Commuting and Land Prices in the Tokyo Metropolitan Area

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We would like to dedicate this paper to Takao Fukuchi, our common teacher, who ignited our interests in the issues discussed here many years ago.

INTRODUCTION

Why are land prices in Tokyo so high compared to those in other major cities of the world? Many explanations have been given, such as land and building lease laws, low assessments of land under the inheritance tax, and the "bubble".[1] These are not mutually exclusive explanations, and no doubt the accumulated effect of these factors accounts for a good portion of the high land prices in Tokyo.

Yet the most basic factor is often neglected in the discussion of the causes of the high land prices in Tokyo: Tokyo is by far the largest metropolitan area in the industrialized world. Figure 1, which is based on Table 1, shows that it is twice as large as the second largest -- New York -- both in population and employment.[2]

As Mills (1967, 1972) and Muth (1969) pointed out, a city with lower commuting cost per kilometer will have a larger population size and higher residential land price than another city with the identical labor productivity at its central business district (CBD) but with a relatively higher commuting cost per kilometer. If the population of New York were doubled keeping the current commuting facilities intact, traffic congestion would become prohibitive. In this sense, the availability of a network of well-developed commuter railroads keeps the commuting cost in Tokyo lower than in New York. This may be the main reason why population size and land price are higher in Tokyo than in New York.

A government intervention policy also contributes to make the commuting cost in Japan artificially low. In fact, the Japanese commuters generally pay no commuting expenses at all; their employers reimburse them. Employers do this because the additional wage payment earmarked to cover the commuting expenses is, up to a generous limit, not taxable under personal and corporate income taxes. Employers can reduce the combined tax payments made by themselves and their employees by reimbursing the commuting fares while reducing the average of the regular wage rate. Note that under this scheme, the larger the city size is, the larger the government subsidy given to the average resident.

Free commuter riding gives strong incentives to the employees to live further away from the city center than otherwise. This makes the city larger than otherwise in terms of both geographical size and population. Moreover, the free ride makes the population density and land price distribution from the CBD flatter than otherwise, as the Mills-Muth theory implies.

The present study has three major aims. First, we will study differences in the population and employment distributions of Tokyo and New York, and examine how the different commuting environments of the two areas explain these distributions. As the Mills-Muth theory shows, the population density function in the residential district of a city has an intimate relationship with the land price function there. The employment density function in the CBD also has a close relationship with the land price function there. Although data on land prices are not available for New York, population and employment density data are available for both Tokyo and New York. A comparison of the latter will shed light on the distribution of the land prices in Tokyo.

Second, we will empirically examine the impact of abolishing the preferential tax treatment of free commuter riding upon the land price structure and the size of the Tokyo Metropolitan Area. Our result shows, for example, that the land price at Toyoda, which is 54 minutes away from

Tokyo, would be realized in Nishikokubunji, which is 47 minutes away from Tokyo, if commuters themselves are made to pay commuter pass fares. To this end, we will first estimate the land price function for Tokyo using micro data on residential land price and distance from Tokyo.

Third, we will evaluate the current urban economic policies in Tokyo regarding the CBD development and commuter transportation from the view point of whether they help attain an efficient resource allocation. It will be shown that the various existing policies have consistently made both population and employment density distributions flatter than efficiency requires.

The existing literature on the estimation of the land price function, such as Muth (1968), Mills (1972), Kau and Sirmans (1979), Mills and Hamilton (1984), Ohkawara (1985), and Alperovich (1990), assumes that commuters pay the monetary expense of commuting. In estimating our land price function for Tokyo, we take into account the fact that commuters actually pay commuting costs only in terms of time and fatigue.

Haurin (1983) studies the effects of the reimbursement of commuting expenses upon profits of the CBD firms, the population density distribution, and efficiency, assuming that the city is closed. When an open city is considered, however, entry of new firms bids up the land price until profits are wiped out. In the present paper, we examine the effect of the reimbursement upon the land price as well as upon population density, assuming that such competition exists at least in the long run.

Section I will compare the population and employment densities between Tokyo and New York, and make three stylized observations. Section II presents a simplified version of the Mills-Muth model. Section III explains the stylized observations in the theoretical framework of Section

II. Sections IV through VI empirically estimate the land price function of Tokyo. Section VII will discuss the policy implications of our theoretical and empirical observations. A summary of the paper is given in Section VIII.

I. TOKYO'S POPULATION AND EMPLOYMENT: FACTS

A. Residential Population.

Table 1 compares the residential population in the metropolitan areas of Tokyo, New York, London, and Paris. It shows that the residential population of the Tokyo Metropolitan Area with 29 million is approximately twice as large as that of New York with 16 million, and more than twice as large as London or Paris.

The metropolitan area of Tokyo in this table consists of the four prefectures of Tokyo, Kanagawa, Chiba, and Saitama, the map of which is given in Figure 2. For the three other metropolises, areas of similar geographical sizes are chosen. In the case of New York, for example, the seven most densely populated Primary Metropolitan Statistical Areas (PMSAs) in the New York–New Jersey–Connecticut Consolidated Metropolitan Statistical Area (NY-NJ-CT CMSA) are chosen, as listed in Table 2. This area is the NY-NJ-CT CMSA minus Monmouth-Ocean, the NJ PMSA and Orange County, and the NY PMSA; the area includes Fairfield, Middlesex, and Hunterdon, for example.

The above statistics are apparently in conflict with the obvious observation that downtown Tokyo has far fewer skyscrapers than Manhattan. Indeed, Figure 3 and Table 3 show that the population density of the central $60km^2$ in Tokyo is one-half of that in New York. The area of Tokyo we chose for this comparison consists of the Chiyoda, Chuo, Minato, and Shinjuku Wards, the map of which is shown in Figure 4. The counterpart in New York is Manhattan. The top panel of Table 3 shows that the population density of the Chiyoda Ward is less than one-sixth of a CBD area in Manhattan that has a population twice as large the Chiyoda Ward. This is also illustrated in Figure 3.

Table 4 through 6 further break down the population density figures of the various areas of the Tokyo Metropolitan Area in Table 8. Table 7 breaks down the figures for the New York Metropolitan Area. Figure 3 is ultimately based on these tables.

Figure 3 indicates that the population density of New York is the highest near the CBD and declines as the area expands. In Tokyo, on the contrary, population density is very low at the central districts, and increases as the area is expanded up to 240km^2. As a result, Tokyo has a higher population density than New York in an area with the size of Manhattan plus Brooklyn. As the area becomes larger, the gap in the population density grows. Thus the population density of New York starts out at a high level near the center and drops sharply as the area is expanded, while the density of Tokyo starts out at a lower level and increases first and then declines more slowly than that of New York.

B. Employment.

Table 1 shows that the Tokyo Metropolitan Area employs 13.5 million, while the New York Metropolitan Area employs only 6.9 million (roughly one-half of the employment in the Tokyo Metropolitan Area), and London and Paris Metropolitan Areas employ even less. Table 8 compares the employment densities of Tokyo and New York for various area sizes, and Figure 5 illustrates this. They show that Tokyo employs twice as many as New York in 600 km^2 areas, which is the 23 Ward District in Tokyo and the combined area of Manhattan, Queens, Bronx, and Brooklyn in New York. Moreover, this table shows that Tokyo employs more than New York even in a central 60km^2 area, which is the combined area of Chiyoda, Chuo, Minato, and Shinjuku Wards in Tokyo and Manhattan in New York.[3]

Near the center of the city, however, the opposite is observed. Figure 5, which is based on Table 8, illustrates that the combined 20km^2 area of Chiyoda and Chuo Wards has a smaller population than a comparable area of South Manhattan. Moreover, the Chiyoda Ward itself employs less than three-fourth of the area in New York with roughly the same area size.[4] A detailed breakdown of population densities is given in Table 9 for the Ward District of Tokyo, and in Table 10 for South Manhattan.

C. Summery Observations.

Our observations may be summarized as follows:

1. Population and employment sizes of the entire metropolitan area of Tokyo are twice as large as that of New York.

2. The CBD of Tokyo is under-utilized relative to the CBD of New York. The employment density of the CBD of Tokyo is less than 3/4 of the corresponding area in New York, while population density of the CBD of Tokyo is less than 1/6 of that of New York.

3. The population density curve is flatter in the Tokyo suburbs than in the New York suburbs. (As the area size is increased, the population density increases first and then declines in Tokyo, while it monotonically declines in New York.) The employment density curve is flatter in Tokyo than in New York in all area sizes.

II. A THEORY OF COMMUTING COSTS, LAND PRICES, AND POPULATION DENSITIES

As a preparation to explain the reasons for the above differences between Tokyo and New York in the next section, we now discuss the relevant aspect of the Mills-Muth model of an urban economy.

A. Commuting Cost and Metropolitan Size.

The fundamental reason why megalopolises like Tokyo and New York exist is the agglomeration economies in production, i.e., the benefits which firms can obtain from each other when they are located in the same city. When a firm is located in the CBD of a large city, costs of communication with other firms in the city are reduced both in terms of face-to-face and telephone contacts. Besides, a firm in a large city can enjoy business support services, such as computer maintenance, elevator maintenance, office cleaning, and business consulting. Moreover, public facilities such as communication and transportation facilities are subject to considerable scale economies. Thus new firms are attracted to a large city. These newcomers to the city further emit external economies to other firms in the same city, and encourage even more firms to move into the city.

This virtuous cycle of agglomeration economies increases the productivity of the firms at the CBD, enabling them to pay much higher wage rates than the rural firms. This wage rate difference attracts workers from the rural area to the city.

But the immigration will not continue indefinitely. The urban workers have to pay commuting costs, which consist of train fares, auto expenses, time, and fatigue. We will call the CBD wage rate minus the monetary equivalent of the commuting cost at a given location the net urban wage rate at the location. It declines as the distance between the CBD and the location is increased. At a location too far from the CBD, the net urban wage rate would become lower than the rural wage rate.

Assume that people are homogeneous and free migration takes place between the city and the rural area. Then a resident at a border between the metropolitan area and the rural area should be indifferent between commuting to the CBD and working in the rural area. If we assume that the rural workers pay zero commuting costs, the net urban wage rate at the border must be equal to the rural wage rate.

Figure 6(a) illustrates the determination of the boundary of the metropolitan area. The rural wage rate, $\bar{w}$, and the CBD wage rate, w^0, are marked on the vertical axis. The net urban wage rate at each location, i.e., the CBD wage rate minus the commuting cost from the location to the CBD, is depicted by the thick line under the assumption that the commuting cost is proportional to the distance from the CBD. The metropolitan area ends at a distance where the thick line reaches the level of the rural wage rate. The distance between the CBD and a border is represented by $\bar{x}$ on the horizontal axis.

The figure makes it clear that the commuting cost at the border reflects the labor productivity difference between the CBD and the rural area. If the CBD productivity is increased, the thick line in Figure 6(a) will shift right ward, and the city size will increase both geographically and demographically. If the transportation cost is reduced, the thick line in Figure 6(a) will become flatter and $\bar{x}$ will increase. This of course implies that if the transportation cost of a city is cheaper in one city than in another city with an identical CBD productivity, the geographic and demographic sizes of the former city will be greater than the latter.

B. Land Prices and Population Density.

Due to the assumption of free migration, a person must be indifferent between living at any location in the city and living in the rural area at an equilibrium. Suppose that a worker living close to the CBD enjoyed a higher living standard than a border worker. Then all of the rural residents would want to migrate near the CBD. Hence the housing rent near the CBD would go up until the living standard of the residents there becomes exactly equal to the living standard at the rural area.

The thick line in Figure 6 (b) represents the housing rent curve, which is derived from the net urban wage rate curve depicted in Figure 5 (a). When non-housing consumption is substitutable for housing floor space in consumption, the population density increases as the location becomes closer to the city center, and hence the housing rent curve is convex to the origin.[5]

If land and capital are substitutable in housing production, moreover, the increase in the housing rent will encourage construction of high-rise buildings, and the floor space per square kilometer of land will expand near the CBD. The land rent curve then becomes more curved toward the origin in comparison to the housing rent curve.[6] Thus the shape of the housing rent curve and the factor substitutability in the housing industry determines the curvature of the land rent curve, as depicted in Figure 6(c).

If either the utility function or the production function or both are substitutable, the land space per resident becomes smaller, i.e., the population density increases, as the location becomes closer to the CBD. The reasoning above suggests that this causes the land rent function to be curved to the origin. We might conclude, therefore, that the steeper the population density curve, the steeper the land rent curve.[7] Indeed, we will later show in equation (8) that the land rent curve and the population density curve are proportional in the economy with Cobb-Douglas utility and production functions when the commuting cost consists of only time and fatigue.

The land price curve is vertically proportional to the land rent curve if the land price is equal to the present value of the future land rent and if a proportional future increase in the land rent is expected regardless of the location. The equality between the land price and the present value of the rent income stream does not hold if "bubbles" prevent the fundamentals from being reflected in the land prices. But so long as the "bubble" effect is proportional to the present value of the future land rent stream regardless of the location in the city, we may still view the land price curve to be vertically proportional to the land rent curve.

These observations yield the following proposition regarding the effect of a change in the commuting cost upon the land price curve and the population density curve.

Proposition 1.

Suppose that the commuting cost per kilometer is reduced, keeping the CBD productivity constant. Then the following hold:

(i) The y-axis intercept of the land price curve remains the same. However, the slope of the land price curve becomes flatter, and the level of $\bar{x}$ is increased.

(ii) The y-axis intercept of the population density curve remains the same, but the slope of the population density curve becomes flatter.

C. Agglomeration Economies.

It was pointed out in Section II that agglomeration economies are the source of the high labor productivity at the CBD in large metropolitan areas. In the present section, however, we have so far implicitly assumed that the labor productivity at the CBD is kept constant while the per-kilometer commuting cost is changed. Since a change in commuting cost implies a change in the urban population size, this amounts to implicitly assuming that the agglomeration economies are already exhausted at the CBD, and the production function obeys constant returns to scale at a high level of efficiency.

This artificial separation between the urban population size and the CBD productivity is conceptually convenient. But Proposition 1 can be easily modified to the situations where an increase in the employment size at the CBD still causes agglomeration economies. We will assume external economies of scale. Thus each firm perceives its production function to be constant returns to scale but the production in the CBD as a whole obeys increasing returns to scale.

Then we have the following:

Proposition 2.

Suppose that the commuting cost per kilometer is reduced in an economy where the CBD technology is subject to external economies of scale. Then the following hold:

(i) The y-axis intercept of the land price curve is increased, the slope of the land price curve becomes flatter for each land price, and the level of $\bar{x}$ is increased.

(ii) The y-axis intercept of the population density curve is increased, and the slope of the population density curve becomes flatter for each density level.

Roughly speaking, various effects of a per-kilometer transportation cost is magnified when the CBD technology is subject to external economies of scale.

D. Idiosyncratic Consumers.

In deriving the above propositions, we assumed that all consumers are alike. But the existence of a relatively small number of idiosyncratic consumers does not affect the shapes of the land price and population density curves.

Suppose, for example, that there is a group of talented persons who get higher wages at the CBD than other workers, even though they earn the same wages as others if they work in the rural area. Their reservation land price at an urban location, i.e., the one that would make them feel indifferent about the choice between that location and the border will be higher than the reservation land price for the homogeneous consumers. If there is a sufficiently small number of these talented people, however, the amount of land demanded of a given location at their reservation land price will be below the amount supplied. In this case, the talented people will not be the marginal buyers of land; the market clearing price will be the one obtained from the homogeneous consumers.[8]

E. Business Land Use.

So far we have implicitly assumed that the CBD firms use a minuscule amount of land. Obviously this is not the case in reality. Suppose that the CBD production uses land, capital, and labor. Also assume that the productivity decreases as a firm is located further away from the city center. Then the line AC in Figure 7 (a) depicts the business land price curve that shows the land prices for various locations under which business firms would be indifferent in their locational choice. If the business firms demand large enough amounts of land in the CBD district to become the marginal buyers, they will outbid the demand for residential use; consequently, the business land prices become the market prices, and the line ABD will become the market price line.

The commuters working in the AB region may first go to the city center by train and then reach their work place from the city center through other transportation modes. In that case, the firms must compensate the additional trip cost from the city center to the work places, and it will be a part of the causes of the reduced productivity of the firms represented by the declining AB curve.

For some work places near B it may be less expensive for commuters to reach directly without detouring through the city center. If these commuters received the same wage rate as the workers at the center, they would be better off than the workers at the center, which would entice more people to work near B. This will drive down the wage rate near B until it becomes equal to the location's net urban wage rate for the workers at the center.

Some grocery shops may find it more profitable to be located in the middle of the suburbs rather than near the CBD. If they are not marginal land buyers, however, they will not affect the market land prices. If a shopping center in a suburb is large enough to be a local marginal land buyer, it will outbid the residents and the land price curve will become as in Figure 7(b). Workers commuting to these suburban work places will bid down their wage rates until they become equal to to the location's net urban wage rate for the workers at the center.

These observations suggest that when small work places are spread all over the metropolitan area, workers will be commuting from suburbs further away from the CBD to non-CBD work places, but they will not affect the shape of the market land price curve for the residential districts. Figure 7(b) suggests that even if a major shopping center exists, it will not necessarily affect the residential land prices in the area away from the CBD and the shopping center.

F. Summary.

In the present section, we have shown that in a Mills-Muth model of a concentric city, a reduction in the transportation cost makes a city larger both geographically and demographically, while it makes the land price and population density curves flatter. We have also demonstrated that the land price and population density curves will stay the same even if the assumptions of homogeneous consumers and concentration of employment at the city center are violated to some extent.

III. TOKYO'S POPULATION AND EMPLOYMENT: AN EXPLANATION

We are now in a position to explain the three major differences in the structural characteristics between Tokyo and New York in the theoretical framework outlined above.

A. The Size of the Metropolitan Area.

1. Dependence on the Railroad System.

We have seen in the previous section that the higher the productivity at the CBD is and the lower the cost of commuting is, the larger is the city size. Since the major source of the high productivity at their CBD of Tokyo or New York is the agglomeration economies, the size of the CBD employment itself affects the productivity of the city. Thus commuting cost must be the major independent factor that determines the difference in the sizes of New York and Tokyo.

Figure 8, which is based on Table 11, indicates that 59% of the commuters to Manhattan and 88% of the commuters to the four central wards of Tokyo use the railroad. Table 11 shows that 93% of the commuters to the Chiyoda Ward use the railroad for commuting.

Passenger cars play a negligible role in commuting to the CBD of Tokyo. Table 11 shows that in 1980 only 5% of the commuters to the four central wards of Tokyo used passenger cars and taxis. On the other hand, 18% used passenger cars and taxis to commute to Manhattan. Moreover, many railroad commuters to Manhattan use passenger cars from home to railroad stations, while Tokyo railroad commuters walk, bicycle, or take the bus to railroad stations. Compared with New York commuters, therefore, Tokyo commuters rely less on passenger cars and more on railroads.

Table 12 shows that subways carry twice as many passengers in Tokyo as in New York. Moreover, suburban commuter trains play a even more important role than subways in Tokyo, while the opposite is the case in New York. The subway system carries only 21% of the railroad passengers in Tokyo, while it carries 83% of them in New York.[9]

Indeed, the Tokyo railroad system carries at least five times as many commuters as the New York system. In 1980 the total number of passengers with commuting passes was 7.1 billion for the railroad system in the "Tokyo Commuting Area" as defined by Unyu Keizai Kenkyu Center. In the same year, the total number of commuters to work was 1.4 billion for the railroad system in the "Tri-State Region" as defined by the Tri-State Regional Planning Commission,[10] which has an area of more than twice the size of the "Tokyo Commuting Area".

If the population of New York were doubled keeping the current commuting facilities intact, traffic congestion would become prohibitive. In this sense, the availability of a network of well developed commuter railroads keeps the commuting cost in Tokyo lower than in New York. This may be the main reason why population size is higher in Tokyo than in New York.

2. Demand and Supply for the Railroad Systems.

In Tokyo, a higher railroad to automobile ratio than in New York is demanded for commuting for two reasons.

First, the commuter train service runs more frequently in Tokyo than in New York, making a train ride more attractive to commuters in Tokyo than those in New York. For example, a Chuo Line train for Tokyo Station stops at Mitaka every 2 minutes during the rash hour, but a New Haven Line train for Grand Central Station stops at Larchmont every 20 minutes, while both Mitaka and Larchmont are 30 minutes away from the respective terminal stations.

Second, commuting cost from home to the nearby suburban train station is cheaper in Tokyo than in New York. Frequent and inexpensive bus services are available to most suburban train stations in Tokyo, while driving passenger cars is often necessary to reach suburban train stations in the New York area. Suburban communities in Tokyo were developed in such a way that the residents can either walk, ride a bicycle, or take a bus to railroad stations, because suburbs were developed before motorization. The resulting high population density in suburbs makes frequent bus service to the train station possible. In the New York area, where many suburbs were developed after motorization, it was taken for granted that most commuters drive cars to the suburban railroad stations. Hence suburban communities with low population densities emerged. As a result, relatively few people live within walking distance of a suburban train station, and bus service to many suburban train stations is not even available.

On the supply side, the railroad services in Tokyo are voluminous and frequent for two reasons.

First, a higher level of fixed investment was made in the train system than in the highway system during the period when Tokyo was suburbanized. This is because the suburbanization of Tokyo took place before passenger cars became affordable to most residents.

Second, the high population density in the Tokyo area makes frequent commuter services profitable. Except for interest subsidies for certain types of investments, commuter train firms in Tokyo operate in the black without government subsidies.[11] This makes them remarkably different from their American and European counterparts.

An examination of demand and supply factors above implies that agglomeration economies exist in the production of mass transit services. Scale economies can always give rise to multiple equilibria. Once the density exceeds a critical level, an equilibrium in a metropolitan area is reached with high population density and with a profitable mass transit system. But if the critical level is not attained, a different equilibrium is reached with a low density requiring passenger cars as a mode of commuting. It appears that the historical accident helped Tokyo reach the level of suburban density above the "critical level."

B. Under-Utilization of the CBD.

1. Employment.

The Tokyo metropolitan area has a population size twice as large as that of the New York Metropolitan Area owing to a better developed transit system. Thus it would be only natural if the CBD of Tokyo should have a higher employment density than that of New York.

In reality, the employment density of Tokyo is lower than that of New York; the space of the CBD area of Tokyo is considerably under-utilized relative to that of New York. Three historical and institutional factors can explain this phenomenon.

The first factor is that the building code used to restrict the height of buildings in Japan until 1970, when advancement in aseismic construction technology made the restriction unnecessary. In the area with convenient traffic access, low level buildings already had been constructed by the time the restriction was removed.

Second, land and building lease laws have prevented conversions of one and two story residential housing into skyscrapers.[12]

Third, other restrictions on building size such as the "Sun Shine Law" makes construction of skyscrapers more expensive.

Owing to these historical and institutional frictions, therefore, Tokyo is out of equilibrium with respect to its CBD employment density. It appears, however, that the CBD in Tokyo is in the adjustment process and is moving toward an equilibrium with a high employment density. Evidence for this is that the employment in the Tokyo CBD has been rapidly expanding relative to the larger business districts, as Figure 9 and Table 13 indicate.

Besides, the market seems to realize that the CBD in Tokyo is in an adjustment phase. Noguchi (1991) points out that the land price in Tokyo is much higher than the present value of the future office rent stream if the rent is assumed to increase in proportion to GNP. When the potentially high employment density is realized in the future by overcoming the above frictions, a square kilometer of land in the CBD will be able to command a much higher land rent than now. In a competitive economy, such future productivity increases in land must be already capitalized in the present land price. Noguchi's observation seems to imply that the market expects such a rapid increase in the land productivity at the CBD.

Moreover, the market seems to expect Tokyo to have an even higher CBD land rent than New York. Currently, we observe a higher CBD land price in Tokyo than in New York despite a lower employment density. It is certainly possible to explain a part of this gap in terms of the "bubble," as Noguchi does. But the gap is also consistent with the hypothesis that the market expects Tokyo to have a higher employment density in the CBD than New York in the future to match its larger population and employment sizes in the entire metropolitan area. Suppose that the equilibrium is restored and the CBD of Tokyo attains a higher employment density than that of New York in the future. Then agglomeration economies would enable Tokyo to have a higher labor productivity, and hence higher rents and land prices, than New York. The gap in the CBD land prices of the two cities is consistent with such a business expectation.

2. Residential Population.

The population density of the CBD is also lower in Tokyo than in New York. But Tokyo's low CBD density does not require special explanations; the business sector can outbid the household sector for the CBD land use in any city in any country. Moreover, the three explanations for the low employment density in the CBD of Tokyo also give additional account for the low population density.

It is the high density in the CBD of New York that requires a special explanation, although we will not venture into this topic here except to note that strict zoning in New York protects residential areas in the middle of its CBD.

C. Flat Population Density Curve.

Figure 3 shows that the population density curve for the suburbs of Tokyo is flatter than the curve for New York. One possible explanation may lie in the fact that the commuter trains in Tokyo maintain fast, accurate, and frequent services, which keep the per-kilometer cost of travel in Tokyo low.

In addition, employers' reimbursements of commuting expenses help keep the per-kilometer cost of travel low. Indeed, among those who bought commuter passes for the railroad in major metropolitan areas of Japan in 1985, only 5% paid the full amount of the commuting passes by themselves.[13] Employers reimburse commuting expenses because the additional wage payment earmarked to cover the commuting expenses is, up to 50,000 yen per month, not taxable under the personal income tax. This preferential tax treatment encourages employers to shift a portion of the initial total wage payment to the reimbursement of commuting expenses.[14]

Free commuter riding gives strong incentives to employees to live further away from the city center than otherwise. This makes the population density and land price distribution from the CBD flatter than otherwise. Moreover, the free ride makes the city larger than otherwise in terms of both geographical size and population. In 1985, the average commuter working in Chiyoda, Chuo, and Minato Wards spent 67 minutes in commuting one way, according to the Ministry of Transportation (1985).

IV. THE LAND PRICE FUNCTION: (1) THE MODEL

In the following three sections, we will expound on the impact of the reimbursement of commuting expenses by estimating the residential land price functions with and without reimbursement.

The basic idea for the estimation is simple. Tokyo commuters pay no monetary expenses for commuting. Hence the nonmonetary costs of commuting time and fatigue are the only reason why the land prices in Tokyo fall as the distance of a location from the CBD increases. Thus the observed land price distribution will reveal the non-monetary costs of commuting, and we should be able us to estimate the parameters of the utility function and the housing production function from the land price distribution. Once these parameters are estimated, we can derive the land price equation that would prevail when commuters have to pay their monetary commuting expenses as well.

The model we use is a formal version of the model developed in Section II. The readers not interested in technicalities may want to skip to Subsection VI.C.

A. The Demand Price Equation.

Consider a household that consumes h square meters of housing services, z units of composite consumption good, and ℓ minutes of leisure. Let

$$u(h, z, \ell) = h^{\beta} z^{1-\beta} \ell^{\alpha}$$

represent his utility function. Suppose that the hours of work is fixed. Let δ represent leisure endowment minus the sum of the time for work and the time required for minimum subsistence such as sleeping and eating. Then the leisure time ℓ is obtained by subtracting the commuting time from

δ. Assume that the household lives at a point with the commuting distance of x minutes from the CBD (hereafter we will refer to it simply as a <u>point with distance x</u>). Then we have

$$\ell = \delta - x.$$

We define the reduced utility function U by substituting this for ℓ in the function u to get,

(1) $$U(h, z, x) = h^{\beta} z^{1-\beta} (\delta - x)^{\alpha}.$$

We assume that the household located at a point with distance x maximizes its utility level under the following budget constraint:

(2) $$r(x)h + z = Y - tx,$$

where r(x) is the housing rent at distance x, Y is income, and t is the per-kilometer fare for commuting that the commuter has to pay. The unit of the compound good is so chosen as to make its unit price equal to one.

A consumer living at distance x will maximize the value of (1) subject to (2) by choosing h and z for the given Y, t, x, and r(x). The maximum utility level that the household attains under the budget constraint is given by the indirect utility function: $v^0(r(x), Y\text{-}tx, x)$.

It is assumed that the rural residents do not have to commute to work, and their utility level is $\bar{v}$. Since we assume that the household can freely migrate between the metropolitan area and the rural area seeking a higher utility level, the utility level of a household living in the metropolitan area has to be equal to that in the rural area, regardless of the distance of the residence from the CBD. At the equilibrium of the model, therefore, r(x) Y-tx, and x have to satisfy[15]

(3) $$v^0(r(x), Y\text{-}tx, x) = \bar{v}.$$

Let

$$r(x) = r^*(Y\text{-}tx, x, \bar{v})$$

be the solution function for r(x) in equation (3). Since Y, t, and $\bar{v}$ are constant in our model, this shows that the housing rent is a function solely of the commuting distance x. The function r^* is the demand price equation for the housing service at distance x. This is drawn in Figure 6(b).

B. The Supply Price Equation for Housing Services.

We assume that the production function of the housing service industry is given by:

$$H(x) = \lambda L(x)^{\nu} K(x)^{(1-\nu)},$$

where L(x) = the size of the land area that the housing service industry employs at distance x,

K(x) = the amount of capital that the housing service industry employs at distance x,

H(x) = the floor space of housing that the housing service industry produces at distance x.

We assume that each firm maximizes profit under the given technological constraint taking prices as given, and that free entry takes place in this industry, deriving the profit to zero. Then, r(x), the price of unit output of housing, must be equal to the unit cost. Thus we must have

$$r(x) = c(R(x), i),$$

where c(R(x), i) = the unit cost function,

R(x) = the land rent at distance x,

i = the interest rate.

This is the supply-price equation for the housing service that governs the relationship among the housing rent r(x), the land rent R(x), and the interest rate i at the distance x from the CBD.

C. The Market Equilibrium.

The market equilibrium requires that the demand and supply prices must be equal, and we have:

(4) $$c(R(x), i) = r^{*}(Y-tx, x, \bar{v}).$$

This equilibrium condition implicitly determines the land rent function. Let

(5) $$R(x) = R^{*}(Y-tx, x; \bar{v}, i)$$

be the solution function for R(x) in (4). This is depicted in Figure 6(c).

Let us assume that the land price of a given location is the present value of the future stream of the land rent at that location. Then the land price function P(x) is obtained by dividing (5) by i. Under our specifications of the utility and the production functions, P(x) is explicitly written as[16]

(6) $$P(x) = B\cdot(Y - tx)^{1/\beta\nu}(\delta - x)^{\alpha/\beta\nu},$$

where B is a constant containing i. Clearly, the first and the second parentheses on the RHS represent the contributions of the monetary and nonmonetary commuting costs, respectively, in determining the land price. This is the basic equation in our model determining the land price at each distance from the CBD.

D. Estimation Procedure.

Equation (6) is the land price equation to be estimated.

We cannot, however, directly estimate equation (6). The Japanese commuter does not have to pay the monetary expense of commuting, and hence t= 0 holds in (6), yielding

(7) $$P(x) = C\cdot(\delta - x)^{\alpha/\beta\nu},$$

where $C \equiv B\cdot Y^{1/\beta\nu}$. We will estimate the parameters C, $\alpha/\beta\nu$, and δ by running a regression of (7).

Although this does not give us an estimate of the parameter mix $1/\beta\nu$ that appears in (6), we can estimate it, by taking advantage of the relationship between the land price function and the population density function. Define the population density function M(x) by

$$M(x) = \frac{H(x)}{L(x)h(x)}.$$

Then we obtain[17]

(8) $$M(x) = \frac{1}{\beta\nu}\cdot\frac{i}{Y}\cdot P(x).$$

Since i and Y are constant, we can estimate the parameter mix $1/\beta\nu$ by running a regression of this equation.

V. THE LAND PRICE FUNCTION: (2) DATA

We estimate the land price function (7) and the population density function (8) by using the land price and population density data along the Chuo Line, which is a major commuter line in the Tokyo Metropolitan Area. (Figure 10 gives a map of this line and a few stations along it.) The income variance of the suburban residents along different commuter lines is considered to be wider than that along a given line. In particular, the Chuo Line is among those that are recognized for the homogeneity of income and social class along them. Besides, this line takes commuters directly to the Tokyo Station without transferring. These are our reasons for Choosing the Chuo Line as our object of study.

To estimate the two equations we need the following data: residential land price per square meter (P), the number of households per square meter (M), and the commuting time cost (t) at various locations along the Chuo

Line, and the average income (Y) and the interest rate (i).

For the land price and the time distance, the Government Benchmark Land Prices (Koji Chika) of 1985 is employed. The data contains the land price, the name of the nearest train station, and the distance from the nearest train station for each sample. We employ only the residential household samples along the Chuo Line, but exclude those samples whose nearby stations are closer than Nakano Station to the CBD. We deem that the land prices of the residential area to the east of Nakano station strongly reflect the commercial value of the land.

Among these data we choose all that are located within 1.5 kilometers, i.e., the walking distance, of the nearest station. It would be difficult to estimate the commuting time between the train station and the residential location for those who live farther away from the train station for a number of reasons. First, they may use a variety of traffic modes. Second, even if we assume that most of them use buses, the bus route may be round about and the actual time cost of riding the bus may not be proportional to the geographical distance found in the data. Third, the different frequency of the bus service will greatly affect the actual time cost. Fourth, many passengers may take trains at stations that are not geographically closest to their residences. On the other hand, the household living relatively near the station will mostly walk or ride a bicycle, and in case they use the bus, the time cost is likely to be monotonically related to the geographical distance from the nearby station.

There are 77 samples in the data that satisfy the above qualification. The unit of measurement of the land price in the present study is 10,000 yen per square meter.

The commuting of course consists of (i) the trip from the residential location to the nearby station and (ii) the train ride from the nearby station to the CBD. We will estimate the former from the data of the geographical distance between the residential location and the station. The latter will be estimated from the data on the trip time by the Rapid Train (Kaisoku) and by the Special Rapid Train (Tokubetsu Kaisoku). The unit of measurement of the time distance from the CBD is minutes required for one-way commuting per day. Table 14 lists the one-way commuting time to Tokyo Station from each station of the Chuo Line west of Shinjuku. Figure 11 shows the relationship between the time distance, which is estimated by the procedure discussed later, and the land price[18].

The Benchmark Land Price Data does not include population density in the location of each sample. Thus we use the census data of 1985 instead. First, for each of our samples, we compute the population density (N) in the basic cell district of the survey in which the sample is located. (Each cell is a square area of 500m x 500m.) Second, assuming that each household has one commuter to the CBD, we estimate the density of the commuters denoted M by

$$M = N/2.52,$$

where 2.52 represents the average number of household members in Tokyo Metropolitan Prefecture based on the Basic Survey of the Residents of 1985.

For the sake of consistency, we use the same time period in measuring commuting time, interest rate, income, and commuting expense. Since we have used one-half of a day for the strategic variable of commuting time, we will also use one-half of a day for measuring the other two variables. It is assumed that commuters work 22 days a month. To convert monthly figures of income and interest into a half-day basis, we therefore divide them by 44.

We assume that the personal income of all of the residents in the metropolitan area is constant regardless of the distance from the CBD. Our estimate of income of the representative resident is based on the figure of 4,932 thousand yen, which is the annual earning of an employee in the Tokyo Metropolitan Prefecture in 1985, as reported in the Annals of Prefectural Economic Accounting, 1988. Assuming that there is only one employee (i.e., commuter) in each household, monthly income per household is 493.2/12 = 41.1 (10 thousand yen per one-half of a day). Half-day income per household is

$$y = 41.1/44 = 0.93409.$$

As for the data of interest rates, we employed the national average loan interest rate of banks converted to one-half of a day as reported by the Japanese Economic Planning Agency (1989), which is 0.012.

VI. LAND PRICE FUNCTION: (3) ESTIMATION.

A. Estimation of (7).

Before explaining the estimation procedure, let us first state the final form of our estimation of equation (7):

$$P = e^{-9.7091+D}(174.89 - X)^{2.6750}, \tag{9}$$

where D is the dummy variable for the samples near Nakano Station and Kichijoji Station. (See Figure 10.) The variable D takes the value of 0.23309 for the samples near Nakano Station, 0.1458 for those near Kichijoji Station, and zero for all other samples. It reflects the fact that the residential land price of Nakano and Kichijoji are shifted upward because of their proximity to the commercial districts. Figure 11 gives a scatter diagram of $(X, P/e^D)$ combinations, which means that the samples of

Nakano and Kichijoji are adjusted by the dummy variables. This figure also depicts the graph of (9) with $D = 0$.

The time distance variable X is the sum of the trip time from home to the station and the trip time on the train, and it is defined by

(10) $$X = 5.2911\ L + (X_R + 0.59332\ D_E - 2.0969\ S),$$

where

L = the geographical distance between the residential location of the sample and the nearby station,

X_R = the time period of a one-way train ride between Tokyo and the nearby station of the sample by Rapid Train,

X_E = the time period of one-way train ride between Tokyo and the nearby station of the sample by Special Rapid Train,

$D_E = X_E - X_R$ if the Special Rapid Train stops at the nearby station of the sample, and zero otherwise. (The Special Rapid Train stops at Mitaka, Tachikawa, and all the stations to the west of Tachikawa.)

S = the dummy that takes the value of 1 for the samples near Mitaka or Koganei and zero otherwise.

The coefficient of L indicates that it takes an average commuter 5.2911 minutes per kilometer (which is approximately 11 km per hour) to make a trip between his residential location and the station. This implies that many of the residents living within 1.5 kilometers of a station use either bicycles or buses.

The terms in the parenthesis of equation (10) represent time spent on the train. If the Special Rapid Trains do not stop at the nearest station for the given sample, and if the station is not Nakano or Mitaka, both D_E

and S take the value of zero, and hence the time cost of the train ride is equal to the time required by the Rapid Train.

If Special Rapid Trains stop at the nearby station of a given sample, and if the station is not Nakano or Mitaka, the terms inside the parentheses become

$$X_R + 0.59332\ D_E = 0.40668\ X_R + 0.59332\ X_E.$$

This implies that the resident living near a station where Special Rapid Trains stop takes these trains about 60% of the time and Rapid Trains 40% of time.

An additional number of trains run between Koganei and Tokyo Stations, and even more trains run between Mitaka and Tokyo Stations. This means that the passengers from Koganei or Mitaka for Tokyo can take the unoccupied trains which originate at these stations, and the passengers have a better chance of getting seats rather than standing during the train ride. The coefficient of S indicates that this privilege is worth the extra 2.1 minutes of the train ride, or 4.2 minutes per day.

Finally, note that (9) indicates that δ = 175 (minutes per one-half of a day). The value of δ, therefore, is approximately 6 hours per day, a quite reasonable number in view of its definition.

Equation (9) is based on the following estimation based on the maximum likelihood method:

$$\log P = \underset{(-0.8822)}{-9.7091} + \underset{(3.3644)}{0.2331}\ D_N + \underset{(2.7875)}{0.1452}\ D_K$$

$$+ \underset{(1.4189)}{2.6750} \log[\underset{(1.9689)}{174.89} - \{\underset{(3.2247)}{5.2911}\ L + (X_R + \underset{(4.1913)}{0.59332}\ D_E - \underset{(-2.6358)}{2.0969}\ S)\}]$$

$$R^2 = 0.923748,$$

where the numbers in the parentheses are t values.

B. Estimation of (6).

Let us now derive equation (6). For this purpose, we need to estimate $1/\beta\nu$ by estimating the population density function, as we argued earlier. The OLS estimate of (8) is as follows:

$$M = \underset{(36.3666)}{5.58861} \cdot \frac{i}{Y} \cdot P. \qquad \hat{R}^2 = 0.686902.$$

Thus we obtain

(11) $$\frac{1}{\beta\nu} = 5.5886.$$

Finally, we have to estimate t in equation (6). We assume that for our samples households have to pay monetary travel expense only for the train. Thus, we run a regression of the half-day-equivalent of the fare of one month train pass fare (Z, unit: 10,000 yen) against commuting time required for a one-way trip to Tokyo Station.

$$F = \underset{(118.20)}{0.00065824}\, X \qquad \hat{R}^2 = 0.951762$$

Thus our estimate of t is

$$t = 0.00065824.$$

From this, (9), (11), and (7), we obtain the following

(12) $$P = e^{-9.28060+D}(0.93409 - 0.00065824X)^{5.5886}(174.89 - X)^{2.6750}.$$

This gives the land price at the hypothetical residential location with a zero distance to the station that is X minutes away from the Tokyo Station.

C. Implications of the Estimated Land Price Function.

The thick line in Figure 12 depicts the graph of (12) for the case where D = 0. This shows the land price function after commuters are made to pay the train fare equal to the commuter pass in 1985. The dotted line of Figure 11 is duplicated in the same diagram. The difference between the two curves shows the effect of the reimbursement of the commuting fare on the structure of the land price in the Tokyo Metropolitan Area. For example, Figure 12 indicates that the land price that was realized at Toyoda, which is 54 minutes away from Tokyo in 1985, would have been realized in Nishikokubunji, which is 47 minutes away from Tokyo.

It should be noted at this point that the effect of stopping reimbursements represented by Figure 12 is a long run effect which will be realized after the emigration process from the urban area has been completed. Immediately after the reform, the utility level of the suburban residents living near the border will be reduced. People living closer to the city center, who have lower commuting costs, will suffer a milder loss in utility. It is perhaps unrealistic to assume that many suburban residents can change jobs and emigrate to the rural area within several years after the reform. But it is likely that many of them migrate to a location closer to the city center, keeping their jobs at the CBD. This will increase the land price curve near the CBD more than Figure 12 indicates until the urban utility becomes equal regardless of location. This will discourage young people looking for jobs for the first time from working in the Tokyo Metropolitan Area. The population size of the Metropolitan Area will be reduced, and the urban land price curve will come down in the long run until the land price curve as indicated by the thick l ne of Figure 12 is restored. In this sense Figure 12 represents the long run impact of the stopping of the reimbursement.

As pointed out earlier, firms in Tokyo reimburse the commuting expenses of their employees because of the preferential treatment of the commuting expenses in personal income taxes. We can interpret the thick curve in Figure 12 to represent the land price curve after the preferential tax treatment is eliminated.

Let us now decompose the effect of the elimination of the deductibility of commuting expenses in two stages. Suppose that in the first stage the firms continue to reimburse commuting expenses, and that only at the second stage do the firms stop reimbursement. At the first stage, a Tokyo resident has to pay income tax for the reimbursement, which becomes his only monetary commuting expense. In this first stage, the land price curve will become steeper than the dotted curve in Figure 12, but its change will be smaller than the change indicated by the thick line.

This, however, is not the end of the story for the first stage. Since the government subsidy for commuting is now eliminated, the population size of the Tokyo area will be reduced. Proposition 2 indicates that this will reduce the CBD productivity. Thus the land price curve in the first stage has to start at a point lower than the y-axis intercept of the dotted curve in Figure 12.

At the second stage, firms stop reimbursements. A firm will now add the average of what it formerly paid as the reimbursement to the regular wage rate. This incremental payment, which is lump sum regardless of the residential locations of the workers, will raise the y-axis intercept of the land price curve.

Thus the first and the second stage effects work in opposite directions on the y-axis intercept, and the net effect is uncertain. Our thick curve in Figure 12 starting at the same point as the dotted curve may be taken as an approximation to this net effect.

VII. POLICY IMPLICATIONS

There are varied opinions as to whether the expansion of the population size of the Tokyo Metropolitan Area should be encouraged or discouraged. Kakumoto (1986), for example, reasons that investment in infrastructure in the business districts of Tokyo should be discouraged, because the commuting capacity has reached its limit. Hatta (1983), on the other hand, argues that once the commuter industry is deregulated, the fare structure and the capital equipment size in the commuter industry will become optimal. He claims that given such deregulations, the government should encourage the expansion of employment in Tokyo so that the economy can take full advantage of agglomeration economies.

In this section, we will examine the policy implications of our theoretical and empirical observations in earlier sections. In the process, we will discuss the issues of whether the population of Tokyo has exceeded its efficient size and whether capital stocks in transportation and in the CBD infrastructure are at their efficient levels

A. Efficiency Measure.

We first need to establish a measure of efficiency. For this purpose, let us examine the welfare impact of a productivity improvement in the CBD in the model of Section II. By assumption, producers are competitive, and hence earn zero (economic) profit both before and after the productivity change. Also by assumption, people are mobile, and hence if there is any improvement in the urban living standard, rural residents will migrate into the city until the land price curve is shifted up by such an amount that the living standard at any location of the city becomes equal to the rural level. In the end, the owners of land -- the immobile factor-- reap all the benefit of the technological change. Thus we have:

Proposition 3. If productivity improvement takes place at the CBD, all of its fruits fall onto the landowners. No one else makes economic gains; producers continue to get zero profits, and the living standard of the urban resident remains exactly the same as that of the rural resident.

In the model of Section II, therefore, the efficiency impact of technological improvement is measured by the increase in the total land value.

B. Urban Land Tax

The fruit of technological progress that goes to the landowners can be recouped and be shared by the others if land tax is imposed on the difference between the value of each urban land and the value of the rural land with the same size.

The urban land tax is an efficient tax. It will reduce the urban land price curve, but the sum of the urban land price and the present value of the future land tax obligations remain the same as the pre-tax land price at any location. This tax therefore will not affect the population density curve, nor does it affect the city size.

Often an urban land tax has been proposed in Japan on efficiency grounds, since it is considered to discourage the idle use of land. But this tax is neutral on efficiency. Its virtue lies in its redistribution capacity.

C. Government Subsidies for Commuting

The government subsidies on commuting expenses reduce efficiency. To see this, take a worker who commutes to the CBD from the city border. For him the rural wage rate is equal to his net urban wage rate. His net social productivity in the city is equal to his net urban wage rate minus government subsidies for commuting, while his social productivity in the rural economy is equal to the rural wage rate. Thus, his net productivity is higher in the rural area than in the city by the amount of government subsidies. The social efficiency would require him to work in the rural economy. This indicates that the preferential tax treatment on commuting expenses create inefficiency.

D. Efficient Fare Structure.

Tokyo's commuter trains are notorious for their rush hour congestion. Indeed, the "congestion rate" during the rush hours in the national railroad in the Tokyo Metropolitan Area was estimated to be 244%, where National Land Agency (1987) defines the congestion rate of 100% as a situation where "passengers can either be seated or hold on to poles or hanging rings comfortably."[19]

Whether or not this is an excessive level of congestion for Tokyo, however, requires scrutiny. For this purpose, examining the fare structure is useful. Hatta (1983) has shown that in a large metropolitan area where many commuter railroad companies compete for customers, free market fare setting and no limitations on investment would automatically internalize congestion, resulting in efficient marginal cost pricing and efficient investment.

Thus, the current free ride system in Tokyo inefficiently encourages the demand for transit rides, causing an excessive degree of congestion during the rush hour and for a long distance ride. Requiring the commuters to pay the current train pass fares will reduce congestion and improve efficiency. In deriving the thick line in Figure 8, we assumed that after the tax reform the commuters have to pay the train pass fares of 1985.

These train pass fares, however, are much lower than the profit maximizing, and hence the socially efficient levels. This is because the following regulations force Japanese railroad companies to set pass fares artificially low:

(a) A discount of approximately 50% is given on the commuter pass, making the peak-load fare 50% less than the off-peak fare.

(b) Fares are set on a per-kilometer basis regardless of the degree of congestion.

(c) Full cost pricing is required.

If correct peak-load prices are imposed on passengers, therefore, the fares during the rush hour have to rise substantially beyond the monthly pass rates assumed in our study. Note that the inefficiently low fares not only cause excessive congestion in the short run, but also stymie incentives for the commuter firms to invest in improving the service in the long run.

If these regulations as well as the tax deductibility of commuting expenses are eliminated, the land price curve in Figure 12 will become substantially steeper than the thick line. Besides, through the effect indicated by Proposition 2, the y-axis intercept will come down. It is possible that the Tokyo population will be reduced. Our equation (12) can be modified for studying the impact of a further fare increase.[20]

E. Subsidizing the CBD Production.

So far in this section we have explicitly ignored the agglomeration economy of the CBD production. Once this is taken into account, a free market mechanism alone does not attain efficiency; the government needs to deliberately encourage production in the CBD area, since the proximity of many offices in a concentrated area increases productivity. Such policy measures will include: (i) elimination of the status-quo-preserving regulations on construction and lease laws, (ii) subsidies on the construction of high density buildings in the CBD, and (iii) an increased investment in the infrastructure in the CBD, such as water, sewage, and local streets, so as to accommodate a high density employment.

It goes without saying that encouragement of the CBD production by the government should be accompanied by discouragement of wasteful use of publicly supplied goods. This can be attained, for example, by imposing marginal cost pricing on the use of water and sewage, and imposing congestion taxes on in-house parking places in the district.

F. Summary

Efficiency requires two sets of policies. The first is the CBD development policies, such as revamping construction and lease laws, heavily investing in the infrastructure of the CBD, and subsidizing high-rise building constructions. The second is marginal cost pricing of transportation and public utility services, such as the elimination of the preferential treatment of the commuting expenses, deregulations of fare and investment determination in the commuter industry, the price increase of water, and charging congestion tax on parking places.

The CBD development policies will increase the employment and population sizes, while making the employment density curve steeper. The marginal cost pricing will make the employment and population sizes smaller and the density curves steeper.

Thus various policies and regulations governing Tokyo have affected both population and employment sizes in conflicting directions relative to the efficient sizes. Thus it is not clear whether Tokyo has exceeded the optimal size. But what is clear is that population and employment are allocated inefficiently within the metropolitan area. The current policies and regulations have consistently made both density distributions flatter than efficiency requires.

VIII. CONCLUSION.

In the present paper, we compared the population and employment structures of the metropolitan area of Tokyo against those of New York. We made three empirical observations and explained the difference in the framework of the Mills-Muth urban model.

First, Tokyo is twice as large as New York with respect to both population and employment. The well-developed mass transit system in Tokyo is an essential factor that supports this size. In order for a mass transit system to be economically viable for the suppliers and convenient for the commuters, a critical level of suburban population density is necessary. Only then can the train system supply frequent services and likewise for the accompanying suburban bus system. The fact that the suburbanization of Tokyo took place before motorization occurred helped Tokyo attain a level of suburban density above the "critical level."

Second, the CBD of Tokyo is under-utilized in terms of both employment and residential population densities. This may be explained by the technological limitations that existed until 1970 regarding constructing aseismic skyscrapers and by the land and building lease laws.

Third, the residential area of Tokyo is more spread out, and its suburban population density curve is flatter than that of New York. This can be explained by the lower cost of commuting time due to the well-developed suburban transit system. In addition, it may be explained by the fact that the commuting expenses of the employees in Tokyo are reimbursed by their employers, which in turn is caused by the exclusion of commuting expenses under the personal income tax in Japan. Our empirical study shown in Figure 12 has demonstrated a substantial impact of this preferential tax treatment of commuting expenses upon the land price structure of the Tokyo Metropolitan Area.

The low cost of commuting time in Tokyo resulting from the well-developed commuter train system, which has enabled Tokyo to attain a large population size and high population densities in the suburban areas, explains the high residential land prices in Tokyo. Besides, government subsidies through preferential tax treatment make the land prices in the suburbs even higher.

On the other hand, high land prices should be accompanied by high employment densities in the business district. In the Tokyo CBD, however, relatively high land prices are accompanied by relatively low employment densities. This appears to reflect the fact that the Tokyo CBD is in the adjustment process toward an equilibrium with a high employment density as a result of the removal of the technological constraint on aseismic construction. In other words, the market seems to have capitalized the future high CBD productivity that will be attained when the potentially high density is realized in the eventual equilibrium. Also, a more rapid increase in the employment density at the CBD relative to the surrounding business districts seems to confirm that the Tokyo CBD is in the adjustment process.

Finally, we examined the normative economics of Tokyo. It was shown that a combination of the following two policies will attain an efficient resource allocation in the Tokyo Metropolitan Area:

(i) a major redevelopment in the infrastructure of the CBD and

(ii) a substantial increase in the commuter fares through deregulations and the elimination of the preferential tax treatment.

These two policies will have offsetting effects on the total population size: the first will encourage the population inflow into the

Metropolitan Area, while the second will discourage it. Thus the efficient size of the population in Tokyo may be greater or less than than its current size. But what is clear is that the efficient population and employment densities achieved by the above policies will be steeper than the current ones.

The the two policies will also make the land price curve steeper. Policy (i) seems already expected as inevitable and its future effects are capitalized in the current land prices in the CBD, but policy (ii) will reduce the land prices in the suburbs. In other words, to improve efficiency in the Tokyo Metropolitan Area, a substantial increase in the train fares are necessary, which in turn will depress the suburban land prices sharply.

FOOTNOTES

1. See Noguchi (1991) and Ito (1991), for example.

2. Kobayashi, Komori, and Sugihara (1990) make a detailed comparison of Tokyo, London, and Paris, including the comparison listed in Table 1. However, they do not compare these cities against New York. Kakumoto (1986, pp. 139-142 and 154-156) conjectures that the population and employment sizes of the comparable metropolitan area of Tokyo must be twice as large as that of New York based on the comparison of employment in a $600km^2$ area.

Our Table 1 verifies Kakumoto's conjecture, and fills the gap in the Kobayashi, Komori, and Sugihara study by supplying the New York data for an areal size of $14,000km^2$.

3. Kakumoto (1986, pp. 154-156) was the first to make comparisons of the two cities with respect to 60 and $600km^2$ areas.

4. The Tokyo figure includes government as well as private sector employees, but the New York figure does not include employees of federal or local governments. Thus the actual employment density of New York is even higher than the figure given in Table 8.

5. If the demand for housing floor space were fixed regardless of the level of rent, the housing rent curve would be linear. In fact, if we choose the unit of housing services so that each consumer consumes one unit of housing floor space, $r - \bar{r} = w - \bar{w}$ will hold at each location within the city.

If housing floor space and non-housing consumption are substitutable, however, the rent curve becomes convex to the origin. Suppose that the rent curve is linear in such a way that it just enables a resident at an interior location to purchase the same combination of floor space and non-housing consumption as a border resident, guaranteeing at least the utility level of a border resident. If an interior resident chose this option, he would not be maximizing his utility under the given expenditure; he would be able to improve his utility by reducing the consumption of the floor space and increasing that of the non-housing consumption goods. This is because he faces a higher relative price of the floor space than a border resident does. Thus the utility compensating rent has to be higher than the rent that just enables this resident to buy the same bundle as the border resident.

We can similarly compare this resident and the third resident living even closer to the center, showing that the rent for the third resident again has to be higher than a linear rent curve based on the second resident's consumption bundle. When non-housing consumption is substitutable for housing floor space, therefore, the housing rent curve must be convex to the origin.

6. If a fixed amount of land is necessary to produce a given floor space, the housing rent difference between two locations will be proportional to the land rent difference. If land and capital are substitutable, the land rent difference will grow more than proportionally as the housing rent difference grows. The reason is similar to the one given for the convexity of the housing rent curve.

7. If housing and other consumptions are not substitutable in the utility function and if capital and land are not substitutable in the production function, population density at any location of the city should be equal to that in the rural area. The above argument suggests, moreover, that the land rent function should be linear in that case.

8. As another example, suppose that there is one deviant person in this

economy who hardly minds commuting up to 20 minutes, but dislikes the additional commuting more intensely than others. Then the price curve that would make him indifferent about the choice of residential location is relatively flat at a high level near the CBD up to a location with the 20 minute commuting distance and then precipitously declines. At the location within 20 minutes of the CBD he is thus willing to pay more for the land than others. But to the extent he is a minority, he will not be the marginal buyer, and his taste will not affect the land prices.

9. See footnote 10 below.

10. The area size of "Tokyo Commuting Area" is 6,400km^2, and is smaller than the "Tokyo Metropolitan Area" defined in Table 3. Its population size was 25.804 million. In 1980 the total number of passengers with commuting passes in this area per year was 7,117 million for the entire railroad system, while it was 1,486 million for subways. See Unyu Keizai Kenkyu Center (1989, pp. 108-109).

The "Tri-State Region" is an area greater than the top seven PMSAs defined in Table 3. In 1980 the total number of people commuting to work in this region was 1.443 million, while it was 1.150 million for subways. See Barry (1985, pp. 17, 19).

11. See Nihon Min'ei Tetsudo Kyokai [Japan Association of Non-Government Railroads] (1989, pp. 12-13 and pp. 44-47), for example.

12. See Noguchi (1991) and Ito (1991) for details.

13. According to the Japanese Ministry of Transportation (1987, p. 164), 94.9% of those who bought commuter passes for the railroad in Tokyo, Osaka, and Nagoya Metropolitan Areas in 1985 received some reimbursement from their employers, 93.4% were reimbursed more than one-half of the purchase amount, and 86.5% received full reimbursement.

14. Suppose a firm decides to reimburse its employees' commuting expenses by appropriating a portion of the initial total wage payment. This action will reduce its employees' aggregate income tax payments without increasing the firm's total labor costs.

15. If the housing rent r(t) at an x were so low that

$$v^0(r(x),\ Y-tx,\ x) > \bar{v}$$

holds, every household would want to move to this location and the housing rent will be bid up until (6) is restored. Were r(t) so high so as to make this inequality reversed, households would leave this location until (6) holds.

16. First consider the following cost minimization problem for unit output:

$$\text{Min} \qquad r \equiv R\,\frac{L}{H} + i\,\frac{K}{H}$$

$$\text{S.T.} \qquad 1 = \lambda\left\{\frac{L}{H}\right\}^{\nu}\left\{\frac{K}{H}\right\}^{1-\nu}$$

The solution functions for L/H and K/H are

$$\frac{L}{H} = \frac{1}{\lambda}\cdot\left\{\frac{\nu\ \ i}{(1-\nu)R}\right\}^{1-\nu} \qquad \text{and} \qquad \frac{K}{H} = \frac{1}{\lambda}\cdot\left\{\frac{\nu\ \ i}{(1-\nu)R}\right\}^{-\nu},$$

respectively. At the free-entry, perfectly-competitive equilibrium, the minimized unit cost is equal to the housing price. Hence we have

$$r = \frac{R}{\lambda}\cdot\left\{\frac{i\ \ \nu}{(1-\nu)R}\right\}^{1-\nu} + \frac{i}{\lambda}\cdot\left\{\frac{i\ \ \nu}{(1-\nu)R}\right\}^{-\nu}.$$

Thus we get the supply price function

$$r(x) = E\cdot R(x)^{\nu}$$

where

$$E \equiv \frac{1}{\lambda}\left[\frac{1}{\nu}\right]^{\nu}\left\{\frac{i}{(1-\nu)}\right\}^{1-\nu}.$$

The expenditure minimization under the given utility level $\bar{v}$ similarly specifies the demand price equation as

$$r(x) = A\cdot(Y - tx)^{1/\beta}\ (\delta - x)^{\alpha/\beta},$$

where

$$A \equiv \beta(1-\beta)^{\frac{1-\beta}{\beta}}\ v^{\frac{1}{\beta}}.$$

Equating the demand and supply price equations and applying the fact that P(x) = R(x)/i, we get (6), where

$$B \equiv \frac{1}{i}\cdot\left[\frac{c}{D}\right]^{\frac{1}{\nu}}.$$

17. Since the production function of the housing service industry is Cobb-Douglas, the share of the land rent R(x)L(x) in the total revenue r(x)H(x) of this industry is ν. Thus we have

$$R(x)L(x) = \nu r(x)H(x).$$

This and the definition of M(x) yield

$$M(x) = \frac{R(x)}{\nu r(x)h(x)}.$$

When t= 0, on the other hand, the Cobb-Douglas utility function yields

$$r(x)h(x) = \beta Y$$

Thus, we get (8).

18. Each selected station is showing in the figure with the one way commuting time distance from it to the Tokyo station. On the other hand, each sample in the figure is located at the time distance that includes the commuting time from home to the nearby station as well as the time from the nearby station to the Tokyo station. Thus samples for which the nearby station is Mitaka are shown in the figure midway between Mitaka and Tachikawa, for example.

19. When the degree is 200%, "passengers feel considerable pressure from each other, but can manage to read weekly magazines." When the degree is

250%, "passengers cannot move hands." When the degree reaches 300%, the official description states that "the passengers can be physically endangered."

20. When train fares are increased to the level of the social cost of commuting, the combined monetary and nonmonetary commuting cost will not increase as much because of the reduced congestion level. In the long run, the offsetting reduction in the combined commuting cost will become even stronger for the following reasons: The fare increase will cause a substantial excess profit, since by and large Japanese commuter lines already make a profit. When the profit induces the competitive commuter lines to expand, congestion will further decline and the nonmonetary trip cost will be further reduced to offset the increase in monetary trip cost even more.

Despite this possibility of moderation, increasing the fare to the efficient level will increase the combined commuting cost. After all, current commuters are facing the average rather than the marginal cost of congestion.

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Table 1. Metropolitan Areas of the World

	Tokyo	New York	London	Paris	
Area Year	13,495 (1980)	14,812 (1980)	15,437 (1987)	12,012 (1982)	(km2)
Residents (Density)	**28,699** 2.13	**16,303** 1.10	**13,152** 0.85	**10,073** 0.84	(1,000) (1,000/km2)
Emploees (Density)	**13,515** 1.00	**6,925** 0.47	**5,702** 0.37	**4,933** 0.41	(1,000) (1,000/km2)

Notes:

1. The areas of the metropolises adopted here are as follows:

   Tokyo: Tokyo, Kanagawa, Chiba, and Saitama Prefectures.

   New York: Seven PMSAs listed in Table 2.

   London: Greater London and the surrounding six counties.

   Paris: Ile de Frence.

2. A more detailed comparison among Tokyo, London, and Paris is found in Kobayashi, Komori, and sugihara (1990, p.21), though New York is not included in the comparison. Kakumoto (1986) compares Tokyo and New York for the areas of 600 km2 and less. See also Table 3.

Sources:

Tables 3 and 8 for Tokyo.

Table 2 for New York.

British Central Statistical Office (1989) for London.

INSEE (1988) for Paris.

TABLE 2 PMSAs IN THE NEW YORK AREA

Primary Metropolitan Statistical Area (PMSA)	Area		Population		Employment				
	Square Miles	km2	Size 1000	Density 1000/km2	Private Sector 1000	Fed. Gov. 1000	Local Gov. 1000	Total 1000	Density 1000/km2
1 Jersey City	46	119	557	4.68	180	11	22	213	1.79
2 New York	1146	2,968	8,275	2.79	3282	85	392	3759	1.27
3 Bergen-Passaic	424	1,098	1,293	1.18	527	5	42	574	0.52
4 Nassau-Suffolk	1198	3,103	2,606	0.84	778	18	96	892	0.29
5 Newark	1226	3,175	1,879	0.59	731	20	74	825	0.26
6 Fairfield	632	1,637	807	0.49	364	4	24	392	0.24
7 Middlesex-etc.	1047	2,712	886	0.33	248	2	21	271	0.10
TOTAL	5,719	14,812	16,303	1.10	6,110	145	671	6,926	0.47

Notes:

1. The population data is for 1980.
2. Listed above are the seven most densely populated PMSAs (Primary Metropolitan Statistical Areas) in the NY-NJ-CT Consolidated Metropolitan Statistical Area.
3. Fairfield is the Bridgeport-Stamford-Norwalk-Danbury, Connecticut New England County Metropolitan Area.
4. Middlesex-etc. stands for the Middlesex-Somerset-Hunterdon, New Jersey PMSA.
5. Private Sector, Fed. Gov., and Local Gov. stand for Private Non-farm, Federal Government, and State and Local Government Employments, respectively.
6. Private Non-farm and State and Local Government Employment data are for the year 1982, while Federal Government Employment data is for the year 1983.

Source:

U.S. Bureau of Census (1986, pp. 202, 214-215).

TABLE 3 TOKYO VS NEW YORK: POPULATION DENSITY

Tokyo				New York		
Area (km2)	Residents (1000)	Density (1000/km2)		Area (km2)	Residents (1000)	Density (1000/km2)
			CBD Area			
Chiyoda Ward				Midtown		
10.4	55	**5.29**		3.6	128	**35.16**
			60km2 Area			
4 Central Wards				Manhattan		
58	683	**11.68**		57	1,423	**24.96**
			240km2 Area			
15 Central Wards				Manhattan and Brooklyn		
236	3,889	**16.48**		237	3,659	**15.44**
			600km2 Area			
All 23 Wards				Manhattan, Queens Bronx, and Brooklyn		
598	8,352	**13.97**		629	6,719	**10.68**
			1,200km2 Area			
"Urban Area"				Top 6 Counties		
1,232	12,746	**10.35**		1,230	8,479	**6.89**
			2,300km2 Area			
"Urban Area" plus				Top 9 Counties		
2,292	18,736	**8.17**		2,240	10,305	**4.60**
			8,000km2 Area			
"Tokyo Metropolitan Area"				Top 15 counties		
8,415	27,348	**3.25**		8,107	14,642	**1.81**
			14,000km2 Area			
4 Prefectures				Top 7 PMSAs		
13,495	28,699	**2.13**		14,812	16,303	**1.10**

(Table 3. - Continued)

Notes:

1. All data are for 1980.

2. The part of the Imperial Palace that is closed to the public is excluded from the area figure of Chiyoda Ward in the first three pannels. It is included in the area figures of larger areas of Tokyo, since its inclusion hardly affects density figures.

3. The four central wards are Chiyoda, Chuo, Shinjuku, and Minato.

4. The 15 central wards are the first 15 wards listed in Table 4.

5. "Urban Area (Kisei Shigaichi)," a legally defined area, consisting of the 23 wards of Tokyo, Musashino, Mitaka, Kawasaki, Kawaguchi, and most of Yokohama. See Note 2 of Table 5 for the precise definition.

6. Table 6 lists 38 suburban cities of Tokyo. All of them are in the "Suburban Area (Kinko Seibi Chitai)" as defined by the law. See note 2 of Table 6 for more on this.

7. "Tokyo Metropolitan Area (Tokyo Daitoshi Chiiki)" is the sum of "Urban Area" and "Suburban Area" defined above.

8. The four prefectures are Tokyo, Kanagawa, Chiba, and Saitama.

9. Midtown is here defined to be the area bounded by 59th St., 14th St., and Lexington Ave. It is District 5 of New York City (1988).

10. The 15 counties in the New York Area with the highest population densities are listed in Table 7 in order of density.

11. Seven SMSAs in the New York area with the highest population density are listed in Table 2.

Sources: Shutoken Seibi Kyokai (1988, p. II:10, p. II:62, and p. II:190) and Tables 1, 4, 5, and 6 for Tokyo, and New York City (1988) and Tables 2 and 7 for New York.

TABLE 4 The 23 Wards of Tokyo: Population

	Day Pop. Density	Ward	Area	Pop.	Density	Cum. Area	Cum. Pop.	Cum. Density
	1000/km2		km2	1,000	1000/km2	km2	1000	1000/km2
1	94.2	Chiyoda	10.39	55	5.3	10.39	55	5.3
2	65.5	Chuo	10.05	83	8.3	20.44	138	6.8
3	38.1	Shinjuku	18.04	344	19.1	38.48	482	12.5
4	35.3	Minato	19.99	201	10.1	58.47	683	11.7
5	33.7	Taito	10.00	186	18.6	68.47	869	12.7
6	30.8	Shibuya	15.11	247	16.3	83.58	1,116	13.4
7	29.4	Bunkyo	11.44	202	17.7	95.02	1,318	13.9
8	28.5	Toshima	13.01	289	22.2	108.03	1,607	14.9
9	19.5	Sumida	13.82	233	16.9	121.85	1,840	15.1
10	19.4	Arakawa	10.34	198	19.1	132.19	2,038	15.4
11	19.1	Shinagawa	20.91	346	16.5	153.10	2,384	15.6
12	19.0	Meguro	14.41	274	19.0	167.51	2,658	15.9
13	16.9	Nakano	15.73	346	22.0	183.24	3,004	16.4
14	16.6	Kita	20.55	387	18.8	203.79	3,391	16.6
15	14.5	Itabashi	31.90	498	15.6	235.69	3,889	16.5
16	13.4	Ohta	49.42	661	13.4	285.11	4,550	16.0
17	12.3	Suginami	33.54	542	16.2	318.65	5,092	16.0
18	11.6	Setagaya	58.81	797	13.6	377.46	5,889	15.6
19	10.7	Katsushika	33.90	420	12.4	411.36	6,309	15.3
20	10.2	Adachi	53.25	620	11.6	464.61	6,929	14.9
21	10.1	Koto	36.89	362	9.8	501.50	7,291	14.5
22	9.6	Nerima	47.00	564	12.0	548.50	7,855	14.3
23	9.1	Edogawa	48.26	495	10.3	596.76	8,350	14.0
		Total	597.89	8,352	14.0			

Notes:

1. The data is for 1980.

2. Day Pop. Density stands for the density of population during the day, which includes employees, students, and residents who are in the ward during the daytime.

3. Pop. stands for the number of residential population.

4. Wards are listed in order of Day Pop. Density.

5. The area of Chiyoda Ward is 11.52 km2. The part of the Imperial Palace that is closed to the public is 1.13 km2.

The area listed as that of Chiyoda Ward is that part of the Ward that is open to the public.

6. The last row gives the total area of the ward district including the Imperial Palace. The total population figure is corrected for rounding error. The impact of these corrections upon the total population density is negligible.

Source:

Shutoken Seibi Kyokai (1988, pp. II:204 and II:205).

Table 5. Cities in the "Urban Area" of Tokyo: Population

	Cities	Area (km2)	Population (1,000)	Density
1	23 Wards of Tokyo	598	8,352	14.0
2	Musashino	11	137	12.5
3	Mitaka	17	165	9.7
4	Kawasaki	136	1,041	7.7
5	Kawaguchi	56	379	6.8
6	Yokohama	414	2,673	6.5
	"Urban Area" Total	1,232	12,746	10.3

Notes:

1. The data is for 1980.

2. "Urban Area (Kisei Shigaichi)" is defined by the Tokyo Metropolitan Area Refurbishment Act (Shotoken Seibi Ho). This consists of the 23 wards of Tokyo, Musashino, Mitaka, Kawaguchi, Kawasaki, and Yokohama except Seya Ward.

Source:

Shutoken Seibi Kyokai (1988, pp. II:205-II:212).

Table 6. Cities in the "Suburban Area" of Tokyo: Population.

	Cities	Area (km2)	Population (1,000)	Density
1	Komae	6	71	11.8
2	Hoya	9	91	10.1
3	Tanashi	7	67	9.6
4	Hatagaya	6	56	9.3
5	Koganei	11	102	9.3
6	Kami Fukuoka	7	58	8.3
7	Kokubunji	11	91	8.3
8	Higashi Kurume	13	107	8.2
9	Chofu	22	181	8.2
10	Kunitachi	8	64	8.0
11	Kodaira	21	155	7.4
12	Higashi Murayama	17	119	7.0
13	Soka	28	187	6.7
14	Matsudo	61	401	6.6
15	Ichikawa	56	364	6.5
16	Fuchu	30	192	6.4
17	Kiyose	10	62	6.2
18	Narashino	21	125	6.0
19	Seya, Yokohama	17	101	5.9
20	Tachikawa	24	142	5.9
21	Shigi	9	51	5.7
22	Funabashi	85	480	5.6
23	Hino	27	145	5.4
24	Akishima	17	89	5.2
25	Zama	18	94	5.2
26	Niiza	23	119	5.2
27	Urawa	71	358	5.0
28	Asaka	18	90	5.0
29	Fussa	10	49	4.9
30	Sagamihara	91	439	4.8
31	Chigasaki	36	171	4.8
32	Higashi Yamato	14	66	4.7
33	Tama	21	95	4.5
34	Ooi	8	36	4.5
35	Toda	18	78	4.3
36	Kamakura	40	173	4.3
37	Fujisawa	70	300	4.3
38	Yokosuka	99	421	4.3
	Total	1,060	5,990	5.7
	"Urban Area"	1,232	12,746	10.3
	Grand Total	2,292	18,736	8.2

Notes:

1. The data is for 1980.
2. Listed above are the 38 most densely populated cities whithin the "Suburban Area (Kinko Seibi Chitai)" as defined by the Act on Suburban Development in the Tokyo Metropolitan Area (Shutoken no Kinkou Seibi Chitai oyobi Toshi Kaihatsu Kuiki no Seibi ni Kansuru Horitsu).
3. "Urban Area" is defined in Table 5.

Source: Table 5 and Shutoken Seigi Kyokai (1988, pp. II:205-II:212).

TABLE 7 COUNTIES IN THE NEW YORK AREA: POPULATION

	Counties	Area square miles	Area km2	Pop. Size 1,000	Pop. Density 1000/km2	Cum. Area km2	Cum Pop. 1000	Cum. Density 1000/km2
1	Manhattan	22	57	1,428	25.0	57	1,428	25.0
2	Brooklyn	70	181	2,231	12.3	238	3,659	15.4
3	Bronx	42	109	1,169	10.7	347	4,828	13.9
4	Queens	109	282	1,891	6.7	629	6,719	10.7
5	Jersey City, NJ	46	119	557	4.7	749	7,276	9.7
6	Essex, NJ	127	329	851	2.6	1,077	8,127	7.5
7	Richmond	59	153	352	2.3	1,230	8,479	6.9
8	Union, NJ	103	267	504	1.9	1,497	8,983	6.0
9	Nassau	287	743	1,322	1.8	2,240	10,305	4.6
10	Bergen, NJ	238	616	845	1.4	2,857	11,150	3.9
11	Passaic, NJ	187	484	448	0.9	3,341	11,598	3.5
12	Westchester	438	1,134	867	0.8	4,476	12,465	2.8
13	Middlesex, NJ	316	818	596	0.7	5,294	13,061	2.5
14	Rockland	175	453	260	0.6	5,747	13,321	2.3
15	Suffolk	911	2,359	1,321	0.6	8,107	14,642	1.8

Notes:

1. The data is for 1980.

2. Listed above are the 15 most densely populated counties in the New York, New Jersey, and Connecticut Metropolitan Area. The 16th is Fairfield County in Connecticut.

Source:

U.S. Bureau of Census (1986, p.202).

TABLE 8 TOKYO VS NEW YORK: EMPLOYMENT DENSITY

Tokyo				*New York*		
Area (km2)	Employment (1000)	Density (1000/km2)		Area (km2)	Employment (1000)	Density (1000/km2)
11km2 and less						
Chiyoda Ward				Midtown and Downtown		
			(a)	5.34	760	**142.4**
10.39	768	**73.9**	(b)	10.99	11,961	**108.4**
20km2 Area						
2 Central Wards				South Manhattan		
20	1,386	**69.3**		21.48	1,609	**74.9**
60km2 Area						
4 Central Wards				Manhattan		
59	2,406	**40.8**		57	1,949	**34.2**
600km2 Area						
All 23 Wards				Manhattan, Queens, Bronx, and Brooklyn		
598	6,234	**10.4**		629	3,223	**5.1**
14,000km2 Area						
4 Prefectures				Top 7 PMSA's		
13,495	13,515	**1.0**		14,812	6,925	**0.5**

Notes:

1. Data for Midtown & Downtown and South Manhattan are for 1987, and include only private sector employment.
2. All other data are for 1980, and include both private and government sector employment.
3. Midtown and Downtown of Manhattan (a) is the first eight zip code areas in Table 10, while (b) is the first 10 zip code areas of the same table.
4. The part of the Imperial Palace that is closed to the public is excluded from the area figure of Chiyoda Ward. See footnotes 5 and 6 of Table 4.
5. South Manhattan is defined to be the area consisting of the first 18 zip code areas in Table 10. See notes of Table 3 for the definitions of other areas.
6. The data of Midtown and Downtown and South Manhattan covers only the employees of private firms. All other New York data and all Tokyo data include employees of national and local government employees.

Sources:

Table 9 and Shutoken Seibi Kyokai (1988, p. II:62) for Tokyo, and U.S. Bureau of Census (1986, pp. 214-5), CACI (1990, p. 425), and Tables 2 and 10 for New York.

TABLE 9 The 23 Wards of Tokyo: Employment

	Day Pop. Density	Ward	Area	Emp.	Density	Cum. Area	Cum. Emp.	Cum. Density
	1000/km2		km2	1,000	1000/km2	km2	1000	1000/km2
1	94.2	Chiyoda	10.39	767	73.8	10.39	767	73.8
2	65.5	Chuo	10.05	619	61.6	20.44	1,386	67.8
3	38.1	Shinjuku	18.04	446	24.7	38.48	1,832	47.6
4	35.3	Minato	19.99	574	28.7	58.47	2,406	41.1
5	33.7	Taito	10.00	257	25.7	68.47	2,663	38.9
6	30.8	Shibuya	15.11	285	18.9	83.58	2,948	35.3
7	29.4	Bunkyo	11.44	167	14.6	95.02	3,115	32.8
8	28.5	Toshima	13.01	205	15.8	108.03	3,320	30.7
9	19.5	Sumida	13.82	173	12.5	121.85	3,493	28.7
10	19.4	Arakawa	10.34	112	10.8	132.19	3,605	27.3
11	19.1	Shinagawa	20.91	242	11.6	153.10	3,847	25.1
12	19.0	Meguro	14.41	130	9.0	167.51	3,977	23.7
13	16.9	Nakano	15.73	115	7.3	183.24	4,092	22.3
14	16.6	Kita	20.55	159	7.7	203.79	4,251	20.9
15	14.5	Itabashi	31.90	223	7.0	235.69	4,474	19.0
16	13.4	Ohta	49.42	360	7.3	285.11	4,834	17.0
17	12.3	Suginami	33.54	161	4.8	318.65	4,995	15.7
18	11.6	Setagaya	58.81	241	4.1	377.46	5,236	13.9
19	10.7	Katsushika	33.90	177	5.2	411.36	5,413	13.2
20	10.2	Adachi	53.25	246	4.6	464.61	5,659	12.2
21	10.1	Koto	36.89	211	5.7	501.50	5,870	11.7
22	9.6	Nerima	47.00	172	3.7	548.50	6,042	11.0
23	9.1	Edogawa	48.26	193	4.0	596.76	6,235	10.4
		Total	597.89	6,234	10.4			

Notes:

1. The data is for 1980.
2. Day Pop. Density stands for the density of population during the day, which includes employees, students, and residents who are in the ward during the daytime.
3. Emp. stands for the number of residential population.
4. Wards are listed in order of Day Pop. Density.
5. Footnotes 5 and 6 of Table 4 apply to the current table.

Source:

Shutoken Seibi Kyokai (1988, pp. II:204 and II:205).

TABLE 10 South Manhattan: Employment

	Zip Code	Area	Emp.	Density	Cum. Area	Cum. Emp.	Cum. Density
		km2	1000	1000/km2	km2	1000	1000/km2
1	10020	0.09	41.5	441.9	0.09	42	441.9
2	10005	0.26	71.9	278.5	0.35	113	322.1
3	10047-8	0.12	33.7	276.1	0.47	147	310.3
4	10017	1.18	195.1	165.9	1.65	342	207.4
5	10006	0.28	39.4	142.8	1.93	382	198.1
6	10022	1.62	183.6	113.6	3.54	565	159.6
7	10004	0.67	73.0	108.7	4.21	638	151.5
8	10018	1.13	122.4	108.7	5.34	760	142.4
9	10016	1.20	110.4	92.2	6.54	871	133.2
10	10036	1.63	123.1	75.7	8.16	994	121.8
11	10038	0.92	65.1	70.6	9.09	1,059	116.6
12	10001	1.91	132.2	69.4	10.99	1,191	108.4
13	10019	2.35	145.2	61.9	13.34	1,337	100.2
14	10010	1.08	63.3	58.8	14.41	1,400	97.1
15	10007	0.92	33.4	36.2	15.34	1,433	93.4
16	10003	1.84	63.4	34.6	17.17	1,497	87.2
17	10013	2.09	57.8	27.6	19.26	1,554	80.7
18	10011	2.21	54.6	24.7	21.48	1,609	74.9
19	10012	1.24	21.9	17.7	22.72	1,631	71.8
20	10014	1.96	22.6	11.5	24.68	1,653	67.0
21	10002	2.51	20.1	8.0	27.19	1,674	61.6
22	10009	1.69	10.2	6.0	28.88	1,684	58.3
Total		28.88	1,683.7	58.3			

Notes:

1. Data are for 1987.
2. The employment figures are for the private sector only.
3. Zip Code 10020 is Rockfeller Center, 10005 is Wall St., and 10047-8 are the twin towers of the World Trade Center.

Sources:

1. CACI (1990, p. 425) for the employment figures.
2. Rehana Siddiqui of Columbia University computed the area size of each zip code district from a Manhattan map.

Table 11. Traffic Modes for Commuting

Traffic Mode	Tokyo: Chiyoda	Tokyo: 4 Wards	New York: Manhattan
(a) Train and subway	93.0 %	88.2 %	59.1%
(b) Car	3.2 %	4.2 %	16.5%
(c) Taxi	1.0 %	1.1 %	1.3%
(d) Bus	0.9 %	1.6 %	13.9%
(e) Bicycle and Motorcycle	0.3 %	0.9 %	0.3%
(f) Walk only	1.0 %	3.1 %	8.2%
(g) Other means	0.6 %	0.8 %	0.7%
Total Commuters (1,000)	753	2,313	1,921

Notes:

1. The New York figures represent only those who commute to work in Manhattan. Tokyo figures include those who commute to attend schools as well as those who commute to work. The four wards are Chiyoda, Chuo, Minato, and Shinjuku.

2. The New York figures represent the percentage of those who use the respective mode for the most distance. Only exception is mode (e).

3. The Tokyo figures for (b) through (f) represents those who use the respective mode only.

4. A Tokyo commuter who uses train or subway in conjunction with another mode is classified in "train and subway". A commuter who uses three or more modes is also classified in this category, since the original data does not decompose this category. Those who uses three or more modes are 8.8% of the total in both 4 Wards and Chiyoda.

5 "Other means" for Tokyo represents a combination of two means among (b) through (e). "Other means" for New York represents a mode

other than (a) through (f) for the most distance.

6. All figures are for 1980.

Sources:

Barry (1985) for New York. Japanese Agency of General Affairs (1985) for Tokyo.

Table 12 International Comparison of Subway Networks

Cities	(A) Annual Volume of Passengers (Million persons)	(B) Kilometers Services Provided (Km)	(C) Annual Volume of Kilometers Served (Mil. km)	(D) Average Passengers Per Operating Kilometer (A)/(C)
Moscow	2417	184	408	5.9
Tokyo	2181	199	230	9.5
Paris	1376	295	248	5.5
Mexico City	1038	78	134	7.7
New York	991	370	434	2.3
Osaka	857	91	74	11.6
Leningrad	763	73	141	5.4
London	498	388	325	1.5
Nagoya	414	58	47	8.9
Budapest	362	26	27	13.5

Source: 1983 UITP Handbook Union Internationale de Transport Publique

Table 13 Dynamics of Employment in the CBD of Tokyo

(1000)

	1965	1970	1975	1980	1985	65-85
Chiyoda	610	673	745	767	850	39.3%
		10.3%	10.7%	3.0%	10.8%	
Chuo	565	587	621	619	658	16.5%
		3.9%	5.8%	-0.3%	6.3%	
Minato	398	461	537	574	694	74.4%
		15.8%	16.5%	6.9%	20.9%	
Shinjuku	300	351	400	446	512	70.7%
		17.0%	14.0%	11.5%	14.8%	
The Entire	5537	5891	6118	6234	6681	20.7%
Ward District		6.4%	3.9%	1.9%	7.2%	

Notes:

The percentage figure under each employment figure gives the growth rate of employment in the preceeding five years. The last column gives the growth rate in the preceeding 20 years.

Source:

Japanese Agency of General Affairs (1985)

Shutoken Seibikyokai (1988).

TABLE 14. TIME DISTANCE FROM TOKYO STATION

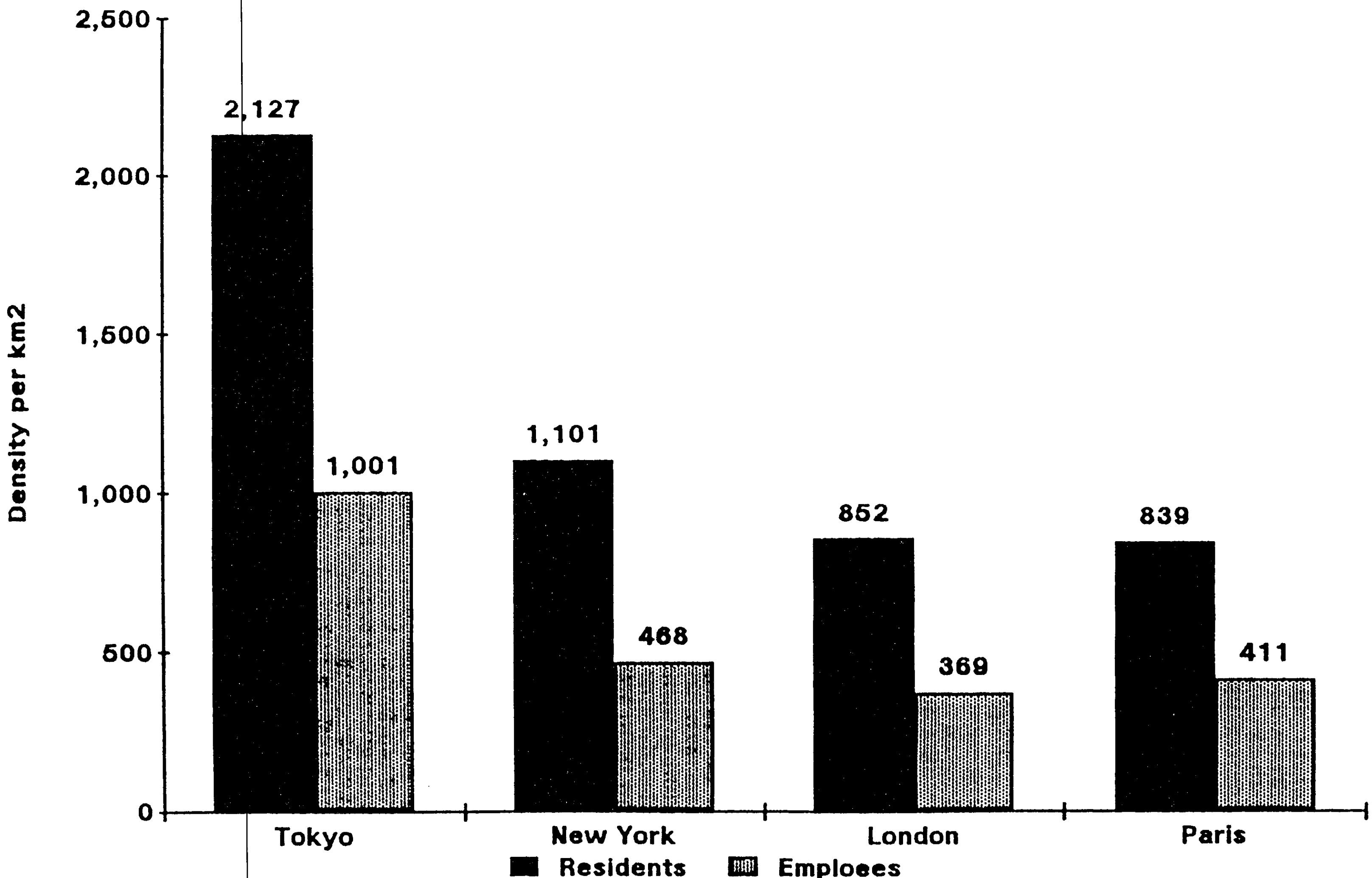
Station	S	One Way Commuting Time: Rapid Train	Special Rapid Train	X
* Shinjuku	0	14	14	14.00
Okubo	0	16	16	16.00
Higashi Nakano	0	18	18	18.00
* Nakano	0	18	18	18.00
Koenji	0	20	20	20.00
Asagaya	0	22	22	22.00
Ogikubo	0	24	24	24.00
Nishi Ogikubo	0	27	27	27.00
Kichijoji	0	29	29	29.00
* Mitaka	1	32	28	27.53
Musashi Sakai	0	34	30	31.63
Higashi Koganei	0	36	33	34.22
Musashi Koganei	1	39	36	35.12
Kokubunji	0	42	38	39.63
Nishi Kokubunji	0	44	40	41.63
Kunitachi	0	46	42	43.63
* Tachikawa	0	54	40	45.69
* Hino	0	57	43	48.69
* Toyoda	0	61	46	52.10
* Hachioji	0	65	50	56.10
* Nishi Hachioji	0	68	54	59.69
* Takao	0	72	57	63.10

Notes:

1. Stars indicate the stations where special rapid trains stop.

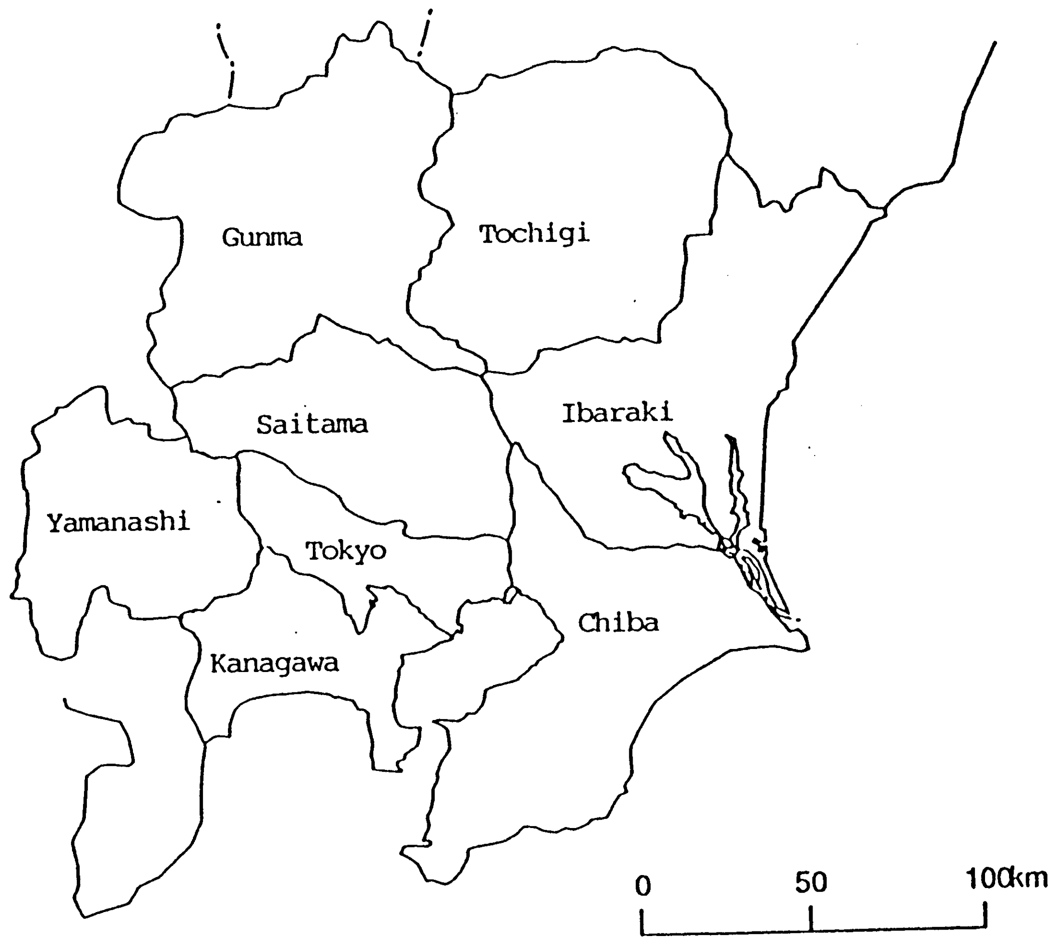
2. The last column gives the constructed time distance.

Figure 1.
Metropolitan Areas of the World



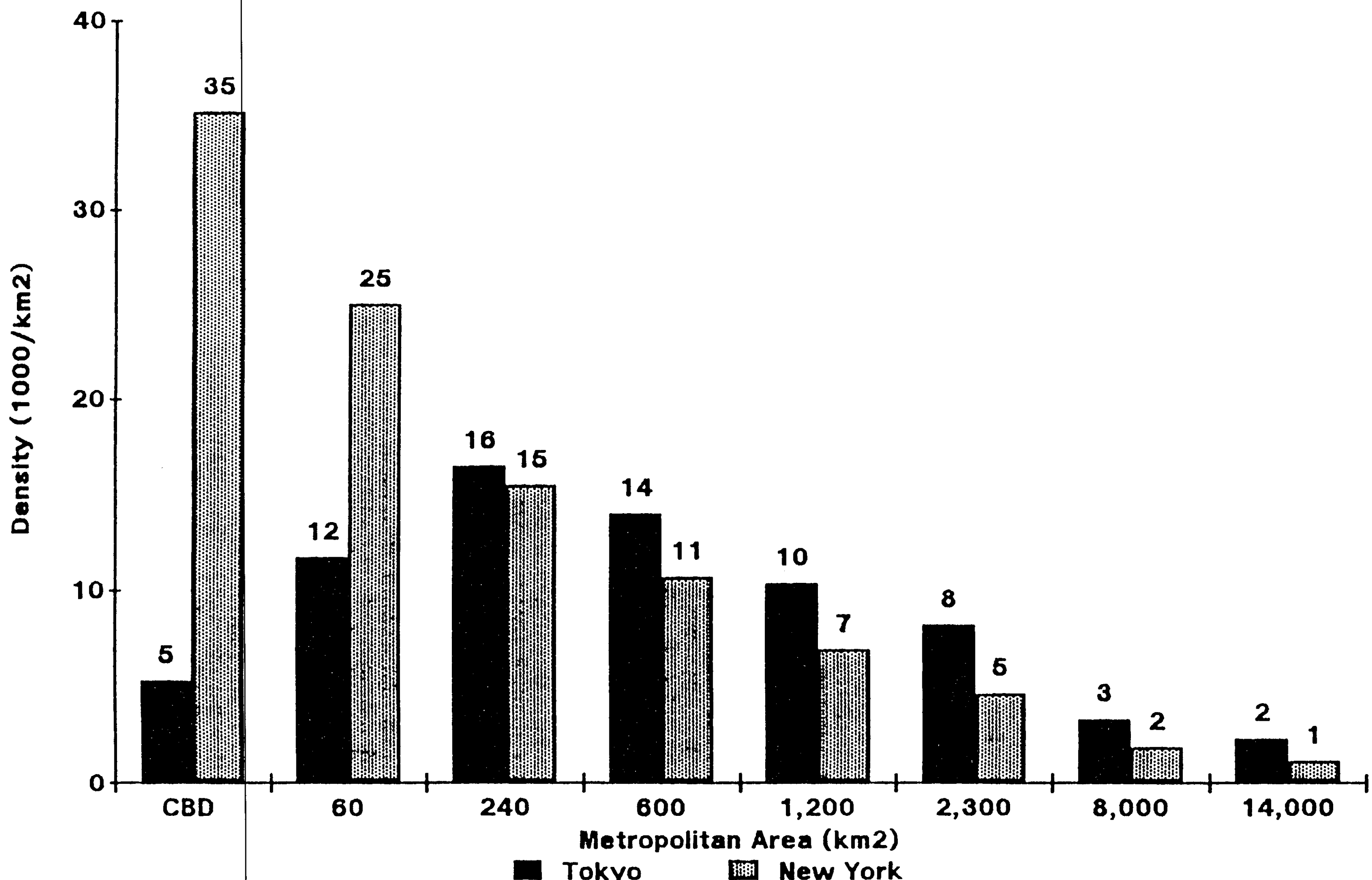
Source: Table 1

Figure 2 Prefectures Around Tokyo



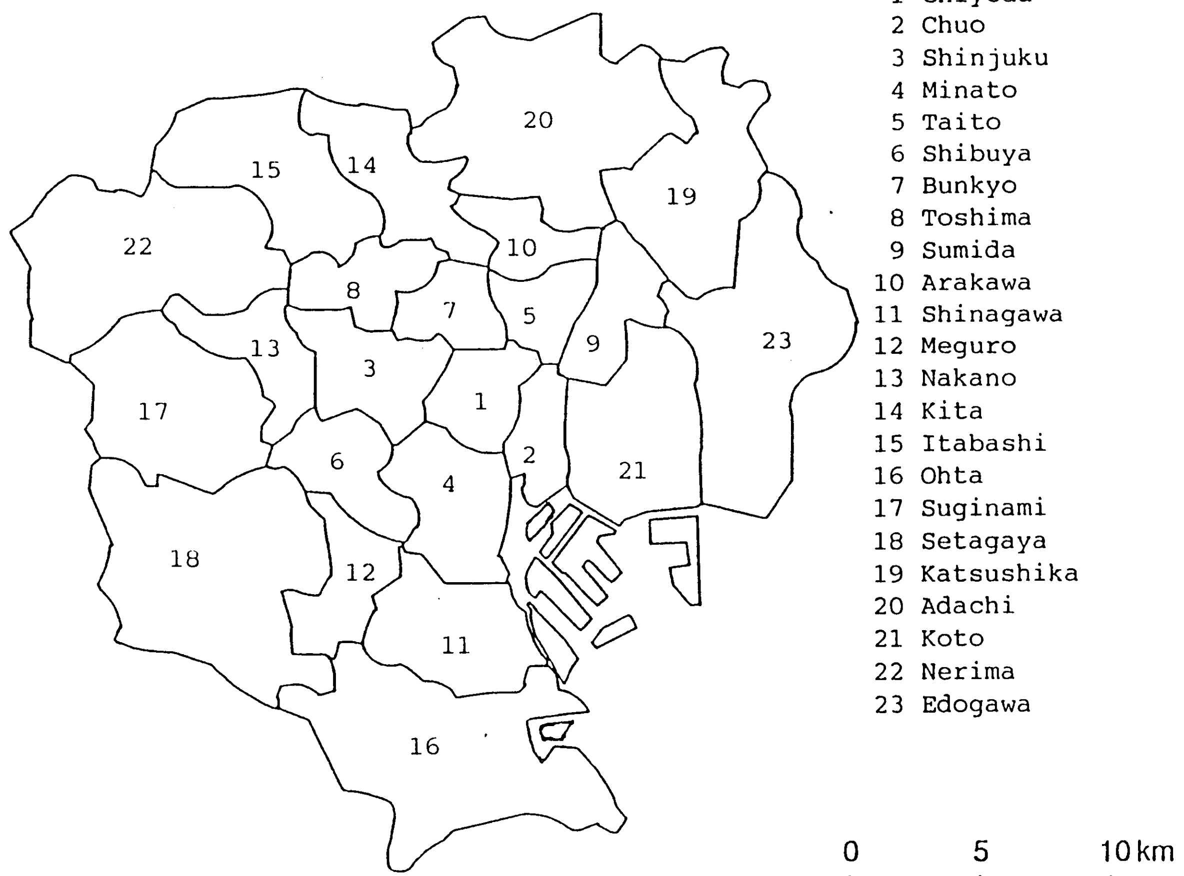
Note: A more detailed map of Tokyo Prefecture is found in Figure 10.

Figure 3.
Population Density: Tokyo vs New York



Source: Table 3

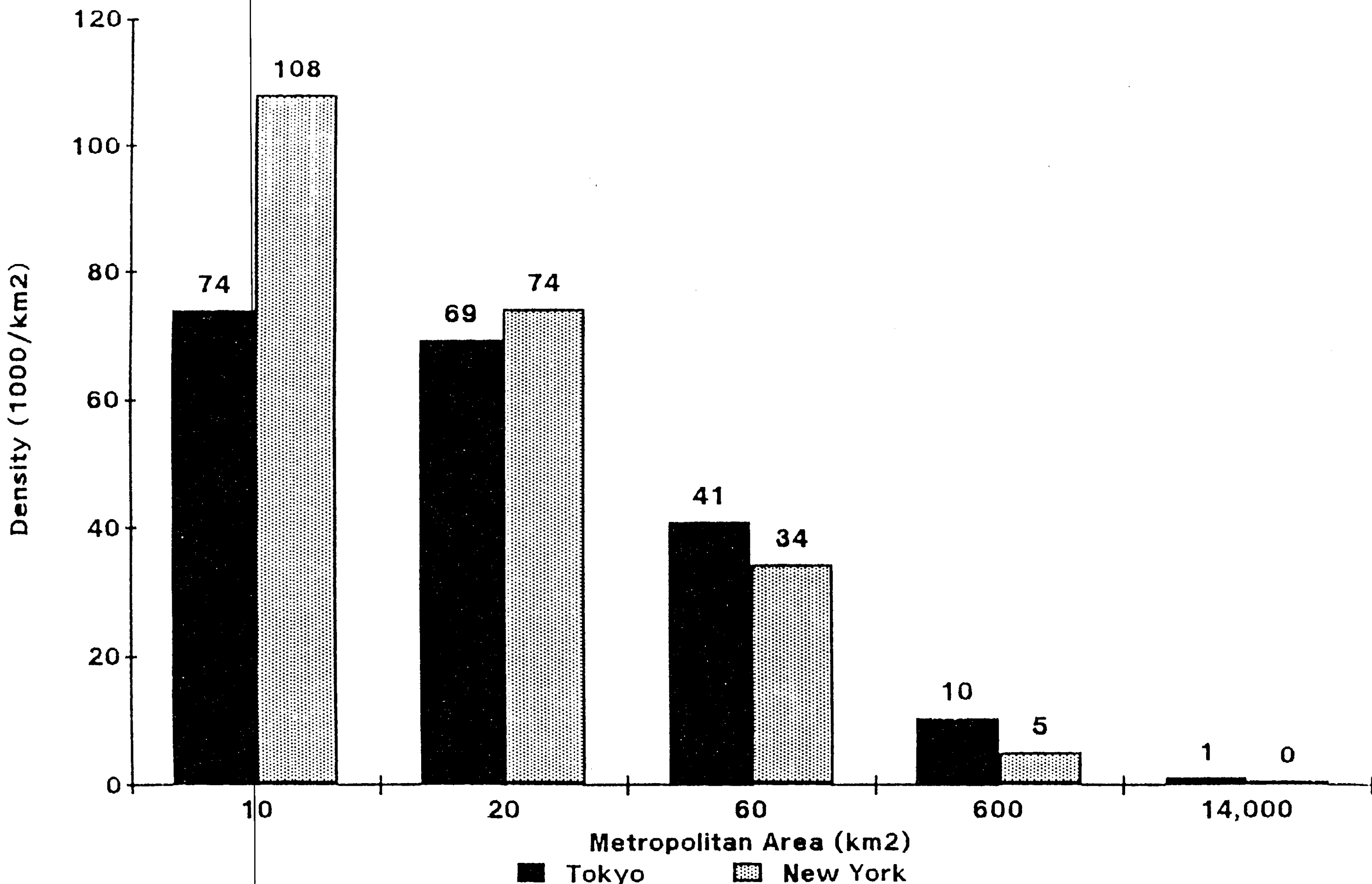
Fig.4 The Ward District of Tokyo



Notes:

1. Wards are listed in the order of the density of population during the day, as in Tables 4 and 9.
2. Figure 10 locates the Ward District of Tokyo within Tokyo Prefecture.

Figure 5.
Employment Density: Tokyo vs New York



Source: Table 8

Fig. 6 The Rent Curves

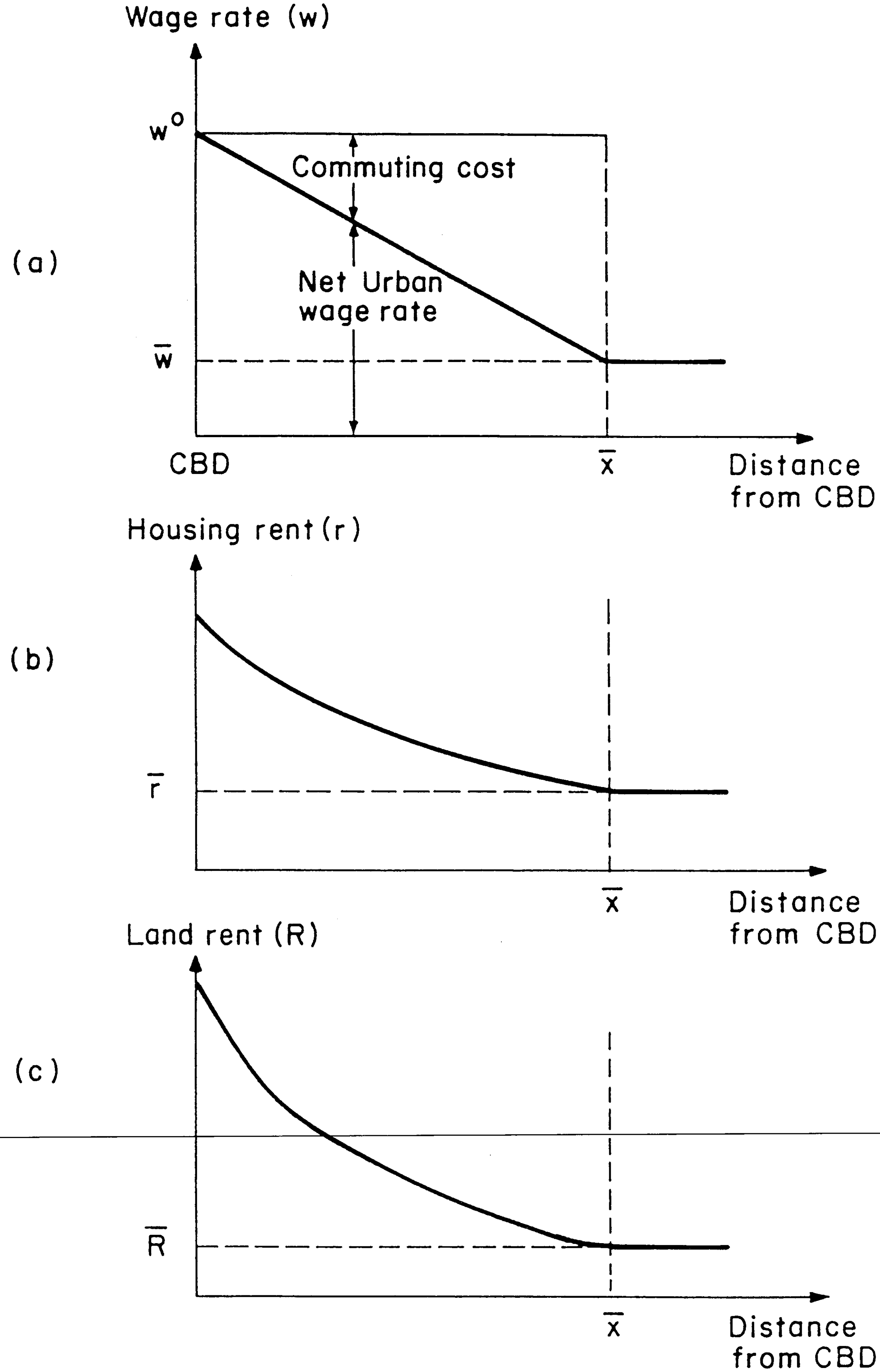


Fig. 7 Land Price Curves

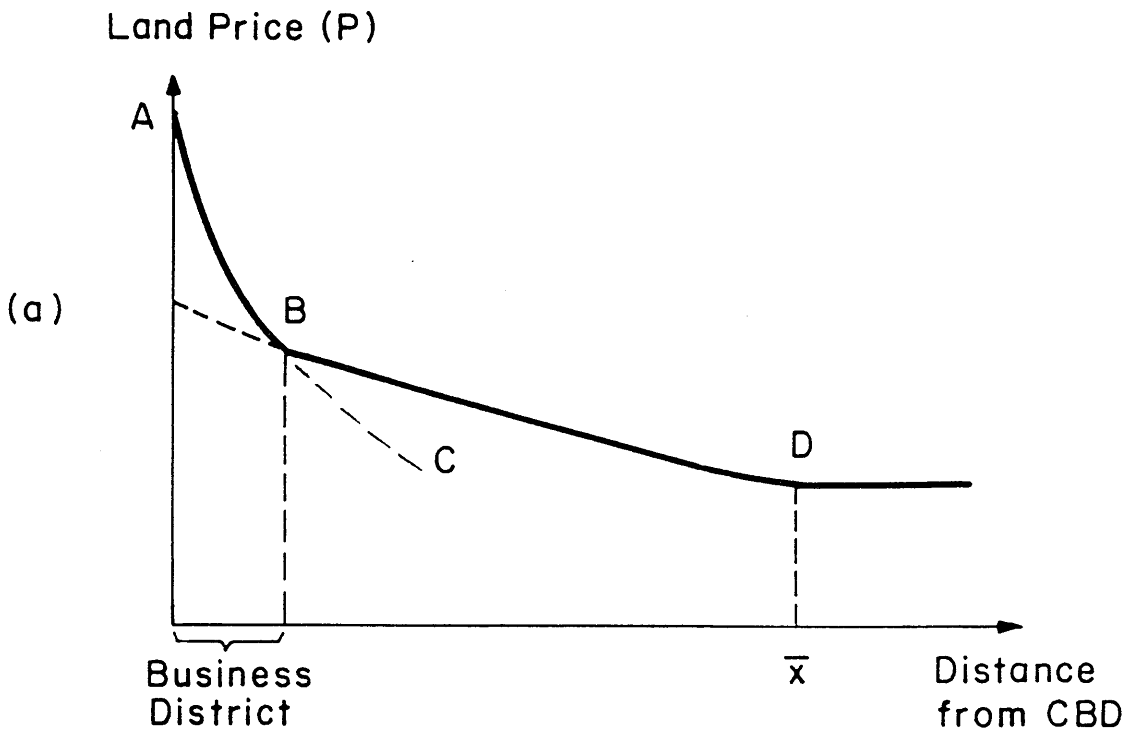
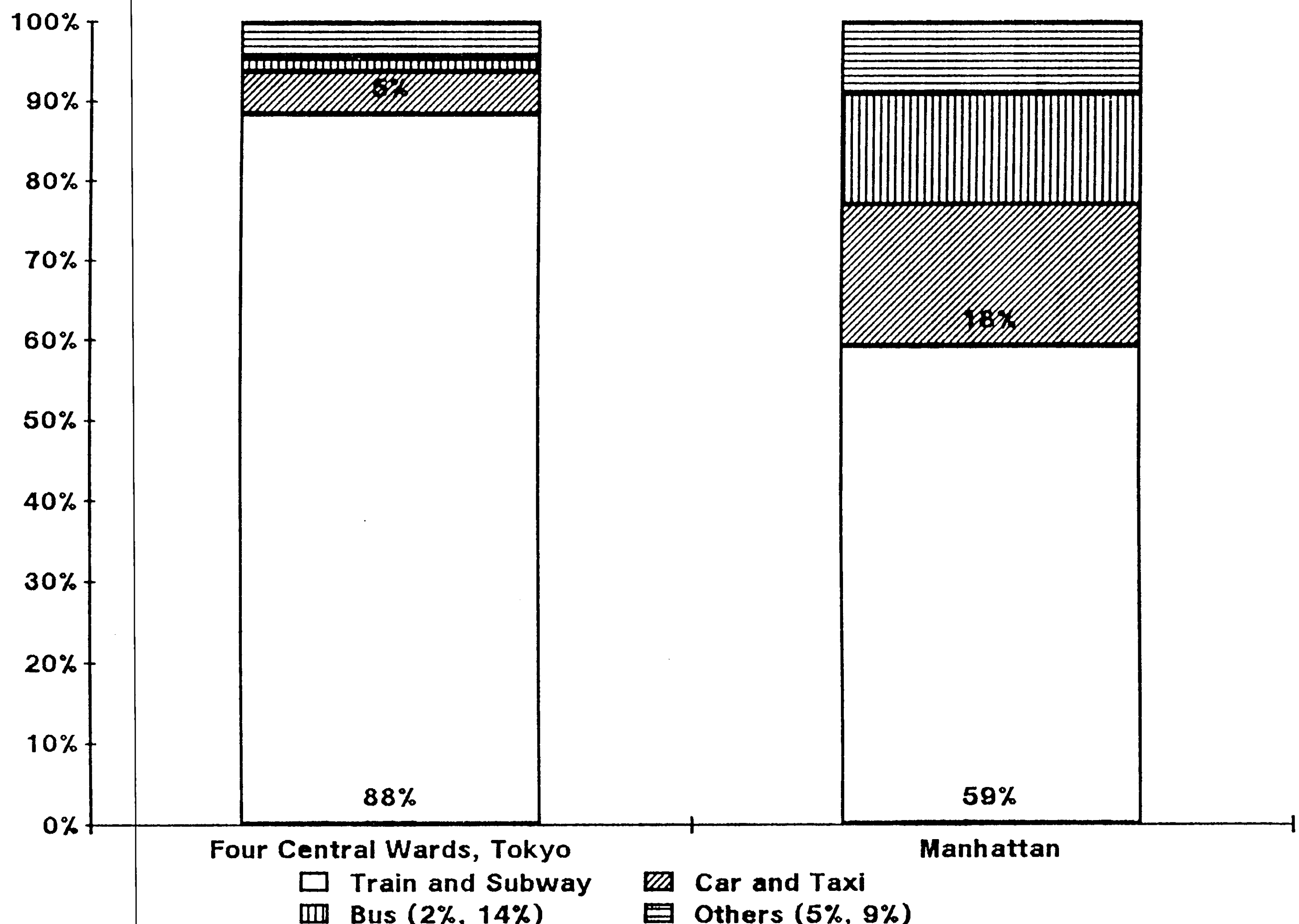


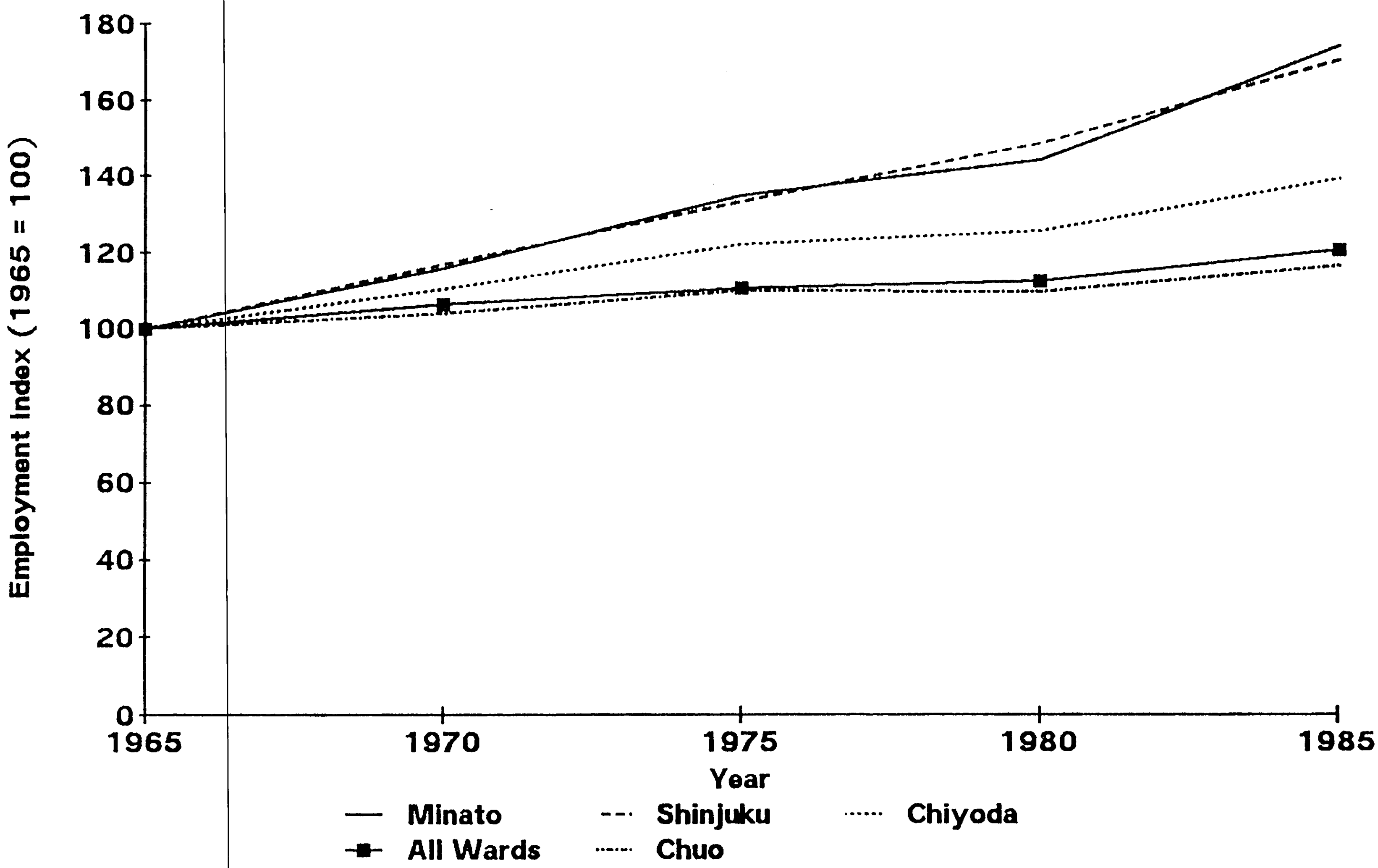
Figure 8 Traffic Modes for Commuting



Source: Table 11

Fig 9.

Employment Trend
Central Wards in Tokyo



Source: Table 13

Fig. 10 Tokyo Prefecture and Chuo Line

Notes:

1. The Ward District consiste of 23 Wards, as shown in Fig. 4. The Tama District consists of counties and cities, some of which are listed in Tables 5 and 6.

2. Figure 2 locates Tokyo Prefecture within the Tokyo Metropolitan Area.

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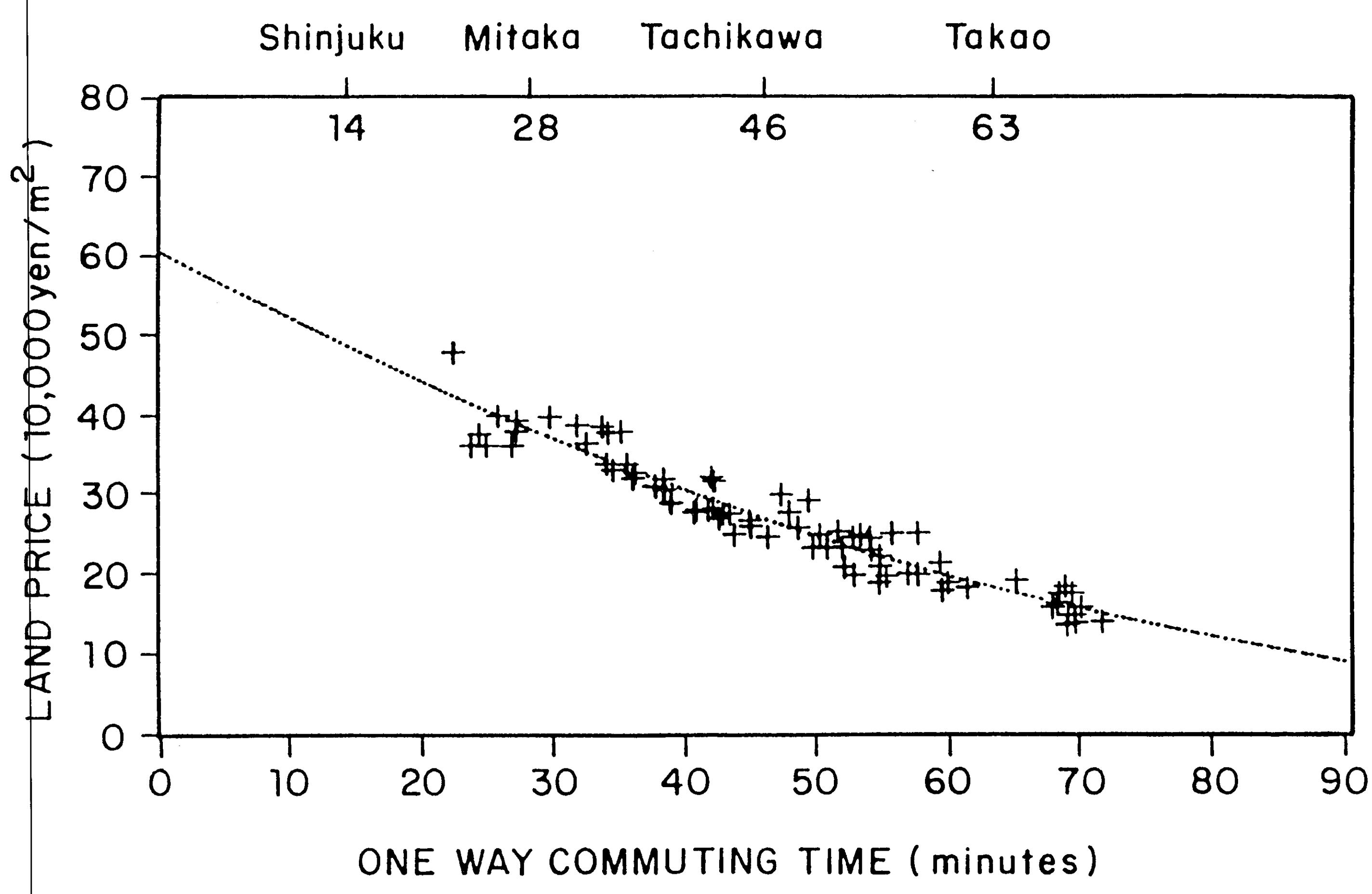

Fig. 11 Land Price Distribution

ED-0180

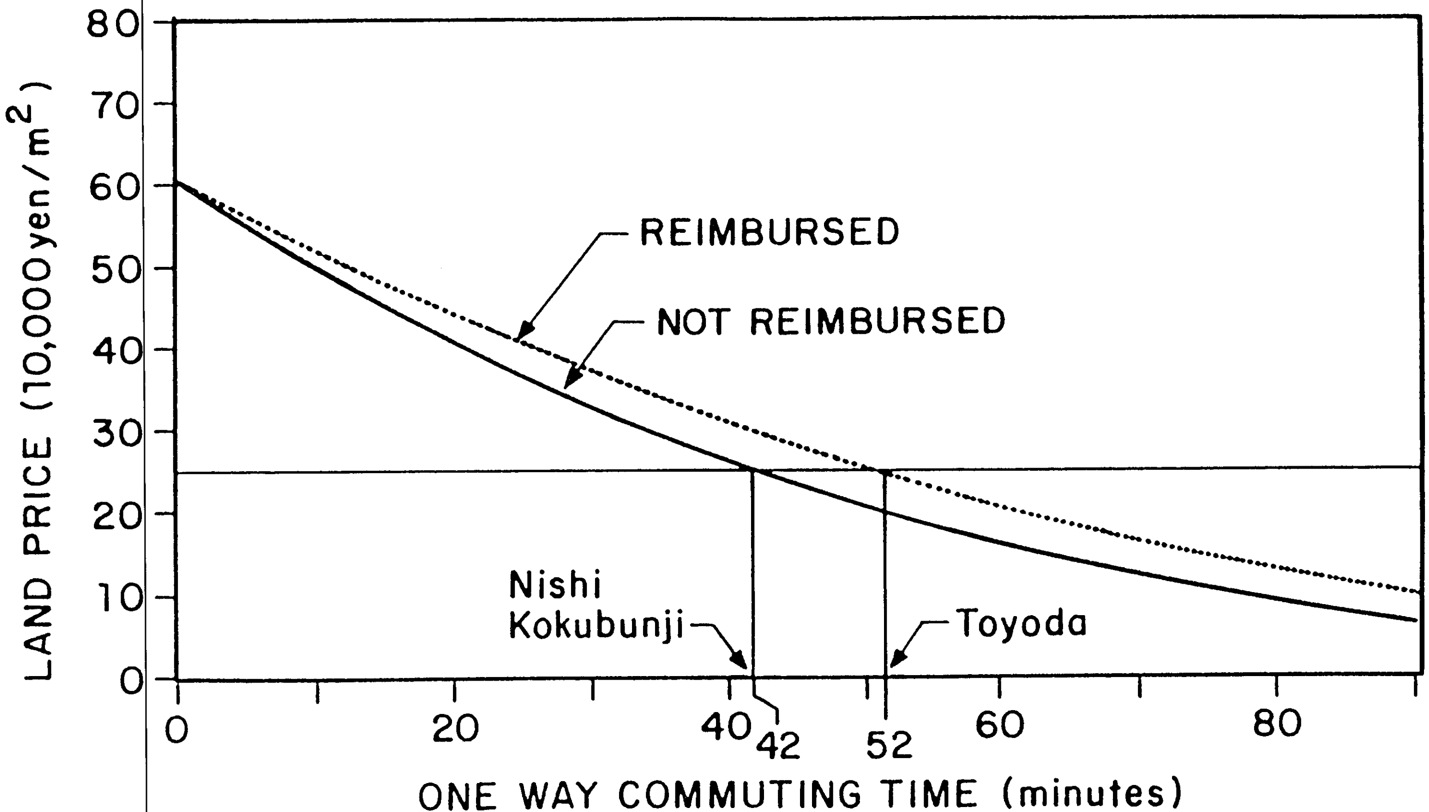

Fig. 12 The Effect of Fare Reimbursement
Upon Land Prices