THE ESTIMATION OF CAPITAL GAINS OF PROPERTY VALUE FOR EQUITABLE COST BEARING OF URBAN RAILWAY IMPROVEMENT

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1. Introduction

In recent years urban mass transit especially railway improvement project have faced serious financial difficulties. One of the central issues to overcome the problem is how to impose charges on those who benefit from the project based upon the rational estimation of benefits and costs. Despite the fact that many theoretical works have proved the benefits of the projects are captured in land value, little attention has been paid to develop the method to estimate benefits and costs using capital gains of property value. Thus the purpose of this paper is to examine the validity of estimation of benefits based on capital gains and to develop the method of presenting the balance sheet of benefits and costs of related agents and interest groups.

First to test capitalization hypothesis and to examine how much the period is required to complete the capitalization process, the study compares user's benefit as major benefit caused by the railway improvement with the capital gain of property value. Several new urban line improvement projects during 1975 and 1984 in Tokyo Metropolitan Region are chosen as cases.

Second since the capital gains of property value are proved empirically practical unified measures of benefits in real urban context, the study develops the method which can depict the dynamic balance of benefit and cost in time horizon for residents, landowers, local and central government and transport suppliers utilizing capital gains as a key variable. From this balance sheet, possible cost bearings for related agents and individuals can be explicitly calculated. The method is applied to one of major railway projects in 1970's and to future suburban railway project. To estimate the future land use with and without the railway project, CALUTAS ("Computer Aided Land Use Transport Analysis System" presented in the last WCTR) is modified to this method.

2. Examination of Capitalization Hypothesis

2-1 Capitalization Hypothesis and Urban Railway Project

Under the "open" and "small" city assumption, the benefits of local public goods including urban railway improvement projects are proved to be captured by the landowners in the long run (see Kanemoto(1983), Ando(1984), Starrett(1981), Polinsky(1976) and others). But the closed city or large scale project case differ and the benefit may not be necessarily capitalized into land value. Ando (1984) shows that the total land value even decreases. Wheaton(1977), on the other hand, proves that if the land lent should belong to the residents, capitalization hypothesis is valid. In real urban context, the reality is between those two extream cases. For practical project evaluation, it is essential to identify how much benefits of investment should be capitalized into land value in specific period of time. Although Foster (1963) rejected to use the land prices as a measurement of benefits, recent modelling techniques can

separate the amount of benefit by transportation project from those by the other factors.

2-2 Test of the Hypothesis

The Benefits Specification

Among various types of benefits, time and cost saving effects for commuting can be easily estimated. Cost reduction effect for commuters, however, belongs to employers since public transportation costs for commuting are basically paid by the employers in Japan. In Tokyo Metropolitan region, the time saving effects can be considered major effects of suburban lines capitalized in residential land value. Thus the study attempts to test the hypothesis using time saving effect of commuting as a major benefit.

The Method

In order to test the capitalization hypothesis on open-small city, this study adopts three approaches: First a land a price model is constructed to identify the increase of land value due to the implementation of suburban line projects. Second capital gains of property values caused by the projects in study areas are measured by comparing with the land price of control area. Lastly land appraisal method of National Land Agency in Japan is applied to estimate the land price with and without the projets. Capital gains estimated by these three methods are then compared with the actual direct benefit caused by the reduction in commuting time.

The Land Price Data and Study Areas

The data are obtained from the official land price statistics at the Department of Land, National Land Agency. These residential land prices are those of typical site whose characteristics are similar to other sites within one square kilometer grid in urban areas in Japan and available from 1970 annually. The Discrepancy between these prices and actual market prices are said less than 10 % in 1984. Since some observation sites are changed during 16 years, we can not complete time series data for each grid.

The study areas for the analysis are chosen among newly opened railway lines in Tokyo Metropolitan Region. Tsukimino District in Denentoshi Line (1976), Ayase District in Chiyoda Line (1979) and Misato District in Musashino Line (1973) are selected since they are implemented during 1970-1980.

2-3 The Land Price Function Analysis

Residential Land Price Function

Traditional way to predict the improvement effects using land price function is hedonic approach (Freeman(1979), Rosen (1974) and others). Bajic (1983) recently tried to estimate hedonic land price function for subway line in Toronto.

Since the purpose of land price function is to identify the effects of transportation investment for the specific study area, microscopic site characteristics of land such as conditions of sunshine, inclination of land, spatial relationships with streets and so on are included. Empirical studies of land price function have already shown that accessiblity for commuters is one of the most dominant factors (see Nakamura(1983)). Time to CBD, shopping accessibility, public utilities, are chosen for major variables. The estimated land price functions in the study areas are shown in Table 1,2,3.

It is found that the distance to the nearest station are as much as time saving effects for commuters.

Empirical Results

Estimated capital gains due to the projects are calculated by the reduction of commuting time to CBD and the distance to the nearest station and are shown in Fig 1.

Table 1. Estimated Parameter in Den-entoshi Line

Variables	Coefficent	t-statistics
Width of Road (5m-6m-e,else-1)	0.180	3.9
Distance to the Nearest Station (100m)	-0.136	-7.5
Pavement Dummy	0.535	7.6
Gas Service Dummy	0.087	2.8
Sewerage Service Dummy	-	-
Direction (south-east e , north-west 1)	0.0022	0.9
Distance to Tokyo Station (minutes)	-	-
Constant	6.96	
R	0.87	
Sample Size	69	

$\ln y = \sum_i \alpha_i \ln X_i$ (1000 yen,1984 price)

Table 2. Estimated Parameter in Chiyoda Line

Variable	Coefficent	t-statistics
Width of Road (5m-6m-e,else-1)	143	2.7
Distance to the Nearest Station (100m)	-274	-6.8
Pavement Dummy	316	1.4
Gas Service Dummy	7.2	1.3
Sewerage Service Dummy	124	1.7
Corner Lot Dummy	160	1.6
Distance to Tokyo Station (minutes)	-179.4	-12.4
Constant	921.75	
R	0.81	
Sample Size	140	

$y = \sum_i \alpha_i \ln X_i$ (1000 yen,1984 price)

Table 3. Estimated Parameter in Musashino Line

Valuables	Coefficent	t-statistics
Distance to the Nearest Station (100m)	−258	−11.4
Gas Service Dummy	101	3.0
Sewerage Service Dummy	115	2.3
Distance to Tokyo Station (minutes)	−636	− 7.0
Constant	466.6	
R	0.83	
Sample Size	73	

$y=\sum_i \alpha_i \ln X_i$ (1000 yen, 1984 price)

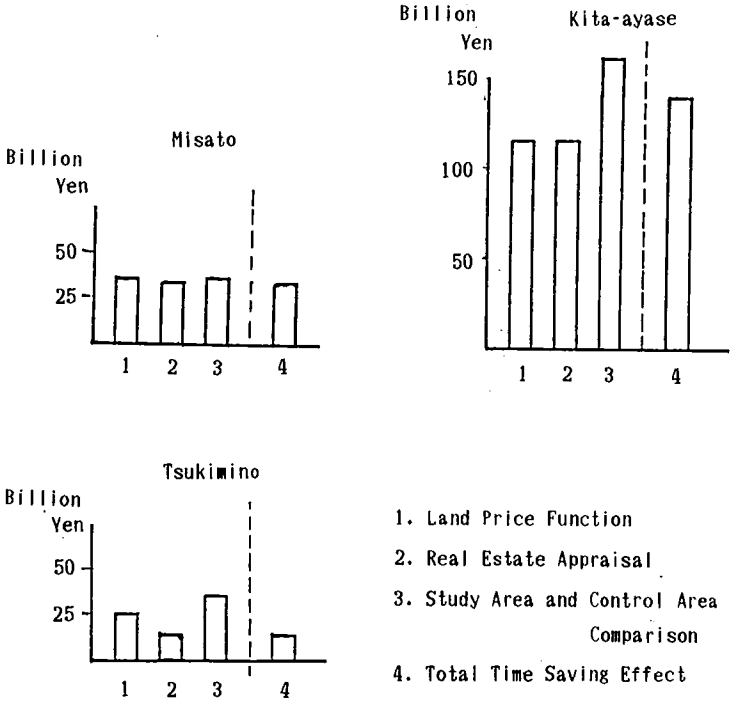

Fig.1 Estimation of Capital Gains

2-4 Study and Control Area Comparison Analysis

Section 2-3 deals with the identification of benefits which are capitalized into land value by using the land price function. But this lacks the generality in the sense of accuracy of the function. This section attempts to measure actual capital gains of land value due to construction of a new suburban line.

The Method

In order to identify the capital gains associated with transportation investment, the effects of other investment such as other railway, highway and trunk roads projects should be excluded. In addition to this, indirect and external effects such as aggromalation or scale economy effects of industries (or commerce activities) may also be capitalized in residential land value. Thus comparison areas are carefully chosen where without suburban railway projects no other large scale investments are implemented.

The Empirical Results

The capital gains, due to transportation improvements, are measured by multiplying the average land price in the study areas by the net increase ratio of the project. This ratio is calculated as average increase ratio of land price in the study areas from base year minus that in the control area. The base years are chosen which are not influnced by the projects. The results are shown in Fig 1.

2-5 Real Estate Appraisal Analysis

Real estate appraisal method in Japan is based upon the comparison of a study lot with a similar lot of land. Comparison is made by guide mannual criteria which are determined by the experience of land appraisers. Advantages of this method are to utilize many sample points in urban areas and to evaluate micro-scopic conditions of land. The results are shown in Fig. 1.

2-6 Direct Benefits and Capital Gains

Measuring the Direct Benefits

The direct benefit of commuters in the area is estimated by the following formula.

Direct time saving effects = F(average saving of commuting time for rail, time value, no.of work trip in a year, no.of workers in the study area).

To measure the valuation of time for work trips, hourly income approach is taken assuming average working day per year and 6 % discount rate is adopted. From 1978 and 1968 person trip date, distribution of work place of residents and numbers of rail trips for commuting are estimated. Then we can get potential benefit which includes future and of those who may use rail for commuting.

Capitalization Process

Fig 2,3,4 show the relationship between capital gains estimated by study and control area comparison method and direct benefits in time horizon. In all study areas, soon after the line was opened, the capital gains amounted to as much as time saving effects of commuters. Especially this is true in Denentoshi Line. However after 5 years capital gains in all districts are as 1.1 and 2.9 times large as the time saving effects of commuters. It implies there exist large amount of non-work trip benefits as well as indirect benefits. The discrepancy between the time saving effects of work trip and capital gains are remarkably large in Denentoshi Line. In this district large shopping centers opened both in early stages

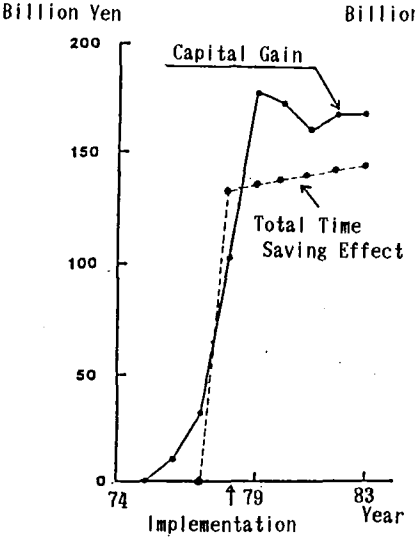

Fig.2 Capital Gains and Benefits
(Kita-Ayase)

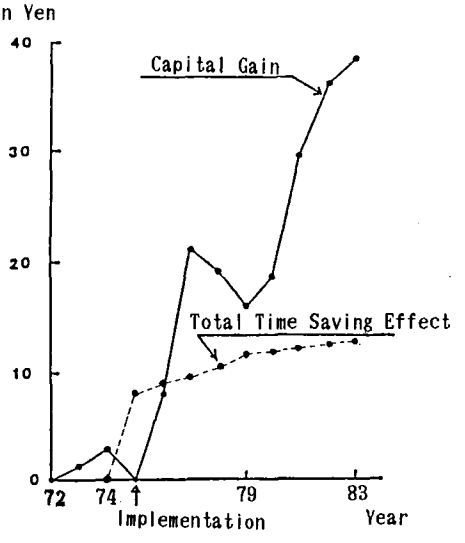

Fig.3 Capital Gains and Benefits
(Tsukimino)

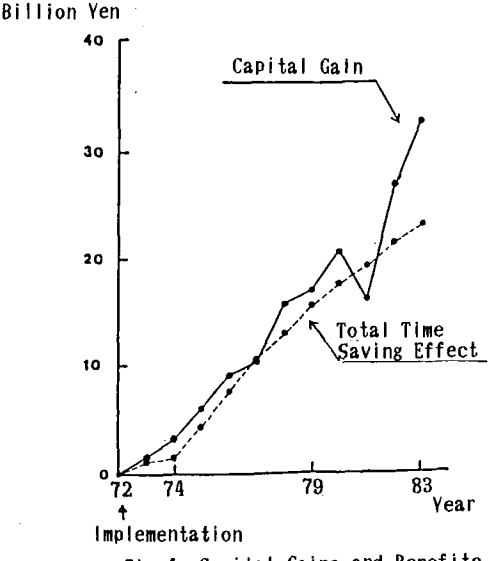

Fig.4 Capital Gains and Benefits
(Misato)

of residential development and in recent years. Moreover Shibuya which is nearest CBD to Denentoshi Line has developed during the time period. These development clearly reduced the generalized costs of shopping trips which are not measured in this study. This is also justified by the fact that shopping accessibility have significant influence in land price function estimated in section 4. Considering these effects after 1980 in Denentoshi Line, this empirical result supports the hyothesis of capitalization of transportation improvement into land value in few years.

Commuter's Time Saving Effects and Capital Gains

These land price increases estimated amount to about at least 80 % to 200-300 % of total direct time saving benefit (see Fig 1). In order to evaluate these capitaization ratio, we should consider following items :

i) These projects were announced before the base years. The land price in the base years may be already somehow capitalized future expected utilities.

ii) Estimated time valuation used in this study may differ from those on study areas. However this effect seems relatively small when we consider the fact that the income differences among commuters to CBD of Tokyo who are willing to purchase land for housing are small in Tokyo Metropolitan Region.

iii)Estimated capital gains by study and control area comparison method can not exclude the impacts of other factors which may influence land price increase.

It should be noted that during 1970 and 1985 immigration from outside of Tokyo Metropolitan Region still exists. Thus the open-small city assumption was mostly satisfied. Although there have been several assumptions about these comparisons, time saving benefit can be said capitalized into land value.

3. Estimation of Capital Gains and Benefits and Costs of Related Groups

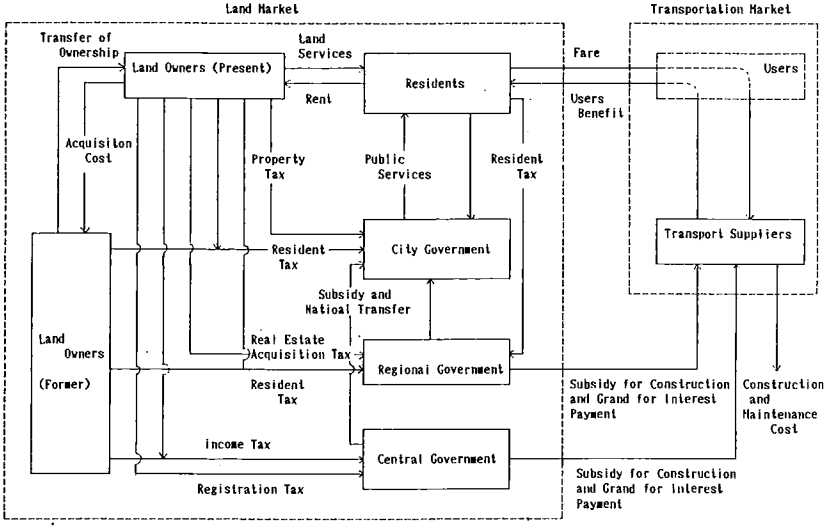

Fig.5 Diagramatic Relationship of Benefits and Costs of the Related Groups

3-1 Capital Gains and Benefits and Costs of Related Groups

In order to disaggregate benefits and costs into those of groups, first it is necessary to identify related groups.
There are several major individuals and groups who are directly influenced by the railway improvement projects in suburban areas, viz. i) users ii) land owners iii) residents iv) railway suppliers (including operators), v) local and other governments. Enterprises are of course important to project evaluation, however, in suburban areas small numbers of companies could suffer the effects compared with residents. The relationships of benefits and costs of these groups can be summarized in Fig 5. This diagram shows that these variables are strongly related with land market and with the institutional condition. Among various indicaters, capital gains (land price) can explain the major benefits and costs of related groups.

3-2 Estimation of Net Benefits and Costs of the Projects by Related Groups

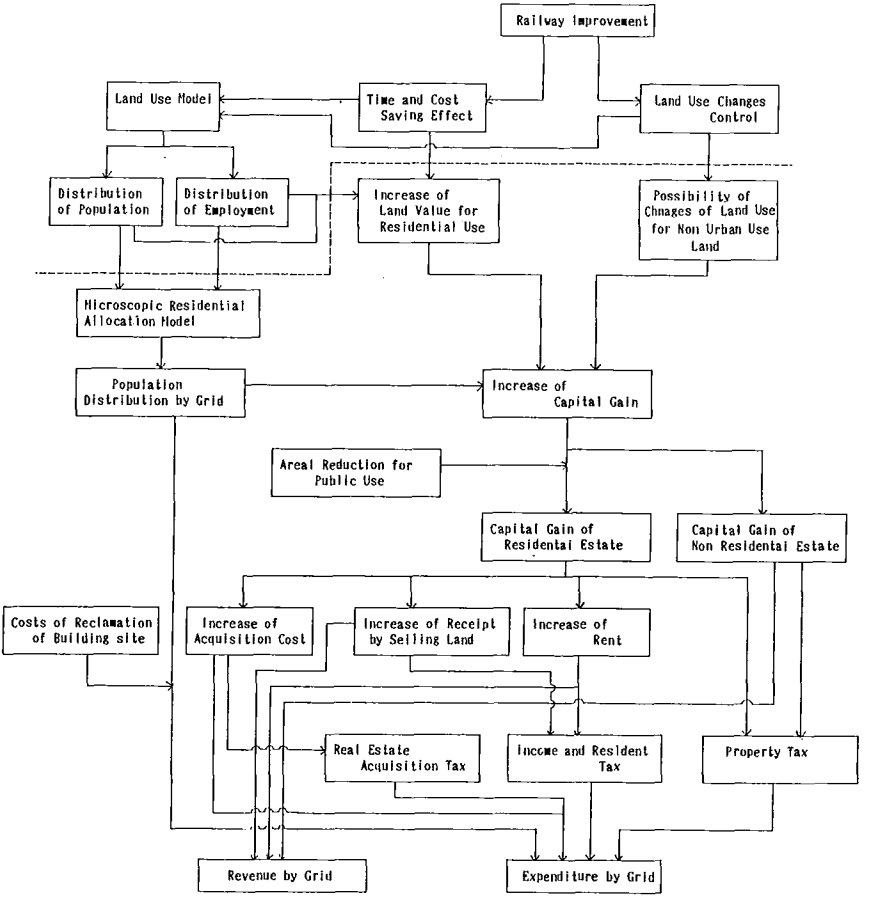

Fig.6 Revenue and Expenditure of Land Owners

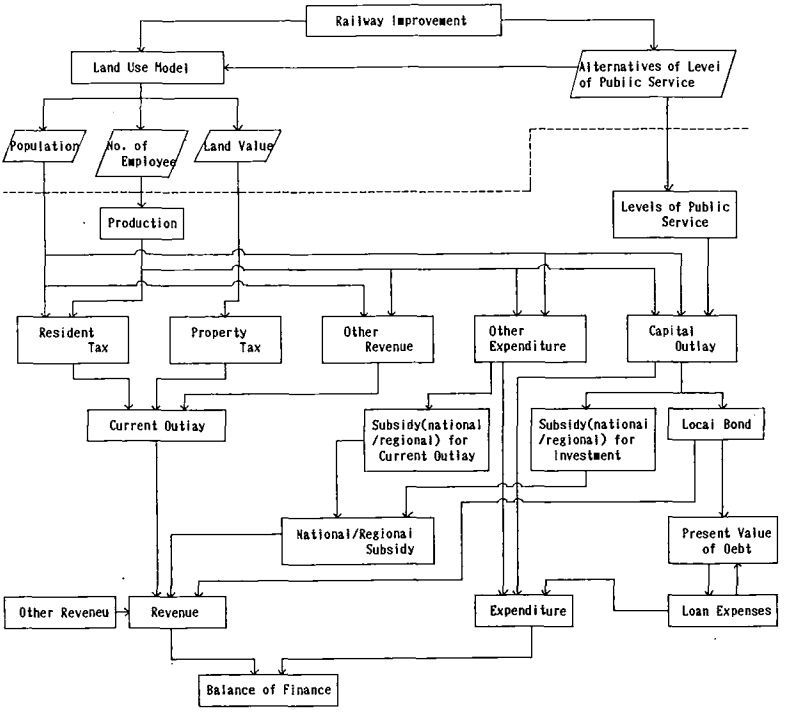

Fig.7 Estimation of Local Government Finance

This study develops a new analysis system to depict the benefits and costs discussed in section 3-1 using land use model and other sub-models such as land owner, local finance models. Based upon the impacts of railway improvement projects on land use patterns, and the zonal distribution of population and employment in Metropolitan Tokyo estimated by CALUTAS developed by H. Nakamura, distribution of residents in each zone at one square kilometer grid level is estimated by the micro scopic residential allocation model. Fig 6 shows the relationship between land use models and land owner's benefits and costs estimation as discussed in the last section, benefits and costs are strongly related to changes of land price and transfer of owership. Fig 7 also shows the diagram of local government finance. This model includes econometric model for expenditure and general revenue equations and institutional equations for taxes based on property value. Since these models are quite complicated to be discussed here, refer to the other papers (Hidano (1975) Hidano & Nakamura (1986)). The validity of all models are also examined in these papers.

4. Expost and Exante Analysis of Railway Improvement Projects

4-1 The Estimation of Net Benefits Distributed Among Groups in Misato District of Tokyo Metropolian Region

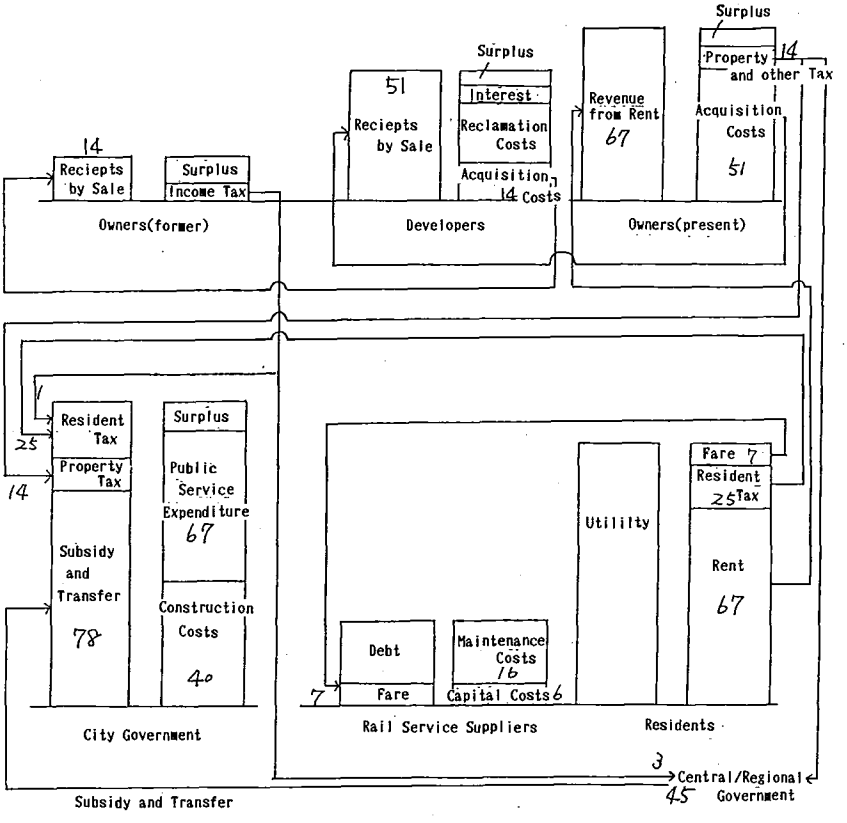

Fig.8 Cumulative Balance Sheet of Benefits and Costs

(1973-82) (Billion Yen 1982 value)

Fig 8 depicts the results of the expost analysis of Musashino Line project. This shows the accumulative benefits and costs of related groups during 1973 and 1982 at 1982's value. Discount rate is 6 % annum. It is clear that landowners and developers have enjoyed about 10 billion net benefits from the project. On the other hand, railway service supplier (including operator) has lost 15 billion yen during the same period of time.

4-2 The Future Estimation of Balance Sheet of Benefits and Costs

Using the system in section 3, the exante analysis is conducted taking North East New Line Project as a case. The estimation is done from 1980 to 2015. For the land owner's benefit estimation, Table 4 and 5 show the land price functions of residential lots in the areas where urban land use is encouraged and in the areas where urban land use is prohibited officially. The dynamic changes of discounted cash flow in the time horizen are shown in Fig 9. Based upon this information, we can discuss many alternative measures for equitable cost bearing of urban railway improvement.

Table 4. Estimated Parameter in Suburban Areas
(Residential Land in Area for Urban Use)

Variables	Coefficent	t-statistics
Width of Road (m)	7.6	1.8
Distance to the Nearest Station (100m)	−18.2	−12.4
Accessibilty to Retail Services (person/km²)	18.4	11.0
Non Residential Use Dummy	−36.4	− 3.8
Water Supply Dummy	12.4	1.7
Gas Service Dummy	8.9	3.3
Sewerage Service Dummy	9.2	3.1
Irregular Site Dummy	− 8.8	− 1.9
Avarage Commuting Time (minutes)	−81.9	−18.3
Density of Job Oppotunity (person/km²)	133.6	6.8
Constant	−341.2	
R	0.92	
Sample Size	460	

$y=\sum_i \alpha_i \ln X_i$ (1000 yen,1984 price)

Table 5. Estimated Parameter in Suburban Areas
(Residential Land in Area for Non Urban Use)

Variable	Coefficient	t-statistics
Distance to the Nearest Station (100m)	−0.49	−1.6
Accessibility to Retail service (person/km²)	2.58	7.0
Avarage Commuting time (minutes)	−1.75	−2.7
Density of Job Oppotunity (person/km²)	2.10	1.6
Constant	−246.1	
R	0.83	
Sample Size	59	

$y=\sum_i \alpha_i \ln X_i$ (1000 yen,1984 price)

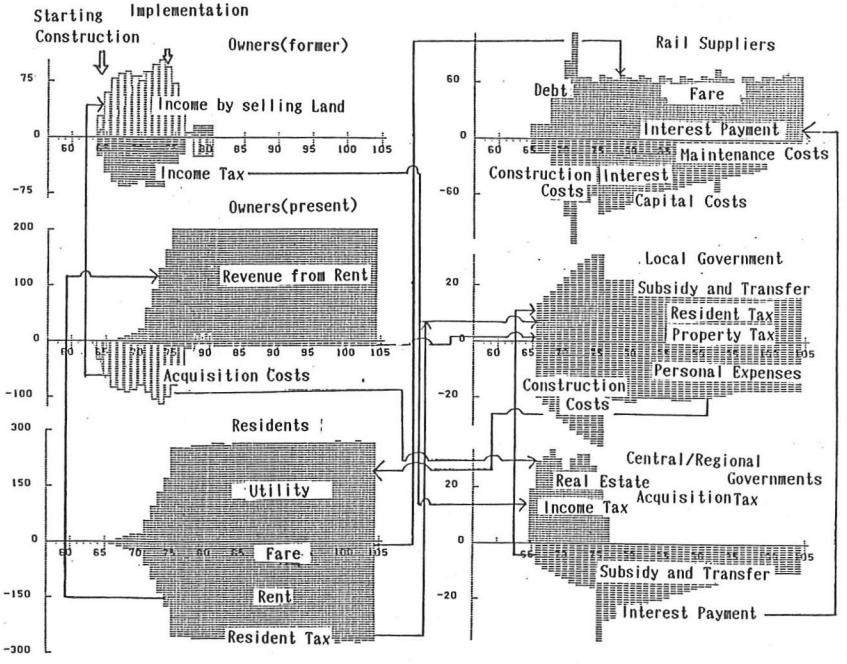

Fig.9 Gain and Loss of Related Group in Time

5. Concluding Remarks

This paper attempts to examine how the effects of new suburban lines should be capitalized into land value and to justify the possibily to utilize capital gain as a unified measurement of the effects of suburban railway lines projects and to construct an analysis system to measure the benefits and costs of related group. First the study adopted three approaches to test the hypothesis, i.e. land price function approach, study and control area comparison and real estate appraisal method. All results support the hypothesis and show that the direct benefits of commuters are catitalized in few years time period when population growth is resonably high. Second the analysis system to identify the benefits and costs of related groups is developed including land use, local finance, land owner submodels. The applicability of the system is demonstrated using expost and exante analysis in Tokyo Metroplitan Region as cases.

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