the assumption that CBD is monocentric and a single dominating employment center exists.

If all economic activities(other than parking) are concentrated at a point in the center of CBD as Lisco suggested, the parking rent should be convex from below. In that case, measuring the value of walking time is straightforward and his work could somewhat suffice our needs. However, the usual implication of traditional model, the convex rent gradient, is no longer true for parking rent if CBD is diffused, and the value of walking time obtained using traditional approach would under- or over-estimate the true value. Song (1995) suggested a method and inferred the value of walking time from parking rent gradient of Minneapolis where CBD is close to monocentric and diffused.

However, many of modern CBDs are multicentric rather than monocentric. In this paper, I suggest a method of inferring the value of walking time when CBD is multicentric and diffused. Then, I infer the value of walking time, employing the data from CBD of Seoul which is multicentric and diffused, and compare the results with that of Minneapolis.

2. TRADITIONAL MODEL

Auto commuters choose a parking distance from the work place at which the savings in parking fees from a small move out are exactly offset by the resulting increase in value of leisure, i. e.,

$$dR/dr = -V_w(r)t \tag{1}$$

where R is parking rent, r is the distance from the center of CBD, V_w is the value of walking time, and t is the walking time. Since $V_w(r)$, $t > 0$, equation (1) implies that the parking bid-rent curve is negatively sloped.

Now, from equation (1), we get:

$$d^2R/dr^2 = -(dV_w/dr)t \tag{2}$$

Assuming that commuters are non-identical in terms of their income, we can derive the following equation from equation (1):

$$d(dR/dr)dy = -y^{-1}V_w t\,\eta_{v,y} \tag{3}$$

where $\eta_{v,y} = (dV_w/dy)(y/V_w)$.

Because the value of leisure increases as income increases, i. e., $dV_w/dy > 0$, and y, V_w , $t > 0$, $\eta_{v,y} = (dV_w/dy)(y/V_w) > 0$. Therefore, $d(dR/dr)/dy < 0$, i. e., increase in income increases the slope of bid-rent curve. Thus, the steepest bid-rent curve belongs to the richest. This implies that $dV_w/dr < 0$, the value of time for those who park farther away is smaller than that of those who park near the center of CBD. Then $d^2R/dr^2 > 0$, i. e, the bid-rent curve is convex. Therefore, parking rent gradient which is the envelope of individual bid-rent curve is convex. The slope of parking rent curve is steep at the nearest the center of CBD, then becomes flat as the distance from the center of CBD increases.

3. MODEL OF CBD WITH DIFFUSED EMPLOYMENT CENTERS

In this section, I introduce a model of diffused CBD and study the implication of the model on the shape of parking rent gradient. Above model with single employment center can easily be extended into a model of diffused employment centers by rewriting parking rent function in terms of r and E:

$$R = R(r, E(r)) \tag{4}$$

where R is parking rent and E(r) is the amount of local employment, i. e., the amount of employment at that block as well as the adjacent block toward the center of CBD, at a location which is r-distance away from the center of CBD. Equation (4) tells us that the parking rent depends on the local employment at location r as well as the distance from the center of CBD.

From equation (4), we get the following:

$$dR/dr = \partial R/\partial r + (\partial R/\partial E)(dE/dr) \tag{5}$$

Since $\partial R/\partial r = - V_w(r)t$, we can rewrite equation (5) as:

$$dR/dr = - V_w(r)t + (\partial R/\partial E)(dE/dr) \tag{6}$$

Equation (6) tells us that the slope of parking rent curve depends on the value of walking time as well as on the change in local employment as r increases, which is different from the traditional model. Equation (6) implies that the parking rent curve is negatively sloped as long as the value of walking time is positive and the second term, $(\partial R/\partial E)(dE/dr)$ is not large enough to outweigh the first term.

Now, from the equation (6), we can get:

$$d^2R/dr^2 = - (dV_w/dr)t + (\partial R/\partial E)(d^2E/dr^2) \tag{7}$$

Typical modern city's CBD consists of a few major employment centers clustered around the center of CBD for a couple of blocks, then the amount of employment abruptly decreases. Therefore, for a couple of blocks from the center of CBD, $(d^2E/dr^2) \leq 0$, and as long as the second term is large in absolute value and outweighs the first term, $(d^2R/dr^2) < 0$, i. e., the parking rent gradient is concave from below. Thereafter, as moving farther out from the center of CBD, d^2E/dr^2 is small or even positive. In those locations, d^2R/dr^2 is positive, i. e., the parking rent gradient is convex from below. Therefore, in a diffused CBD, the parking rent is concave for a few blocks, then it becomes convex from below.

4. EMPIRICAL STUDIES

4.1 Data

In order to infer the value of walking time from parking rent gradient, controlling for local employment, I used daily rates of parking and the local employment data. Hourly and daily parking rents were collected from parking facilities management companies in the CBD of Seoul in October 1997, and if daily rates were not available, I estimated it using hourly rates. Since employment data for each block was not available, I estimated employment for each block using the data provided by the Korea Transport Institute(See Shin and Lee (1995)).

4.2 Econometric Model

If CBD consists of a few major employment centers clustered around the center of

CBD, we can not simply infer the value of walking time as Lisco (1967) did. In order to infer the value of walking time from parking rent gradient, we have to control for local employment factor because parking rent reflects the effects of local employment as well as the value of walking time.

From equation (6), we can derive the following equation:

$$V_w = \{- (dR/dr)/t + (\partial R/\partial E)(dE/dr)/t\} \tag{8}$$

Equation (8) tells us that the value of walking time depends not only on the distance but on the local employment at location r. Therefore, we need to control employment factors to infer a true value of walking time from parking rent gradient. Note that if CBD were a single point, the second term of equation (8) would be zero. Then equation (8) is equivalent to equation (1).

Therefore, based on above argument, parking rent function can be defined as:

$$R = f(\text{distance, local employment}) \tag{9}$$

where local employment is number of people employed in each and adjacent block.

Since the Seoul is a multicentric city and each center's parking rent is different from other centers, I introduce rent difference, RD_{ij}, rather than parking rent itself as in Song (1995), and the explicit form is assumed to be:

$$RD_{ij} = \beta_0 + \beta_1 Empl_{ij} + \beta_2 Distance_{ij} + \beta_3 (Distance_{ij})^2 + \varepsilon_{ij} \tag{10}$$

where $Empl_{ij}$ is local employment, $Distance_{ij}$ is distance of block j from center i.

Note that this approach is similar to hedonic pricing(See Rosen (1974), O'Sullivan(1996), Dubin and Sung(1990)), in the sense that it includes effects of variable of local employment, but local employment is neither attributes nor neighborhood quality of parking facility.

4.3 Regression Result and Parking Rents

Regression result in Table 1 shows that not only the distance variable but the employment variable significantly affect parking rent difference, therefore parking rent, at 5% significance level.

Table 1. OLS Estimates for Parking Rent Difference

Variable*	Coefficient	t-ratio
Constant	0.56172	1.615
Distancel	0.38589	2.721
Distance2	- 0.33383E-01	-2.365
Empl	- 0.26422E-03	-2.619

Empl: Number of employment
Distancel: distance from the center
Distance2: distancel*distancel

We can see that the distance from the center affects the parking rent difference negatively, and the amount of employment affects the parking rent difference positively, i. e., as the distance from the center increases, the parking rent difference increases at decreasing rate and as the amount of employment becomes larger, the parking rent difference decreases.

Using the regression result, I estimated parking rents for selected part of CBD of Seoul with and without controlling for the local employment, and it is shown in Table 2 and Figure 1. From Figure 1, we can see that the parking rent gradient is generally concave from below for a couple of blocks then it becomes convex from below thereafter.

Table 2. Employment and Parking Rent for Each Block

	Jung-Ku Area			
Distance (meters)	Empl* (person)	PR1($)	PR2($)	PR3($)
0	2017	7.33	7.33	7.33
100	2550	7.33	7.60	6.42
200	1339	7.33	6.95	6.07
300	1551	7.00	6.18	5.71
400	1764	4.00	5.70	5.36

PR1: Actual Parking Rent.
PR2: Estimated Parking Rent.
PR3: Estimated Parking Rent controlling for employment.
Empl: Average Employment for each block.

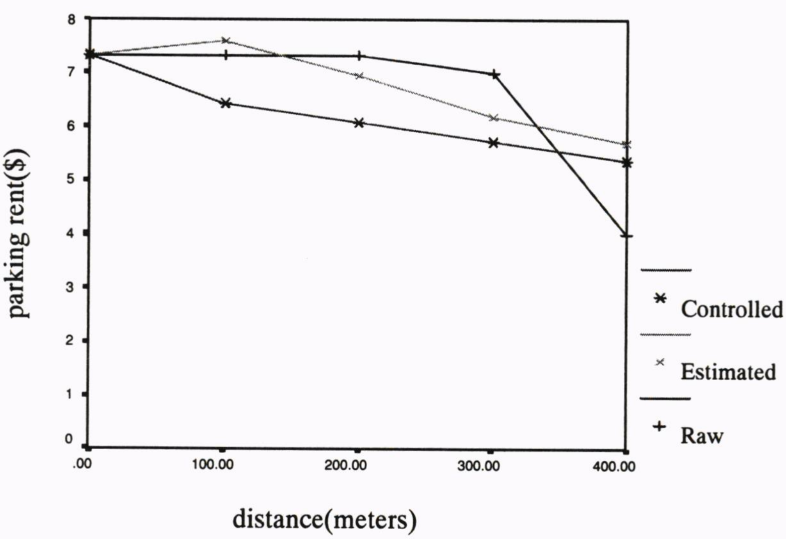

Figure 1. Parking Rent Gradient

4.4 The Value of Walking Time

The value of walking time is calculated using regression results above and based on the following equation:

$$V = (\text{Difference in Parking Rent between two locations}/\text{walking time(minutes)})*60/2 \quad (11)$$

Results are shown in Table 3. The value of walking time between the center of CBD and a block which is 100 meters away is estimated to be $0 per hour when we use raw parking rent data where true value of walking time controlling for local employment factor is $13.71 per hour. For blocks between 100 meters and 200 meters from the center of CBD, they are $0 and $5.29 respectively, and for blocks between 200 meters and 300 meters from the center of CBD, they are $0 and $5.29 per hour, and so on. Therefore, the average value of walking time estimated in this study is $7.40, where the value of walking time from raw data is $1.25. What we can see from this result is that the value of walking time is under-estimated if we use the raw parking rent data.

Table 3. Value of Walking Time(meters, $)

Distance (meters)	Value of Walking Time/hour from: raw data	controlled
0	-	-
100	0.00	13.71
200	0.00	5.29
300	0.00	5.29
400	5.00	5.29

4.5 Comparison with Previous Studies

If we assume that the value of travel time is approximately between 25% and 50% of average hourly wage, as most literature suggested, where the average hourly wage for residents of Seoul is approximately $7.10 per hour, then the value of travel time calculated under this assumption is $1.78 and $3.55. The average value of walking time obtained above is approximately 2.1 to 4.2 times of the value of travel time. This result is consistent with previous findings (Quarmby (1967), McFadden (1974), Lisco (1967)) which claimed that the value of walking or waiting time is between two to four times of the value of travel time.

Furthermore, the results in this study is similar to Song (1995). Song (1995) inferred the value of walking time from parking rent gradient of Minneapolis, which is monocentric and diffused, and found the value of walking time to be about 1.7 to 3.29 times of the value of travel time.

Table 4. Distribution of Means of Transportation to Work, Minneapolis and Seoul

Means of Transportation	Minneapolis	Seoul
Auto	87.2	21.7*
Public Transportation	5.3	78.3
Other Means	7.5	-

* Auto and Other Means combined.
Source: 1990 Census of Population, STF3C, U. S. Bureau of the Census, and Korea Transport Institute

Minneapolis and Seoul have different CBD structure in the sense that Minneapolis is close to monocentric where Seoul is multicentric and the distribution of means of transportation to work is quite different between two cities(See Table 4). However, comparison of results between two cities suggests that the methods I employed in this study is quite reasonable.

5. CONCLUSION

This study is devoted to inferring the value of walking time from parking rent gradient. An alternative approach is employed and the value of walking time is inferred from the parking rent gradient of the CBD of Seoul. The results obtained in this study are consistent with previous studies on the valuation of walking time. Comparison of the results obtained in this study and that of Minneapolis reveals that results from two cities are somewhat consistent, even if two cities are different in terms of public transportation usage and multicentricity. The overall conclusion of this study is that results using traditional approach would be misleading and, reasonably precise value of walking time can be inferred from CBD parking rent gradient using the approach suggested in this study.

However, this study has limitations. The value of walking time estimated in this study is limited to auto commuters and this study ignored possible gender difference and seasonal variations. We would expect that female commuters' value of walking time would be higher than that of male commuters if female commuters put more weight on safety and possibly comfort and convenience than male commuters. We can also speculate that the value of walking time during summer or winter time would be higher than that of spring or autumn. However, due to unavailability of data, I couldn't consider these factors. The analysis considering these possible gender difference and seasonal variations may be useful for identifying various sources of the value of walking time differences, and further research on these topics is warranted.

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