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A Framework for Urban Transport Studies

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This paper is a product of the continuing investigation of the Economics of Urbanization Division into methods for approaching urban development and, in particular, for appraising urban projects.

After previous works on the interrelationship between land use and transportation are examined, an urban transport study method is proposed. On the project analysis level, the quantification of benefits is discussed.

Economics of Urbanization Division  
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## A FRAMEWORK TO URBAN TRANSPORT STUDIES

### I. Introduction

1. This paper presents a framework to urban transportation studies which could be adopted as part of a general urban development study for operational purposes as opposed to educational purposes. Such an urban transportation study is designed to produce a long-range transportation investment program for an urban area and to identify and evaluate high priority transport projects to be undertaken in the immediate future. A general urban development study covers a number of other sectors as well. However, it is maintained here that decisions on transportation are coordinated with those in other sectors in the general urban development study.

2. We shall assume that the objective of an urban development study is not the development of a particular urban area, but the general economic development of the country in which the urban area is located. There are at least three implications to this distinction. First, in most countries a large portion of income and wealth is created in urban centers and, therefore, urban centers are expected to play a significant role in the development of the country in the future. If an overriding objective of a country is economic development, it has to be achieved, to a significant degree, within the urban area in question. The urban development program derived from the study must be consistent with the objective of increasing national income. Second, since urban areas are open to any citizen of the country, in contrast to countries which are generally closed, the development program has to take full account of its impact on national resource

allocation through market forces. It is just not possible to build and maintain a pleasant, highly capital intensive city when the rest of the population is substantially below the level of affording such luxury. A usual reaction, for example, is squatting next to glass and concrete palaces. Third, an urban development program cannot be made without regard to the resource availability. In most countries resource availability is significantly controlled by the central government. The central government allocates resources on the basis of national priorities. No development program for an urban area can be made useful without reference to resource allocation at the national level.

3. Two extreme views are often expressed in regard to the method of urban planning and decision making. One states that an urban system is a complex organism in which all elements depend on each other and, therefore, a comprehensive analysis is required to derive a correct solution to any problem. According to this view, the decision to build a traffic signal at a specific intersection cannot be made until the child-rearing practice of migrants has been sufficiently studied. The other extreme view is that only one specific project needs to be studied; for comparison purposes all other projects can be represented by the opportunity cost of the resources. A project is analyzed in isolation by making appropriate assumptions, often of certeteris paribus, in regard to all necessary information required for evaluation.

4. Consider the comprehensive approach. Two things must be considered: first, the amount of data required for a comprehensive analysis and, second, the accuracy of the analytic process used. Data on the developing countries

is almost always insufficient to carry out an ideally comprehensive analysis. Therefore, the economic cost of such a comprehensive analysis could be enormous, merely in terms of the time required for collecting data and for completing the analysis. The extra cost of comprehensive analysis must be compared with the extra benefit it can generate. In terms of accuracy of analysis, there are equally profound questions. Although it is easy to state that every element depends on every other element, it is difficult to quantify the exact relationship for most of the variables, particularly for those not related in any directly measurable way. As will be discussed later, the accuracy of the analytic processes itself must receive due consideration when any quantitative analysis is undertaken.

5. Any social science model is constructed according to our understanding of the system involved. A model is not a mysterious black box, but a set of interrelationships between variables in the mind of the model builder. Interrelationships are conceptualized only in a number of discrete ways. Therefore, even though the urban system is a complex system in which every element depends on every other element, we can reason the impacts of a policy variable by following the stipulated interrelationships. For this purpose fairly simple analytic techniques are usually required. We should be cautious against the approach of building a gigantic model without clarifying the basic interrelationships beforehand and testing policies with the model at random.

6. An urban transportation study requires information on the preference of individuals and organizations with respect to the choice of location and the mode of transportation and on the policy tools available to the government in transportation programs. As will be demonstrated below, transportation policy decisions are not so powerful in determining the pattern of urban development as have been believed by many. We should recognize that individual preferences determine the location of different types of land use in a large part. However, such an objective is misdirected for transportation studies. We should be concerned more with the efficiency of resource use than guiding land use development. For this purpose the objectives of such a study should be kept clearly in mind when the study is designed. The art of transportation studies is in the selecting of key variables and key interrelationships which are relevant to the objectives so that the impacts of transportation decisions can be properly evaluated without spending a great deal of resources on the study itself.

7. A proper transportation study rests on the formulation of a proper methodology. Knowledge for this comes from previous empirical and theoretical research efforts. In the next section, a review of past efforts in the area of transportation will be presented, and some basic guidelines will be established for future urban transportation studies. In Section III, an approach to urban transportation studies is described on the basis of the findings in Section II. In Section IV, conceptual problems in measuring benefits of transportation investment are discussed. Conclusions are presented in Section V.

## II. A Review of Urban Transport Studies

### A. Complexity of Analytic Techniques

8. William Alonso casts serious doubt on the current practice of building complex models for predictive purposes.<sup>1/</sup> He analyzes the accuracy of prediction in models of different degrees of complexity. He distinguishes between two types of error which lead to error in prediction: error of measurement and error of specification. "Error of specification arises from a misunderstanding or purposeful simplification in the model of the phenomenon we are trying to represent.... Measurement errors are those that arise from inaccuracy in assessing a magnitude."<sup>2/</sup> He proceeds to demonstrate that the relative magnitude of the measurement error frequently increases as the variables are processed through mathematical operations and that the reliability of the predicted value declines as the number of the processes increases in the model. As far as the specification error is concerned, assuming correct knowledge on characteristics of phenomenon, the magnitude of error diminishes as the number of variables and equations in the model increases, i.e., as the complexity of the model increases. However, after a certain degree of complexity is reached, the reduction in the prediction error resulting from the specification error is more than offset by the increase in the prediction error resulting from the compounding effect of the measurement errors. Therefore, he argues that an increase in the complexity of a model does not necessarily improve prediction. According to his view, the optimal complexity of a model or of an analytic process depends upon the types of mathematical operations and the accuracy of data used. In general when data is less accurate, simpler analytic processes are recommended. Also, he discourages a long chain of analytic processes as errors cumulate in the process.

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<sup>1/</sup> William Alonso, "The Quality of Data and the Choice and Design of Predictive Models," Urban Development Models, Highway Research Board Special Report 97, Washington, D.C., 1968, pp. 178-192.

<sup>2/</sup> Ibid., p. 178.

9. Alonso's argument is made without reference to any specific subject. He does not discuss the bias in prediction associated with particular processes, nor does he discuss the error of a predicted variable with respect to another predicted variable, which is often more important than the absolute error of a predicted variable. However, his analysis is particularly relevant to the study of urban transportation in cities of developing countries. In a number of respects, urban transportation in cities in developing countries is more complex than that in cities in developed countries. Take for example, the transportation modes seen in different cities. On the streets of U.S. cities, there are only a few types of vehicles, whereas on the streets of Calcutta, there are automobiles, buses, animal-drawn hand carts, rickshaws, bicycles, scooters, pedestrians, streetcars and sacred cows. In terms of the distribution of land uses, cities in developing countries present more complex patterns than developed country cities. In American or European cities, land uses are distributed in fairly discrete groups. However, in developing countries urban land uses are heavily mixed. Mixed uses are the rule rather than the exception. Therefore, even when there is a fair amount of data about land use and transportation, it is more difficult to build a satisfactory prediction model for cities in developing countries than for those in developed countries. One obvious way to reduce this difficulty is to improve the data, but experience in the United States indicates that such improvement alone does not lead to a successful result unless a corresponding improvement is made in the analytic technique.

B. Transportation and Land-Use Models

10. Let us now consider the interrelationship between the transportation network and land-use pattern as it affects the overall efficiency and welfare of urban areas. In this connection U.S. experience is quite instructive. The U.S. Bureau of Public Roads and other agencies have been financing large scale transportation studies. From 1944 to 1961 more than two hundred studies were conducted which involved large-scale home-interview surveys.<sup>1/</sup> The objective of the earlier studies was to derive a transportation system which would satisfy the predicted transportation demand. The demand was predicted independently of the transportation system to be implemented. The task of the transportation study was conceived as fulfilling the transportation requirement. The concept of choice among alternatives was not incorporated into the study.<sup>2/</sup>

11. Since the advent of the contemporary planning doctrine around 1960, a number of studies have tried to evaluate alternative urban development plans and policies. David Boyce reviewed 13 major transportation planning studies conducted between 1959 and 1968 which are, to a large extent, based on the following beliefs:

- (1) in order to find a desirable development plan, a comprehensive analysis of alternative development plans considering both land use and transportation is necessary;
- (2) the cost of transportation can be varied by altering the mix of transportation modes and the pattern of the transportation network;

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<sup>1/</sup> Richard M. Zettel and Richard R. Carll Summary Review of Major Metropolitan Transportation Studies in the United States, University of California, Institute of Transportation and Traffic Engineering, Berkeley, Calif., 1962.

<sup>2/</sup> A typical study of this kind is the Chicago Area Transportation Study, of which the final report was published in 1959. Such studies are discussed in Zettel and Carll, op. cit., and N.A. Irwin, "Review of Existing Land-Use Forecasting Techniques" Highway Research Record No. 88.

- (3) the density of development is strongly related to the transportation facility and services, and therefore transportation policies can be used as an effective lever for obtaining a more desirable physical pattern of development.<sup>1/</sup>

12. The thirteen studies covered the following metropolitan areas: Baltimore, Boston, Chicago, Detroit, Los Angeles, Milwaukee, Minneapolis-St. Paul, New York (2), Philadelphia, Pittsburgh, San Francisco and Washington, D. C. In terms of time, the shortest study took three years, and the longest, eight years so far, though it is still in process. In terms of cost, a typical study cost more than one dollar per inhabitant in the metropolitan area studied.<sup>2/</sup> The plan-making process common to these studies is:

- (1) generation of alternative concepts, (2) elaboration of each concept into an alternative plan, (3) evaluation of alternative plans, and (4) the decision process with respect to the alternatives. Alternatives were conceived in terms of land use patterns such as "radial corridors," "spread city," "multi-towns," "linear city"; in terms of structural characteristics such as low density versus high density, concentration versus dispersal; or in terms of transportation systems such as highway versus transit, arterial versus freeway, grid versus radial, minimum transport versus maximum transport. In many of the studies, from three to four alternatives were evaluated.

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<sup>1/</sup> David E. Boyce and Norman D. Day, Metropolitan Plan Evaluation Methodology, Institute for Environmental Studies, University of Pennsylvania, March, 1969.

<sup>2/</sup> Zettel and Carll, op. cit., p. 15. The cost of travel survey constitutes a large portion of the cost.

In many cases alternatives were evaluated on the basis of performance in transportation services and cost of facility and service systems.

13. After reviewing the planning process and the evaluation process, Boyce concludes:

- (1) In those planning programs using urban development models to elaborate alternative land use patterns in which only transportation policies were varied, no significant differences in land use patterns were identified.

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- (2) In those programs in which land use patterns exhibiting significant differences were used as the basis for testing a single transportation system including both highway and transit, no large difference in network performance and cost was demonstrated for the land use alternatives.
- (3) In those programs using urban development models to generate land use alternatives in which both transportation policies and land use policies were varied, the resulting land use patterns and transportation requirements were not sufficiently different to provide a technical basis for policy decisions. <sup>1/</sup>

The significant difference as, used by Boyce here, is a difference large enough to enable either the professional staff or the committee supervising the study to choose among the alternatives on the basis of the difference. The lack of sufficient difference in the outcome of the urban development models used led the study groups to choose on the basis of non-economic criteria, such as the attractiveness of a strong metropolitan core.

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<sup>1/</sup> Boyce, op. cit. p. 61

14. Boyce attributes the above observations to the following factors:

- (1) the land use and transportation policies tested were too conservative and too similar to obtain differences among the alternatives;
- (2) the models and methods available were too blunt to produce differences in alternatives in response to the policies assumed;
- (3) for the increment of growth and change and for the forecast period commonly used beyond the future base year, no significant variation could have possibly been obtained;
- (4) the size of the districts used for forecasting development and travel demand was probably too large to detect the assumed land use and transportation interaction; the expected differences in spatial arrangements of activities and environmental quality may not exist at this aggregate district scale.<sup>1/</sup>

Next he states:

"Different regional land use and transportation alternatives will be obtained only if:

- (1) significant variations are made in the proposed development policies, including not only transportation but also sewer and water, open space, and location and density of employment and population;
- (2) the alternatives are specified over a long time period with a large increment of growth or change relative to existing development;
- (3) the size of the analysis districts is sufficiently small to capture the kinds of differences desired;
- (4) properly specified land use and planning models are used.<sup>2/</sup>

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<sup>1/</sup> Ibid., p. 62.

<sup>2/</sup> Ibid., p. 63.

Then he recommends:

"If these conditions cannot be met in the development of alternatives, either for technical or policy reasons, then alternative plans should not be attempted, given the state of existing methods. Rather a single 20-year regional projection should be developed as a target or framework for testing of alternative facility system plans."<sup>1/</sup>

15. Boyce tried to attribute the lack of significant difference among alternatives to the method of analysis used in the studies and to the conservatism of planners, and carefully avoided the implication that either transportation policies or land use patterns are not significant in affecting the use of resources in urban areas. As the study of Bone and Wohl indicates,<sup>2/</sup> there is evidence to support the proposition that transportation policies change the pattern of land use. Therefore, if the study methods and data are sufficiently refined, significant differences in land use may be obtained for alternative transportation policies.

16. Such improvement in the methods and data are, however, not likely to be readily made particularly for developing countries. Mere collection of sufficient disaggregated and detailed data requires a resource which is beyond the practical limit of the developing countries in the short run. As to the methodological improvements the experience in the U.S. tends to indicate that there is an even poorer prospect in developing countries.<sup>3/</sup>

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<sup>1/</sup> Ibid., p. 63.

<sup>2/</sup> A. J. Bone and M. Wohl, "Massachusetts Route 128 Impact Study," Highway Research Board Bulletin, 1959, pp. 34-38.

<sup>3/</sup> Other evaluative works to the modeling experience are: Urban Development Models, Highway Research Board Special Report 97, Washington, D. C., 1968, particularly a chapter by Britton Harris, "Conference Summary and Recommendations," pp. 3-17; Ira S. Lowry, "A Short Course in Model Design," Journal of The American Institute of Planners, May 1965.

17. One point, however, implies that the prospect of the land use transportation simulation approach is better in developing countries. According to Boyce, one reason for not producing significantly different alternatives was, the short time horizon, typically 20 to 25 years, used to evaluate alternative plans. The appropriate time horizon, however, is related to the growth rate of the city. Among the 12 metropolitan areas reviewed, the fastest growing area was Washington, D.C. which, according to the prediction, will take 30 years to double its population. Many of the cities in developing countries are growing at a much faster rate. Typically, they take 15 years to double their population. Therefore, there is a chance that the same time horizon would produce more meaningful differences for cities in developing countries. However, this factor alone is not a sufficient reason for undertaking this particular type of study.

C. The Cost of Urban Infrastructure

18. Although not implied by Boyce in the reasons he gave for the models not producing significant differences, the following interpretation can be made: even if ideal methods are used for prediction and evaluation, large differences in the physical layout of transportation networks and land use may not in fact produce substantial differences in cost savings and other performance criteria. Many of the alternatives conceived by planners may be equally good despite their obvious differences in visual and geometrical differences. A study by Robert Jones is directed to this question and is extremely helpful in understanding the tradeoff relationships among different urban infrastructure costs.<sup>1/</sup> He has identified three major areas of trade-offs.<sup>2/</sup>

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<sup>1/</sup> Robert Jones, "Transport, Urban Design, and Housing," in Edwin T. Haefele, editor, Transport and National Goals, The Brookings Institution, Washington, D.C., 1969.

<sup>2/</sup> Ibid. pp. 54-55.

- (1) As the number of floors in residential buildings increases, the amount of land required for a fixed number of families decreases. This leads to an increase in building cost per unit of housing and decrease in transportation and public utility costs.
- (2) When the residential density is low enough to use soil-absorption instead of a system of sewer pipes, the sewage disposal cost decreases but transportation and other facility costs increase.
- (3) As employment locations are decentralized within the city, the average commuting distance usually decreases, but the average intraurban freight transportation distance increases.

Using prices prevailing in Venezuela around 1960, he proceeds to quantify tradeoff relationships.

19. The cost analysis is made on two levels: the neighborhood and city-wide. At the neighborhood level, the cost per housing unit including basic improvements such as streets, ditches, water main distribution, sanitary sewer and transportation depends primarily on the materials used for construction of housing units, the quality of finishings, the size of the unit and the distance between neighboring units. Four-story walk-ups require reinforced concrete, while one-story houses only require local materials and self-help labor. Therefore, the building cost per square foot is about three times higher for four-story walk-ups than for self-help built one-story houses when each has low quality finishing. The cost difference per housing unit varies depending on square footage and the type of labor used, but ranges from Bs. 2,800 to 6,000.<sup>1/</sup> The cost of standard site improvements per unit

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<sup>1/</sup> The exchange rate of Bolívares (Bs.) for US dollars was 3.35 to 1 until 1964 and 4.50 to 1 since then.

declines if the units are clustered together because the average amount of land per unit and the average distance between units are both reduced. The cost of standard improvements is about Bs. 1,000 less for four-story apartment buildings with a density of 40 to 70 units per acre than for one-story houses with a density of 17 to 22 units per acre, and by about Bs. 2,000 less for the same four-story apartment buildings than for one-story houses with a density of 4 to 4.6 per acre. Combining building and standard improvement costs, the difference between four-story walk-ups and one-story houses becomes greater as the size of a unit increases and self-help is used for one-story houses. Cost differences are more systematically presented in Table I. Typically they are around Bs. 3,000.

Table I: COMBINED COSTS PER DWELLING UNIT FOR HOUSING AND STANDARD IMPROVEMENTS AS RELATED TO METHOD OF CONSTRUCTION  
(In bolivars per dwelling unit)

	Neighborhood	Neighborhood		Difference
	4-71 <sup>a</sup>	1-17 <sup>b</sup>		
Floor area per dwelling unit	Low quality contract construction	Low quality contract construction	Self-help construction	
Floor area 350 square feet	7,249		4,360	2,889
Floor area 645 square feet	10,649		5,760	4,889
Floor area 350 square feet	7,249	5,560		1,689
Floor area 645 square feet	10,649	7,560		3,089

Note: a. Neighborhood 4-71 refers to a neighborhood consisting of four-story structures with a gross density of 71 housing units per acre.

b. Neighborhood 1-17 refers to a neighborhood consisting of one-story structures with a gross density of 17 housing units per acre.

Source: Jones, op cit., p. 64.

20. In addition to building and standard improvement costs other costs were considered at the neighborhood level. The total cost of distance-related services such as mail delivery, meter reading, police patrolling, refuse collection, utility repair, fuel delivery and freight delivery, when they were capitalized for 20 years at 12 percent, turned out to be Bs. 100 with low market wage rates and Bs. 29 with subsistence wage rates for the lowest density development of 4 units per acre. This is less than 5 percent of the standard improvement cost for that development and is considered to have little significance for comparison.

21. The method of sewage disposal affects the cost of improvement. If a neighborhood of 4 units per acre has pit privies with natural soil absorption and public water taps, while a neighborhood of 17 units per acre has sanitary sewers and an indoor toilet, the cost saving of the former is about Bs. 600 per unit (Bs. 340 vs. Bs. 960) for water and sewage alone. However, the cost advantage of the former diminishes and eventually disappears as other site improvements are considered such as ditches, paved streets, walkways, electricity and storm sewers. The cost of water and sewage for a neighborhood of 17 units per acre can be reduced by Bs. 510 per unit by making do with outdoor public water taps and pail-and-truck sewage collection. With truck distribution of water and collection of sewage, it can be reduced to Bs. 240. Therefore, it can be concluded that when the income level is low and substantial improvements are not required the soil-absorption sewage with low density development is worth considering. In addition, technological alternatives tend to give a wider range of variations in cost for the same density.

22. In order to examine the tradeoff relationship between the extra building cost and the savings in distribution systems in high density multi-story development, a city-wide cost analysis was made for a city of 336,000 families.<sup>1/</sup> The sum of the building, site improvement, transportation and utility costs was computed for two density alternatives, each with a single employment center, one with and the other without four-story walk-up apartment buildings. For each alternative, two different residential land use patterns were compared: one with the low-income group inside and the high income outside and vice versa. For each alternative, the land use pattern of lower total cost was considered as the relevant one. As far as the cost of transportation and major utility lines is concerned, the high density alternative gives savings from about Bs.1,250 to 3,100 per low income family. The exact amount of the savings depends on the modal composition of commuting transportation, the valuation of commuting time and the frequency of commuting. The results of the cost analysis on the neighborhood level indicate that the use of multi-story housing gives a higher cost for the system as a whole except when one or more of the following rather unrealistic conditions holds: travel time is valued almost at the wage rate even for unskilled workers, future costs are discounted at an interest rate well below 12 percent, and the dwelling units are small and are finished by contract construction.

23. In terms of the composition of various costs, it was found that, for one housing unit, the major water mains cost about Bs.200, the sanitary sewer mains Bs.50, the basic two-lane roadways Bs.100 and the overhead electric transmission and gas lines together even less than Bs.50. The single most significant element is the capitalized cost for passenger and truck transportation which ranges upwards from Bs.4,200. Even more important is the fact that the variation in total utility costs from one pattern to another is much less than the variation

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<sup>1/</sup> In the context of Latin American countries, this implies a population of 1.5 to 2.0 million.

in the transport costs. In addition, a counterbalancing tradeoff relationship was found within the transportation costs. Between the two land use patterns, i.e. one with the low income in the inner ring and the high income in the outer ring and the other vice versa. The more expensive travel modes and higher values of travel time for the high-income commuters approximately offset the higher densities for the low-income commuters, resulting in about equal overall commuting costs.

24. Jones proceeds to test the cost implication of having more than one central workplace. Within the same framework he assumes 5 and 17 major workplaces with one workplace in the center, to which 30 percent of the workers from every neighborhood commute. By approximating the Venezuelan situation in terms of modal composition and valuation of time it was concluded that the capitalized transportation costs would average at least Bs. 300 less per family with 5 or 17 major workplaces than with just one. However, the costs of utility systems go up as the number of major workplaces increases, largely because of the stand-by capacity in the water mains needed for fire flow for the workplaces. There are some diseconomies of decentralization in other utility systems, too. Considering all the utilities together, the additional cost with several decentralized workplaces would be Bs. 200 or less per family. Consequently, although land use patterns with the decentralized workplaces reduce transportation costs, a substantial portion of these savings are cancelled out by an increase in utility costs, the net savings are not necessarily impressive when unmeasurable costs such as loss of face-to-face contact are added for the decentralized patterns.<sup>1/</sup>

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<sup>1/</sup> The interpretation given in this sentence is the author's.

25. In sum, the study by Jones supports the hypothesis that the cost of urban infrastructure is rather insensitive to the pattern of land use. More importantly, it makes explicit important tradeoff relationships which have never been analyzed individually in the simulation analyses. Generally, it demonstrates that technological alternatives, as opposed to alternatives in land use layout, such as use of indigenous materials versus reinforced concrete for housing and natural absorption or truck collection versus piped sewage disposal, are more significant in affecting the cost of urban infrastructure.

D. Modes of Urban Transportation

26. It is quite conceivable that there is a significant difference in the cost of providing different modes of transportation which Jones did not examine. His commuting costs are solely based on bus service. Unlike bus service, a mass transit rail system is capital intensive. However, because of high performance per track which results in savings in road construction, and possibly in the overall cost of rolling stocks, this system may prove to be less expensive under certain conditions of population size and density. According to Wilbur Smith and Associates<sup>1/</sup> rapid rail transit carries up to 40,000 persons per hour per track, while bus transit carries up to 25,000 using an exclusive reserved land, and automobiles carry about 2,000 persons per hour per lane on expressways and about 600 persons on surface streets assuming a ridership of 1.2 persons per automobile.

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<sup>1/</sup> Wilbur Smith and Associates, Future Highways, and Urban Growth, 1961.

27. When the costs of fixed and rolling stocks, of collection in residential areas and of distribution in downtown areas are added together, the relative status of different modes changes drastically. The study conducted by Meyer, Kain and Wohl is quite illuminating on this issue.<sup>1/</sup> They demonstrate that rapid rail transit was rarely the least cost solution in U.S. metropolitan areas during the 1960's unless the density of transportation demand was very high. More specifically, they concluded that automobile computation is about as inexpensive as any available urban transport mode when hourly maximum load point volumes per corridor are in the range of 5,000 to 10,000 persons or below. Once hourly maximum load point volumes per corridor reach a level of 10,000 passengers per hour or higher, an integrated bus service appears to be competitive with or cheaper than other urban transport within a wide range of circumstances. The rapid rail transit does not demonstrate a cost advantage unless the peak passengers per hour exceeds 20,000 or 25,000 and the residential density is high.

28. Deen and James studied the costs of bus and rail transit systems in a medium-size metropolitan area in the U.S.<sup>2/</sup> After analyzing capital and operating costs under alternative assumptions, they concluded that rail transit has a cost advantage when the peak passengers per hour exceed 12,000 for similar levels of service. In their study the cost for bus service is relatively high since exclusive "busways" on line hauls are assumed for bus service.

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<sup>1/</sup> J. R. Meyer, J. F. Kain and M. Wohl, The Urban Transportation Problem, Cambridge, Mass., Harvard University Press, 1965.

<sup>2/</sup> Thomas B. Deen and Donald H. James, Relative Costs of Bus and Rail Transit Systems, Alan M. Voorhees & Associates, Inc., McLean, Virginia, undated.

29. There are several reasons to believe that the modal preference would be different in developing countries. In many of the cities in the developing countries, population density is much higher than that in the U.S. Consequently, the generation of passengers of up to 5,000 per station assumed in the Meyer-Kain-Wohl study can easily be exceeded, the maximum peak of 12,000 passengers per hour in the Deen-James study can also be exceeded. Second, people are willing to walk greater distances in developing countries. Therefore, the feeder bus service considered in both studies is to a large extent unnecessary. Third, greater utilization of rolling stocks can be achieved than is assumed in these studies, as a load factor of two or more is common in cities in developing countries.

30. Another factor to be considered in choosing modes of transportation is the impact of a mode on the long-run growth of the city. Although the transportation studies surveyed by Boyce did not reveal, probably due to the short time horizon used and already widespread use of automobiles, there are several historical findings that tend to demonstrate that popularization of transit systems before the spreading of automobile ownership affects the density of urban development in the long run. Compare the density of Los Angeles with that of New York City or Chicago. Since Los Angeles started developing at a later date than the other two cities when ownership of automobiles was fairly widespread, it has achieved low density in comparison to the other two large metropolitan areas. Therefore, it can be argued that the density of development is related to the technology available at the time of development. At the same time, the above example tends to demonstrate the irreversibility of urban development in terms of density. The Japanese case

reinforces the argument of irreversibility. In Japan, although income per capita is highest in Tokyo, automobile ownership in Tokyo is not. Higher automobile ownership is observed in medium-size cities where rail mass transit systems are not very well developed.<sup>1/</sup>

31. Therefore, an early development of rail mass transit systems can be thought of as a device for achieving compact development. If rail mass transit systems can be used to guide development along several corridors so that the peak passenger demand is sufficiently high for each corridor, such development would achieve considerable economy. The merit of such a strategy should be examined.

### III. Study Method

32. Three lessons can be drawn from the above review. First, complexity in analytical structure does not pay when each individual relationship specified in the model is not accurate or when the input data are not accurate. In such cases, a fairly simplified model would produce equally as well as and be much less costly than a complex analysis. Second, the alleged interdependency among policies and the economic variables is not ubiquitously significant, though significant interdependency does exist in limited relationships. More significantly, there are several counterbalancing forces working in an urban system. Third, visual or geometrical difference in land-use pattern and in transportation system is not significant in terms of welfare criteria.

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<sup>1/</sup> The automobile ownership of Tokyo Prefecture was the 7th highest out of 46 prefectures in 1968, and that of Tokyo City is the 18th highest among the capital cities of the 46 prefectures in 1965.

Source: Economic Planning Agency of Japan, Keizai-Chiki-Yoran, Tokyo 1968.

33. In developing a methodology for urban transportation study, the experience of the U.S. can be interpreted in the following way: an attempt was made to cover every aspect of transportation and land use and, consequently, the accuracy of both data and relationships with respect to specific transportation projects was poorer than it would have been had the studies been more selective. This inaccuracy made researchers and policy makers distrust, at least partially, the difference among the alternatives tested. Much of the effort was misdirected to irrelevant alternatives primarily based on physical patterns. Study needs to be focussed more on subjects in which differences are significant, such as modal choice and individual project evaluation.

34. The following steps are recommended for a study method of urban transportation:

- (1) establishment of general land use development plan,
- (2) analysis of transportation supply and demand,
- (3) evaluation of individual projects.

As has been discussed, land use and transportation development alternatives are more or less equally satisfactory when each is prepared by expert planners and engineers with due considerations to the relevant factors. Therefore, to eliminate unnecessary effort, a general land use development plan should be prepared by a team of experts without a comprehensive quantitative economic analysis. Since we know that the land use pattern does not significantly affect transportation demand and transportation flow characteristics, demand and supply analysis of transportation will be conducted more or less independently of the land use development plan. Finally, individual projects will be appraised through rigorous economic techniques.

35. The general land use development plan, although prepared without reliance on rigorous quantitative analysis, should be developed after considering economic and demographic factors which affect the metropolitan area. However, since the role of the general development plan is to indicate the direction and overall pattern of development, the precise timing of development should not be indicated in the plan. Although this is not the place for discussing in full the method of determining the general land use development plan, a brief comment is in order. The composition of population, its growth rates, the composition of labor force in terms of skill and occupation, the level and distribution of income, and the industrial structure ought to be analyzed and predicted in relation to the trends of the national economy in order to derive an appropriate framework for formulating general land use development plans. Particularly important is the distribution of employment locations. These must be located in full recognition of the market forces determining their location. In choosing industrial areas, the space requirement for the industries considered and the costs in transporting goods and personal contacts ought to be considered. As far as the location of central business and administrative functions are concerned, the significance of linkages among them should be fully recognized. It has been demonstrated in the past that such activities tend to agglomerate in one very small area called the central business district. This is the destination of a large portion of commuter traffic.

36. In establishing the general land use development plan, some decision must be made with regard to the direction of growth. This should be established

after considering the linkages of the particular metropolitan area with other metropolitan areas, the topography around the metropolitan area, the soil conditions and the accessibility to recreational areas. It should be consistent with the general growth trend of the metropolitan area.

37. Transportation demand to the major employment center should be analyzed into the future approximately, for 30 years. Its prediction should be based on the approximate land use configuration, but more importantly on the number of commuters to the central business district, the income level of commuters and the residential density distribution of commuters around the central business district. A particularly important factor is the prediction of automobile ownership among commuters in the time perspective both with and without introduction or expansion of rail transit systems. The predicted time profile of automobile ownership under alternative transport policies would, in turn, be used to determine the failure or success of rail mass transit systems.

38. The cost of each mode of transportation service must be examined. Not only rail mass transit on elevated, underground or open cut tracks and bus transit on the regular roadway and reserved expressway, but also bicycle and other types of vehicles must be considered. The cost depends on the intensity of demand for the route, the distance of line haul, the comfort levels demanded and the walking distance allowed. It is important that the service levels are consistent with the economic situation of the area considered.

39. The choice of the mode can be made by comparing the demand and cost characteristics. A transportation network system consisting of different modes in different localities can be established on the basis of the above analysis. The modes for which demand is sufficient to meet the cost requirements will be chosen for each route or combination of routes.

40. High priority projects can be identified on the basis of the demand forecast in the time perspective. For those projects, economic benefit-cost analysis should be conducted. This is the only step in the entire study of urban transportation in which rigorous economic analysis can be introduced. Since we are assuming that the overall land use development plan will be implemented with some flexibility in exact timing and appropriate modes, the object of economic analysis is not to accept or reject a proposed project but to determine its appropriate timing. This does not necessarily imply that every project conceived will be implemented. Certain projects may never be justified within the time span considered in the development program. The overall decisions about the transportation development programs can be modified in the face of new information obtained through project feasibility study or elsewhere.

41. In this connection, it is important to define the term "project". A project can be defined in various levels of aggregation. A portion of an expressway can be a project. The entire expressway network can be a project or an expressway network plus the development of new, associated industrial sites can be a project. If we extend the scope further the entire transportation system becomes a project. However, a project should be defined in such

a way that the efficiency of the investment can be maximized. The efficiency of investment depends not only on the expected economic rate of return but also on the time and cost required for analysis, the reliability of prediction, its relative independence and the management capability. If the efficiency of the investment is increased by including the industrial development alongside the expressway system in our previous example, such industrial development should be included as a part of the expressway project. Before the analysis, such information cannot be obtained. Selected alternative delineations must be compared before a full project analysis is conducted.

42. The role of project feasibility study is quite significant as nowhere else in the entire system of urban transportation studies is rigorous quantitative analysis undertaken. Although the project feasibility study is confined by the overall guidelines established previously, its economic analysis may lead to modification of these guidelines. In some cases, a new set of priority projects may have to be identified.

#### IV. Benefit Measurement

##### A. Approaches to Benefit Measurement

43. Traditionally, economic benefits from investment projects have been classified into economic efficiency and income redistribution. However, some factors which affect welfare are usually excluded from this classification. Some of these are called environmental effects. They include external economies or diseconomies and non-economic impacts. Others relate to the degree of flexibility in handling uncertain events. The following four groups of benefits

will be discussed:

- (1) Economic efficiency
- (2) Distribution of income
- (3) Environmental effects
- (4) Flexibility to uncertain developments

44. The economic efficiency benefits are the resource savings resulting from the project. Properly valued, these resource savings represent an increase in income as they are presumably channelled into the production of income. If a particular resource is underutilized, its saving would have no value. Fully utilized scarce resources will necessarily be positively valued. Therefore, by measuring savings we are estimating an increase of national income. The same economic efficiency benefit can be measured from many facets. For example, it might be measured as an increase in land value affected by a transportation project. However, when the benefit is measured in this way, all the counterbalancing changes in land value elsewhere must also be measured. It is highly likely that an increase in land value occurs in the direct vicinity of the transportation project at the expense of land values elsewhere in varying degrees. Therefore, if the land value is used to measure the transportation benefit, it must be measured for the entire metropolitan area. Everywhere in the world, data on land value are notoriously inaccurate. In addition, there are many conceptual problems in using land value as a measure of the benefit of transportation investment. For example, transportation operating firms can recoup some of the benefits without passing them on to the land value. On the other hand, when the benefit is

measured by the savings to the user, it is much easier to measure the aggregate efficiency benefit. In this way, benefits are measured at their source, before they are spread to different locations and shifted to a variety of individuals and organizations. It has been demonstrated in theory that the entire efficiency benefit can be measured as savings to users and producers of transportation service. (See paragraph 51.)

45. Three kinds of users receiving benefits are frequently distinguished for operational purposes:

- (1) Original users
- (2) Diverted users
- (3) Induced users

The original users are those who would use the facility even in the absence of the proposed investment. The diverted users are those who would use other routes without the investment but are diverted to the facility when it is improved. Induced users are those who would not use the facility without the investment but become users after the investment either because of the reduction in the transportation cost or because of land use changes resulting from the reduction in the transportation cost.

46. In a sense, the classification of benefits according to the users described above is misleading. The actual incidence of benefits may be different. The savings in transportation costs may be passed on to other individuals or organizations such as landlords, transportation companies

and producers of goods and services. The degree of benefit transfer depends on the elasticities of supply and demand for the goods traded by users and related agencies. Therefore, these user categories are merely for the convenience of measuring the aggregate user benefits and do not imply that the users obtain such a benefit. The real question of distribution will be discussed later.

47. Another distributional issue involved in benefit measurement is the intertemporal distribution of benefit in the usual sense, i.e., the tradeoff between current and future consumption. This is usually explained by the rate of time preference which is a matter of value adjustment. There are two typical approaches to this issue; one is the growth maximizing approach, the other the satisfaction maximizing approach. In the first approach, consumption at present and within the foreseeable future is not valued at all, only the increase in the productive capability is valued. In other words, the rate of time preference is zero, consequently, consumption can be postponed indefinitely into the future. In the second approach, the consumers time preference is used as the basis of investment decisions.

48. Development economics is heavily oriented toward the growth maximizing approach. The performance of an economy is frequently measured solely by the rate of GNP. According to this approach, investments which encourage consumptive activities are discouraged. For example, an increase of leisure time which is a major benefit from urban transportation investment is not measured as part of GNP. If this is ignored, public commuting facilities will

not be given high priority. Such an action would cause congestion and long waiting times in queues which might in turn, lead to an increase in automobile ownership to satisfy consumer's urgent demand, a higher demand for taxi rides, possibly a demand for higher wages, and a reduction in employment. This illustrates that even to maximize the growth rate, it is best to value, to a certain extent, the time saved in commuting trips. To what extent the traveling time should be valued in order to maximize the growth rate cannot be answered until a separate quantitative analysis is made.

49. The satisfaction or utility maximizing approach employs the valuation of consumers for weighing future and the present consumption. According to micro-economic theory, if the working hour is controllable by the worker, the marginal valuation of time is equal to the wage rate. However, the working hour is not usually controllable by workers. The actual valuation of time spent in travel can be estimated from the observed behavior of modal choice. This has been done frequently. The studies indicate that, by and large, people value their time substantially below their wage rate.<sup>1/</sup> In a study of the British, Beesley found that the value of traveling time is one-third the wage rate.<sup>2/</sup> Another study shows that if the time saved in commuting is less

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<sup>1/</sup> The following are excellent reviews on this subject: James R. Nelson, "The Value of Travel Time", S.B. Chase, ed., Problems in Public Expenditure Analysis, Brookings Institution, Washington, D.C., 1968; Dan G. Haney, The Value of Time for Passenger Cars: A Theoretical Analysis and Description of Preliminary Experiments, Stanford Research Institute, Menlo Park, Calif., 1967.

<sup>2/</sup> M.E. Beesley, "The Value of Time Spent in Travelling: Some New Evidence", Economica, May 1965, pp. 174-185.

than about 7 minutes, its value per minute is considerably less than that when more time is saved.<sup>1/</sup> If we value traveling time this low, the difference between the two approaches in evaluating economic efficiency benefit over time may not be so large.<sup>2/</sup>

B. Economic Efficiency Benefit

50. Given the valuation of traveling time, the next question is how to measure the entire economic efficiency benefit. Van der Tak and Ray have presented a very simple scheme for measuring the efficiency benefit of transportation investment.<sup>3/</sup> Assuming marginal cost pricing in commodity markets and in the transportation sector and linear demand and supply curves for transportation, they demonstrate that the entire economic benefit can be measured by three variables associated with the improved facility:

- (1) The downward shift of the supply curve;
- (2) The quantity of traffic without the facility improvement and;
- (3) The quantity of traffic with the facility improvement.

What is striking in their analysis is that the entire economic efficiency benefit including that of original, diverted and induced users can be measured by the above three variables, which subsume all the benefits obtained **elsewhere.**

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<sup>1/</sup> Thomas C. Thomas, The Value of Time for Passenger Cars: An Experimental Study of Commuters' Values, Stanford Research Institute, Menlo Park, Calif., 1967, pp. 88-96.

<sup>2/</sup> There is no assurance in other sectors of the urban economy that the economic efficiency benefits measured by the two alternative approaches are not much apart with each other.

<sup>3/</sup> H.G. van der Tak and A. Ray, "The Economic Benefits of Road Transport Projects", World Bank EC-160, November 13, 1969.

Specifically they present the simple formula:<sup>1/</sup>

$$(1) \quad B = s \left( T + \frac{1}{2}t \right)$$

which says that the entire benefit is equal to the vertical downward shift of the supply curve (s) times the sum of the original traffic (T) and half of the increased traffic (t). When demand and supply curves are not linear, such a simple equation does not hold, but the essential relationship remains valid.

The above equation can be generalized as follows:

$$(2) \quad B = \int_0^T (S_0 - S_1) dq + \int_T^{T+t} (D - S_1) dq$$

where  $S_0$  and  $S_1$  are respectively the supply curves without and with the facility improvement and  $D$  is the demand curve. In this case the demand curve should not necessarily be interpreted as a fixed one. Whenever the demand curve shifts as a result of a change in the price of transportation on this route, it should be interpreted as the locus of equilibrium points. Diagrammatically, the benefit is the sum of the dotted area and the vertically shaded area minus the horizontally shaded area in Figure 1.

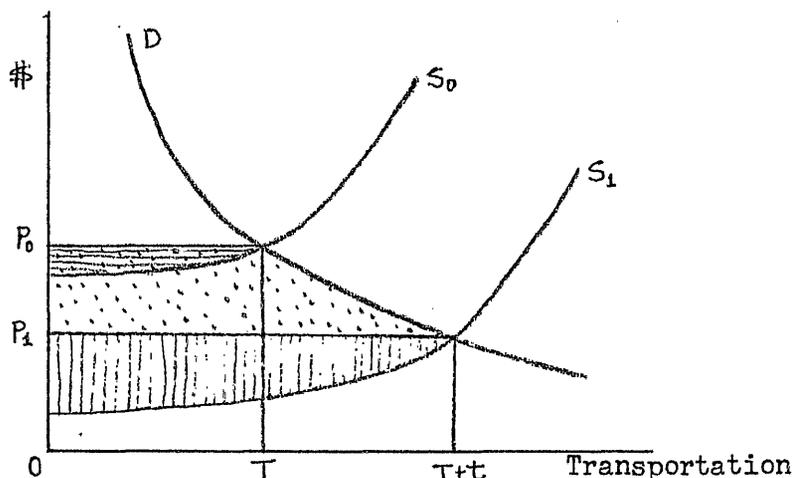


Figure 1

<sup>1/</sup> Van der Tak and Ray, *op. cit.* p. 19.

51. There is one type of benefit which is not explicitly considered in the Van der Tak - Ray analysis. That is what Morhling and Williamson call the reorganization benefit.<sup>1/</sup> This benefit results from the locational adjustments of producers in response to reductions in transportation costs. They have demonstrated that such benefit can be measured as a part of the usual consumers' surplus.

52. On a close look, the Van der Tak - Ray analysis contains an element applicable to the organization effect. This appears in the analysis of railroad and road transport as imperfect substitutes. The demand for two different modes is interpreted as two demands existing in two different locations. These two different locations are regarded as imperfect substitutes. Hence, the same analysis applies. For practical purposes, the sum of consumers' and producers' surpluses realized from the improved facility constitutes the entire economic efficiency benefit.

53. The Van der Tak - Ray analysis does not provide much clue for measuring benefits when marginal cost pricing is not practised. However, in the transportation sector, monopoly and non-marginal cost pricing is the rule rather than the exception. Particularly in the case of urban highway transportation, average social cost is the price perceived by private users. Marginal cost is not perceived by individual users at all. In the case of bus and train services, the prices are fixed by government agencies or by the monopolistic pricing policy of the operating firms. Under such cases the

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<sup>1/</sup> H. Morhling and H. Williamson, Jr., "Scale and 'Industrial Reorganization' Economics of Transport Improvements," Journal of Transport Economics and Policy, September, 1969.

measurement of benefit should be examined too. In the following we shall merely focus our discussion on the measurement of economic efficiency benefit under such non-marginal cost pricing in policy without placing much emphasis on the merit or demerits of such pricing policy.

54. Let us consider, first, a typical highway in which private automobile users perceive average social cost and not marginal social cost. In this case, suppliers are the individuals who demand the transportation. The resulting supply curve is in fact the average cost curve instead of the marginal cost curve. In general, such an average cost curve increases as the volume of traffic increases because of congestion effects. Therefore, the marginal social cost curve rises above the average cost curve. When the facility is improved, the average cost curve is lowered. The concept of consumer's surplus is still applicable in this case but the producer's surplus is nil because the total cost is the average social cost times the quantity of transportation: the users as a group pay the total social cost. See Figure 2, where  $MC_0$  and  $MC_1$  are, respectively, the marginal cost curves without and with the facility improvement and  $AC_0$  and  $AC_1$  are, respectively, the average cost curves without and with the facility improvement.

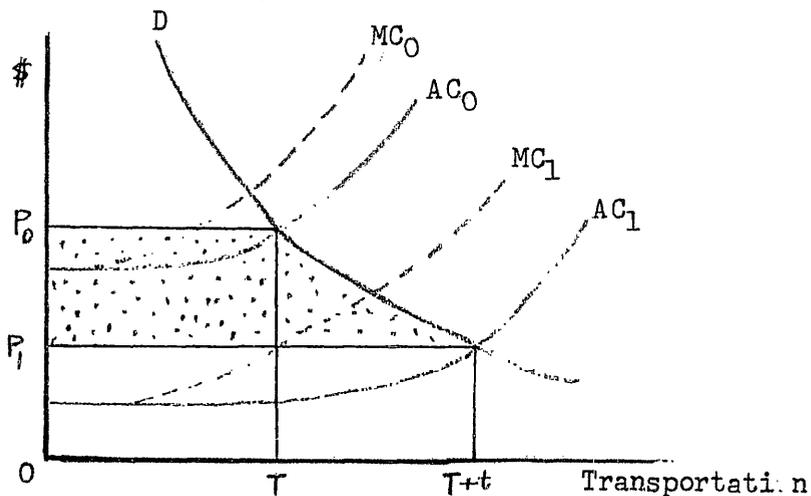


Figure 2

Notice in this case the downward shift of the supply curve (the average cost curve) is irrelevant for measuring the benefit. The entire benefit consists only of consumers' surplus.

55. Let us suppose that monopoly pricing prevails in the supply of transportation service. If the price charged does not change when the facility is improved, then there is no consumers' surplus, only producers' surplus. The producer's surplus is the entire economic benefit. Let us now suppose that the prices are set by the monopolist so that the marginal revenue is equated with the marginal cost. In this case, the facility improvement will lead to change in the price. The situation is illustrated in Figure 3, in which there are both consumers' and producers' surpluses.

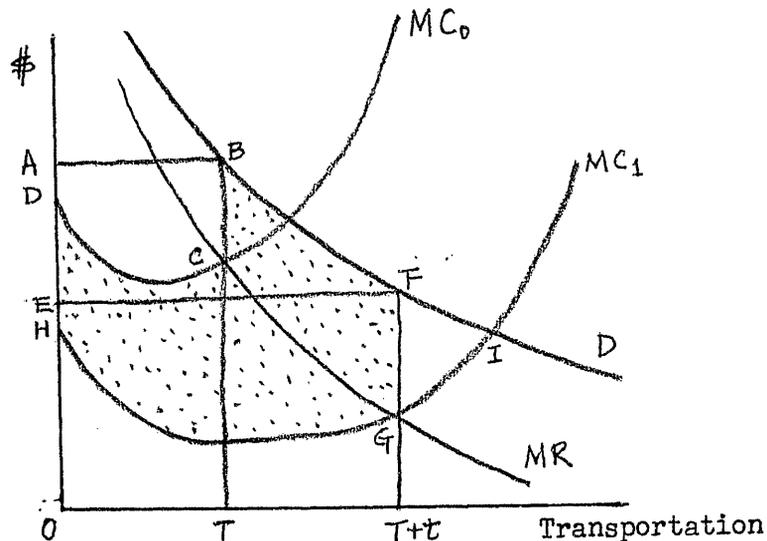


Figure 3

The facility improvement shifts the marginal cost curve from  $MC_0$  to  $MC_1$ . The price is determined by the intersection of the relevant marginal cost curve with the marginal revenue curve, MR. The price is reduced from A to E and the traffic is increased from T to  $(T + t)$ . The resulting consumers' surplus is the area ABFE, and the producers' surplus is EFGH.

However, the original producers' surplus ABCD is lost in this process. The net increase in the benefit is the dotted area DCBFGH. It is likely that the consumers' surplus is apt to be proportionally less than in the previous cases.

56. Incidentally, this diagram shows the net loss associated with monopoly pricing. The triangle FIG in Figure 3 is the loss of benefit due to monopolistic pricing. In this connection, the distinction between the financial and economic return can be pointed out. The revenue for transportation operator declines when monopolistic pricing is abandoned in favor of benefit maximizing pricing. Therefore, benefit maximization leads to a lower financial rate of return. The use of financial returns for economic justification should be carefully avoided.

#### 6. Other Benefits

57. As has been mentioned earlier, the economic benefits are distributed to various classes of people in the area. The distribution can be measured by income class, neighborhood basis, producers of transportation services versus consumers, landlord versus tenant, or producers of goods versus consumers. Generally, it is agreed among policy makers and academicians that more egalitarian distribution is desirable. But to what extent a specific distribution is desirable is a matter of value judgment. When distributional impacts are considered important, they must be examined and the factual distributional effect must be presented as reference to policy makers. If we proceed to evaluate distributional impacts, subjective elements come into the analysis, but there are some methods which employ less subjective criteria. One method derives the implicit value judgment of politically elected decision makers with regard to the welfare value of a dollar in

different income classes.<sup>1/</sup> Similar methods are advanced by Weisbrod, McGuire and Garn.<sup>2/</sup> There are ways of integrating distributional and economic efficiency benefits. However, at this stage of the art, such a mechanical technique should be used as a reference, not as the determining criterion. The basis of making recommendations should be the best judgment of the researcher.

58. The environmental effects of transportation investment encompass traffic safety, air pollution, noise and vibration, creation of unsightly and undesirable areas, and crime induced. The general strategy for evaluating these environmental impacts is quite similar to the one used for measuring the value of travelling time. In the case of noise from a highway, the depreciation of property value along the traffic route can be observed. That amount can be counted as a negative economic benefit. It can also be argued, as for the case of leisure, that most of these impacts are irrelevant for maximizing the growth rate. What is more difficult to evaluate is the benefit of increased traffic safety. There have been a number of attempts to attach a monetary value to lives saved, but the problem of valuing human lives which have other dimensions than economic benefit cannot be sidestepped. Therefore, the best the researcher can do in this area is to present objective estimates of each variable affected by the investment based on the behavior of the population.

59. Another type of environmental effect is the comfort associated with each mode of transport. Such difference in comfort can be reflected in the demand for each mode. If the demand is correctly estimated, there is no need

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<sup>1/</sup> Koichi Mera, "Experimental Determination of Relative Marginal Utilities," Quarterly Journal of Economics, August 1969, pp. 464-477.

<sup>2/</sup> Burton A. Weisbrod, "Income Redistribution Consequences of Government Expenditure Programs," S.B. Chase, ed., Problems in Public Expenditure Analysis, Brookings Institution, Washington, D.C., 1968; Martin C. McGuire and Harvey A. Garn, "An Experiment in the Integration and Efficiency Criteria in Public Project Selection," unpublished, 1968.

to consider difference in comfort further. In order to estimate demand correctly, the comfort difference between the modes of urban transport should be considered. For example, a train gives a stable ride in which reading is quite possible whereas a bus ride is not so smooth. However, for commuters, bus stops are more readily accessible than train stations.

60. In developing a long range land use development plan and, in particular, predicting transport demand for specific routes, allowance for uncertainties should be given. Technology, the level of income and also consumers' taste change day by day. More significantly the art of predicting transportation supply and demand and that of land use development are in the formative stage. We should not assume that we can predict the future with any degree of accuracy. When an unexpected development takes place, the demand for specific facilities change and subsequent decisions must be changed accordingly. For this reason, flexibility of the system itself is highly desired. Such flexibility can be obtained in the stage of modal choice as well as in the allocation of space for specific purposes. Specifically, rail service is less flexible than road mass transit service since it involves a large fixed investment on the right of way which can only be used for specific limited purposes. We must recognize this additional benefit inherent to bus service over rail service.

61. To translate the amount of flexibility into economic benefit requires information on the probability distribution of future events and the preference for different events. Such information cannot be obtained for any specific area without spending substantial amounts for research. At this stage, it can only be said that flexible systems are preferred to less flexible ones.

62. The above discussion shows that we have the firmest ground for economic efficiency benefit and rather weak ones for other benefits. Therefore, a convincing case can be made if the economic efficiency benefit alone is large enough to justify the cost of investment and other benefits are not negative. If a project is conceived primarily on the basis of redistribution benefit or environmental effect, some of the developing techniques must be used to justify the cost.

#### V. Summary and Conclusions

63. A review of urban transportation studies has led to the following conclusions: (1) the urban transportation and land use simulation analysis which has been used frequently during the 1960's in the U.S. has been ineffective in improving the planning of urban development; (2) the employment of a complex simulation model for planning urban transportation systems would require at least substantially improved data and analytic techniques which cannot be expected even in the developed countries in the near future.

64. The physical pattern of land use and of transportation network is not so significant in affecting the efficiency of resource use in transportation. Greater attention should be given to technological alternatives. For example, the transportation cost savings due to high density development are not likely to be large enough to compensate for the increased construction cost necessary to achieve high density.

65. Considering the above findings and the particular situation of the developing countries, the following points are made: (1) the duplication of the U.S. experience of building complex models should be avoided in developing countries and (2) in an analysis of a particular issue, significant variables and relationships should be explicitly identified and the scope should be limited;

a lengthy chain of reasoning should be avoided as much as possible.

66. The following three steps are recommended for an urban transportation study: (1) development of the general urban development program without particular reliance on any extensive simulation analysis, (2) comparison of different modes of transportation based on demand and supply conditions which are consistent with the predicted population and income levels and (2) the evaluation of priority projects which should be conducted with the full use of economic techniques.

67. The benefits of urban transportation investment can be grouped into (1) economic efficiency, (2) distribution benefit, (3) environmental effects and (4) flexibility to uncertain developments. Among them, the economic efficiency benefit is most readily quantifiable. Some techniques are emerging for quantifying distribution benefit and environmental effects, but they have not yet reached the stage where they can be used for operational purposes.

68. There are two approaches for evaluating savings in traveling time: growth maximization and utility maximization. There may be some difference in the value of time savings depending on the approach used, but it does not seem to be significantly large.

69. The economic efficiency benefit of a particular urban transportation project can be measured by the variables associated with the project alone. In estimating the benefit, the pricing policy must be explicitly considered as it affects the composition of consumers' and producers' surpluses which are to be included in the benefit. The financial rate of return does not necessarily coincide with the economic rate of return and the degree of deviation depends upon the pricing policy.