RICE UNIVERSITY

THE DISTRIBUTION OF BENEFITS AND COSTS IN URBAN AREA TRANSPORTATION

by

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IN URBAN AREA TRANSPORTATION

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1. Abstract

THE DISTRIBUTION OF BENEFITS AND COSTS
IN URBAN AREA TRANSPORTATION

William John Anthony II

This thesis deals primarily with economic impacts of transportation and their distribution and has two basic goals. The first is to describe why the distribution of benefits and costs from urban transportation is important. The second is to describe how the economic impacts of highway systems and rapid transit systems are distributed.

The thesis deals with each mode separately. The distribution of the benefits and costs from the operations of present systems is described. The difficulties of this task are outlined. However, some indicators of benefits and costs do give an idea of the distribution of impacts from the day to day operations of systems, and data on these indicators are compiled.

The impacts of new facilities are discussed, including the long term as well as the short term impacts.
2. Introduction

The purposes of this thesis are:

(a) to establish the need for analyzing a distribution of benefits and costs in the evaluation and choice of urban transportation systems;

(b) to identify the major indicators of the distribution of economic benefits and costs for each mode, private and public;

(c) to compile evidence as to how these indicators of benefits and costs actually are distributed.

The framework for analysis of transportation systems is the first purpose. Distribution of benefits and costs is the second and third purpose for automobile and public transportation systems respectively.

Analysis of urban transportation systems or proposed system improvements has generally been presented in terms of the total impacts to the society. Although knowledge of the total impacts of urban transportation is far from comprehensive, the need also exists for a more careful description of the distribution of the impacts of urban transportation systems. This thesis is intended to fill a part of that gap in knowledge which has resulted from concentration on total impacts.

The thesis has changed in emphasis and scope since its inception. The original intent had been to do a mass transportation developing plan. It was then recognized that the daily or yearly operations of the present urban transportation systems inflict differential benefits and costs, and that an understanding of these was necessary to an understanding of the impacts of any changes to the present system. Analysis of the present system provides a background. Consequently, a great deal of emphasis has been given to identifying the factors felt to be influential in determining
the distribution of benefits and costs, both for present systems in their
daily operations and for proposed improvements. Since there is no com-
plete understanding of what these benefits and costs are, the description
of their distribution can be by no means comprehensive.

The emphasis throughout the thesis is upon economic costs and bene-
fits, although other impacts are discussed. The author considers social
and environmental factors to be equally as important as transportation
related measures, and they should be treated as such in any comprehensive
evaluations of transportation alternatives.

Following the Abstract and Introduction which are sections one and two
respectively, the thesis is organized primarily into three sections. The
major three sections of the thesis are as follows:

SECTION 3--The Framework for the Analysis of Transportation
Systems by Their Distribution of Benefits and Costs

SECTION 4--The Distribution of Benefits and Costs from High-
way and Automobile Systems

SECTION 5--The Distribution of Benefits and Costs from Rapid
Transit Systems

2.1 THE NEED FOR ANALYSIS OF DISTRIBUTION

Topic 3 presents the issues involved in choosing among transportation
systems which make desirable a careful analysis of the distribution of
impacts. It is a general discussion of the contribution which analysis
of the distribution of the benefits and costs from urban transportation
might make to the problem of social choice. Many persons are likely to
agree with the approach presented here since most issues which arise in
social choice problems are not really new. Those persons who are familiar
with the issues of social choice, and convinced of the need for analysis
of the distribution of impacts may skip Topic 3--The Framework for the Analysis of Transportation Systems. For others, this topic provides the reasons why the long neglected problem of distribution should be ignored no longer in transportation systems analysis.

2.2 AUTOMOBILE AND HIGHWAY SYSTEMS

A division was made by mode in order to facilitate comparison of private and public transportation systems. The distribution of benefits and costs on individual persons arise of course from a combination of the effects of many modes. The impacts of the different modes seem to be separable enough so that each can be analyzed apart from the others. Topic 4 describes auto and highway systems.

The operations of the present system are described in terms of the impacts of urban travel patterns and assessment of costs upon the distribution of benefits and costs. While it is quite important to understand the operations of the present systems if one is to evaluate alternatives, measuring a distribution of benefits and costs from the present system is a somewhat ambiguous problem. There is really nothing against which to compare the present system in the manner of the traditional highway literature, since new projects are typically evaluated in regard to their changes in benefits and costs when compared to the present systems. There are also no unambiguous measures of benefit on which professionals in transportation systems analysis can agree. Is benefit to be measured for instance by some accessibility index corresponding to the number of travel opportunities within a particular time, or should it be measured by the ability to make trips, or by the characteristics of the particular trip?
There is something lacking in all of these. Accessibility is an aggregate measure which does not tell everything about the trips actually desired by particular trip makers. Ability to make trips, as measured by auto ownership, is probably tied quite strongly to a need to make trips. Therefore, measuring a lack of auto (and auto trip-making) many give a misleading estimate of lack of benefit. The quality of the service provided by public investment in transportation for each individual trip is the hardest thing to measure. The quality of a trip is influenced greatly by the sort of auto in which one rides, from a comfortable luxury car with a stereo tape deck and air conditioning, to a more utilitarian car. These are not provided by public investment in transportation, however. One must settle for using several indicators of the level of service provided by investment in roads. Those that seem to be helpful approximations to the distribution of benefits from highways include:

(a) Accessibility--nearness in terms of travel time to other locations. Accessibility does not appear to be lacking for those who have autos.

(b) Auto ownership or auto availability--this seems to be a limitation for those with very low incomes, and would also be worse for those living further from the center, where public transportation is also not available.

(c) Vehicle operating speed, which provides a measure of the accessibility provided by transportation alone and not in combination with density. It also provides a measure of level of service if operation in congestion rather than free flow is more onerous to drivers. Vehicle speeds are generally higher further from the inner neighborhoods of urban areas.

Automobile insurance costs are a very interesting yet heretofore overlooked indicator of the distribution of benefits and costs from the operation of automobiles in an urban area. With a few assumptions it is
THE FRAMEWORK FOR THE ANALYSIS OF TRANSPORTATION SYSTEMS BY THEIR DISTRIBUTION OF BENEFITS AND COSTS
3. The Framework for the Analysis of Transportation Systems
   By Their Distribution of Benefits and Costs

3.1 THE IMPORTANCE OF EQUITY

Most people would regard equity as a desirable social goal, although there may be a great deal of disagreement as to what sort of distribution is equitable or as to how equitable a social system and particular programs within it are. Perception of equity of fairness is very subjective, but it is by no means an unworkable concept for analysis. Neither is it an irrelevant subject to analyze, for much of politics and business activity has as its goal either equity or some change in distribution which is subjectively considered more equitable.

For a particular field, equity may not be so important for the choice between alternative programs if compensation is being paid to those who do not receive a "fair share" of the distribution of impacts. It is not enough that compensation be theoretically possible. If compensation is not provided for the undesired distributive effects of a particular program, then perhaps the wrong choices are being made. This is a much stronger requirement for equity in a particular program than analysts usually make. Especially in regard to urban transportation systems, it is often presumed that there are more efficient or better ways of influencing the distribution of impacts than through transportation investments. For instance, some economists may argue that direct transfer payments, from the rich to the poor, through a negative income tax mechanism would be much more easy to administer and probably result in more freedom for the poor to choose their own expenditures. However, if such direct methods are politically
infeasible, as might be the case, then analysts should present alternative means of achieving different distributions. Also, the level of such direct redistribution may not ever be very high even if the political process does make a judgment that direct redistribution is desirable.

Transportation may be a good which opens up opportunities for people, meaning that it may in fact be economically cheaper to provide good transportation service than to simply provide people with income. Government must, it seems, provide the facilities for urban area transportation, and some of these facilities have to be in the proper places and of the proper type, if there is to be any expectation of a certain class of individuals using them and deriving benefits thereby. The configuration of the transportation system does determine who can possibly be served, and it is the responsibility of government to see that transportation facilities are built so that equitable impacts are possible. The high quality transportation service must be available for purchase.

It would also be desirable to be certain that transportation investments with an undesired distribution of impacts are not implemented. The only way to do so is to make the distribution of impacts explicit in the analysis. The analyst must supply this information if considerations of equity are to be decided upon.

3.2 THE REASONS FOR ANALYSIS OF DISTRIBUTION

There are two reasons for analyzing the distribution of impacts from transportation systems. The first has to do with welfare economics and equity, and the second has to do with the overlap between analysis and the political decision making process.
The welfare economist would argue that "there is no meaning to total output independent of distribution." There is no perfect way to "add up" many different impacts which fall upon different groups of people. This is not an argument that aggregation should not be performed. Everyone can agree to use a particular rule to add up the impacts upon all groups. This would be what is called a "legitimate" way of adding up the distribution of impacts. Agreement might be reached for instance, that the governor of a state is to decide on the transportation system, or that the decision will be reached by means of referendum, by means of logrolling in the state legislature, or by means of expert judgment. Even the last is probably not objective, nor does it become so even if everyone agrees it is the fairest way through which the decision can be made. The best which can be hoped for is that the expert or other decision maker does not exert a systematic bias in favor of one group or another.

The second good reason for looking at the distribution of benefits and costs is the impact of this information upon the decision making process. A contention of this thesis is that information about distribution will make the analysis more useful for making decisions, and that the decision making process itself will change because of the availability of information about the distribution of impacts. The contention is no less than that analysis of the distribution of impacts is an essential part of a proper and desirable approach for evaluating urban transportation systems, and that the decision making process will be improved through using information on distribution.
The political process involves negotiation and bargaining in order to reach decisions upon complex issues being dealt with by more than one decision maker. Bargaining and negotiation occurs between these decision makers over the issues which arise and over the distribution of impacts which will result from the choice. Analysis should be used to clarify the differences in impacts between various choices, not necessarily to take the place of bargaining and negotiation.

An extremely simple numerical example can be used to illustrate the usefulness of analyzing the distribution of impacts. Suppose a transportation system improvement is proposed for some particular area. Two mutually exclusive alternatives are being considered in addition to the null or "do nothing" alternative. Call one alternative A, one alternative B, and the null alternative N. Suppose the total benefits and costs for each of these alternatives are examined. It is found that A has benefits of 10 units and costs of 7, B has benefits of 9 units and costs of 7, and N has no benefits and no costs. Which system improvement would be chosen? First, if there were no opportunity of paying for either A or B, obviously the choice must be N. But if costs could be incurred, it would be desirable to receive those benefits which were greater than the costs. Thus, one might wish to choose alternative A or alternative B rather than do nothing. Alternative A is obviously superior of B since the costs are the same and the benefits from A are one unit greater. This is a familiar and obvious problem for analysis. Once the information is developed, the choice is trivial.

What happens if one becomes concerned with the distribution of benefits and costs? Would the choice be different? Suppose there are
two groups of people, group x and group y, who get the benefits and pay the costs. There are two different cases of distribution within this simple example. Case 1: For case 1, assume the distribution of benefits and costs to be:

<table>
<thead>
<tr>
<th></th>
<th>A benefits</th>
<th>A costs</th>
<th>B benefits</th>
<th>B costs</th>
<th>N benefits</th>
<th>N costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>group x</td>
<td>6</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>group y</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>10</td>
<td>7</td>
<td>9</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Alternative A has the greatest total benefits and costs, as it always will in our example, but clearly, as far as group y is concerned, alternative B is preferable to A and the null alternative is also preferable to A. Also for group x, although alternative A is preferred, alternative B is better than the null alternative. This can be represented by preference statements. Group x prefers A to B and prefers B to the null alternative. Group y prefers B to the null alternative and prefers the null alternative to A. Thus, if agreement between x and y must be reached on an alternative, group y will obviously never agree to alternative A. Group x will agree to alternative B, since alternative B is better than the null alternative. The outcome must be that alternative B will be implemented, although it has lower total benefits than A. As long as unanimous agreement is required, B will be chosen.

Case 2 introduces the possibility of compensation.

Case 2: This case has the same distribution as case 1; however, it is now possible for each group to influence the choices of the other
group by offering to transfer benefits to that other group or costs from that other group.

<table>
<thead>
<tr>
<th></th>
<th>A benefits</th>
<th></th>
<th>B benefits</th>
<th></th>
<th>N benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group X</td>
<td>6 2</td>
<td></td>
<td>4 3</td>
<td></td>
<td>0 0</td>
</tr>
<tr>
<td>Group Y</td>
<td>4 5</td>
<td></td>
<td>5 4</td>
<td></td>
<td>0 0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>10 7</td>
<td></td>
<td>9 7</td>
<td></td>
<td>0 0</td>
</tr>
</tbody>
</table>

If a transfer is possible, then group X can offer to give some of its benefits from A to group Y or else group X can offer to pay some of the costs of group Y resulting from a choice of alternative A. If complete compensation is possible, alternative A should once again become the agreed upon choice. Group X can for example, offer to pay one unit of group Y's costs for alternative A and also offer group Y 1-1/2 extra units of benefit from alternative A. The benefits and costs for each group would be:

<table>
<thead>
<tr>
<th></th>
<th>A' benefits</th>
<th></th>
<th>B benefits</th>
<th></th>
<th>N benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group X</td>
<td>4-1/2 3</td>
<td></td>
<td>4 3</td>
<td></td>
<td>0 0</td>
</tr>
<tr>
<td>Group Y</td>
<td>5-1/2 4</td>
<td></td>
<td>5 4</td>
<td></td>
<td>0 0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>10 7</td>
<td></td>
<td>9 7</td>
<td></td>
<td>0 0</td>
</tr>
</tbody>
</table>

Alternative A' is preferred to alternative B by everyone. Each group gets exactly 1/2 unit more benefits from A' than from B while paying the same costs. The outcome in terms of how the benefits are split in alternative A' depends of course, upon the respective negotiating and bargaining skills of group X and group Y.

With more than two groups, the bargaining and negotiation problems may become extremely complex. However, this simple case points out that
information about distribution may change choice, as in case 1, or it may lead to constructive negotiation over compensation, as in case 2. Thus, potentially, the information about distribution may change both the decisions being made and the decision making process.

Of course this simple example uses a single unit of measurement. Problems of distribution become even much greater when the impacts on group X are not measurable in the same units as the impacts upon group Y. For instance, group Y may save time from some improvement, while group X may suffer increased noise from that same alternative.

3.3 PRESENT RATIONAL ECONOMIC ANALYSIS

The present state of rational analysis of transportation systems is such that there are economic decision rules for use in comparing the impacts of different alternatives, and these are sometimes used. Benefit-cost analysis is one such rule sometimes used today in the fields of highway or rapid transit systems. In most present practice, when highway proposals or rapid transit proposals are analyzed, no explicit attempt is made to look at the distribution of impacts.

Rather the law row, or "total" in our case example is the sole set of figures presented by the analyst. This criterion of "total value" is supposed to be the basis for choice among alternatives. The "total value" used in highway analysis is usually only the value to the highway users as a whole. No distinction is even made between different types of highway users or different income classes of highway users.

There are arguments for this lack of use of the distribution of impacts in choosing among alternatives. One such economic argument is
that public programs should be separated into two classes, those which are intended to increase total benefit, and those which are intended to accomplish a redistribution between different groups in society. It can be contended that means of redistribution other than through transportation investments may be much more efficient or desirable, and that transportation investments themselves should be made on the basis of total benefits to society.

This, of course, is not an argument against analyzing distribution, but only against letting the distribution of impacts influence the choice of transportation system investments. Knowing the distribution of impacts, but not letting it influence choice, presumes either that there are indeed other ways of accomplishing whatever redistribution "society desires", or that the distribution arrived at on the basis of choosing upon the total benefit criterion is the distribution "society desired". Such phrases as "society desires" should be in quotes of course, since there are no objective ways of measuring whether society is getting what is best for it. This is a problem which will not be dealt with here in all its general ramifications.

A second possibility, however, that the society is implicitly achieving some desired distribution through this total benefit criterion, can be examined experimentally. It presumes that, although there is ignorance about distribution. A reduction of ignorance would not lead to agitation for a change in the decision process. 7

If the recent trends in the amount of political controversy over transportation planning are a measure of satisfaction with the present
process, then it is probably not safe to assume that the distribution of impacts is widely considered satisfactory. The possibility exists that a reduction in ignorance, without a corresponding change in the way decisions are made, has been a cause of present social unrest. It may be that many groups have become suspicious of their own lack of benefits from decisions and are attempting to change the distribution of impacts.

If this is true, then it is certainly worthwhile in terms of equity to increase the amount of information about distribution, and decrease the ignorance about the process. Then alternatives might be implemented which make the distribution of impacts more equitable. The entire process might become more rational, in that people would be operating politically on the basis of fact rather than fear. However, some analysts may argue that new projects may be more likely to get done if they are removed from "politics". If everyone becomes intensely interested in the outcome of the decision, the possibilities of agreement may be less and the "do nothing" alternative may be chosen. But increasing the amount of information about distribution is probably worth a try despite this supposed political danger.

It is proposed that the political danger of never reaching agreement is the short run price which must be paid to achieve adjustments in the proposed systems such that impacts will be more equitable. Making the information about impacts available means that many formerly unconcerned people will be concerned. One hypothesis is that in the long run, providing information about the distribution of impacts may lead more equitable systems to be proposed. Once equitable system proposals become the rule, then the process will no longer involve much political heat and negotiation.
The political decisions about transportation which must be made in American urban areas soon are likely to be subjects of great debate in the near future, since there are now many more vocal groups about such subjects than there were 10 or 15 years ago.  

3.4 EVALUATING WITH REGARD TO DISTRIBUTION

Although there is no objective way to measure an impact on one group vs. an impact upon another, the simple fact is that a choice between alternatives must be made. While choice cannot be made objectively, the different groups impacted can agree upon a process (perhaps negotiation) by which the choice will be arrived at. Analysis with regard to distribution will be useful in this process. Some predefined measure of total value to society will not be sufficient. At least some information must be displayed in a disaggregated form so that the impacts upon different groups are apparent.

Once the need is established for some degree of disaggregation, there is the problem of how much disaggregation is useful to the analysis, and how much aggregation is relevant to the process through which agreement on an action is reached.

The impact matrix will be introduced as a generalized concept of the type of organization of information about alternatives which might be useful. The columns of the impact matrix contain the individuals or groups affected by the transportation system, and the rows contain the alternatives proposed, so that each entry in the impact matrix is a description of the impact of a particular alternative upon the particular individual or group. The entries do not have to be numerical. They might be text, statements by the transportation analyst or someone else, or visual
representation. Thus, an impact matrix would have the following general form:

<table>
<thead>
<tr>
<th>Actors</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Actor A</td>
<td>Impact 1</td>
<td>Impact 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>n</td>
</tr>
<tr>
<td>Actor B</td>
<td>Impact 1</td>
<td>Impact 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>n</td>
</tr>
<tr>
<td>Actor J</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It is probably impossible to examine alternatives or to choose on the basis of a completely disaggregated impact matrix. Suppose one looked at a completely disaggregated impact matrix of perhaps 1000 individuals and groups and 10 alternatives. It is apparent that the analyst or anyone else would want to aggregate in some ways in the process of making a judgment. There are simply too many measures of performance available; it is confusing to try to aggregate so much in one's head, either for the process of choice or for the process of negotiation. Therefore, implicitly, someone making a judgment will tend to focus on what he considers the important differences between alternatives. This might be called issue analysis. There will have to be some way to make sure that no important actor or impacts will be excluded within a process in which many actors and impacts are sometimes lumped together.
3.51 Distribution by Income Class

Important to the analysis of equity in particular programs is the wealth of the people on whom the impacts fall. Explicitly, within our society a normative rule may be that it is undesirable to tax the poor to benefit the rich. Implicitly, of course, many aspects of the political and economic order have the selective benefit of the rich as their purpose.

In many instances, some implicit regressive aspects may occur because of the ignorance of all but the rich beneficiaries as to what the distributive effects actually are. Favorable publicity, public opinion and political power can be bought for a certain expenditure of resources. Technical analysis and expert recommendation are also available to agencies and individuals who are able to purchase them.

From a less cynical point of view, it may be that in some programs, the distributive aspects are unknown even to the rich beneficiaries, who may assume that everyone is in fact receiving the same benefits from the programs. This may be the case in urban transportation. Roads seem to go everywhere, and new freeways seem to be proposed for everywhere, so the impacts are implicitly assumed to be equitable, or "for the good of society as a whole".

In a society concerned with fairness, equity of impact becomes a politically important goal, whether or not information as to distribution is available. If it is not available, and then becomes so, either adjustments in the system can be expected to bring reality more in line with the goal of equity in society, or the goal of equity may be compromised or obscured. The importance of distribution across classes rests on the
assumption that there is a significant social benefit to improving the lot of the less well-to-do as opposed to improving anyone's lot indiscriminately. This is, of course, a subjective judgment. However, if the society does indeed have some normative rule that the rich should not receive proportionately greater benefit from public actions than the poor, then we need not be concerned with objectivity, but only with how well the society is achieving this distributive goal. Equity is also important even if everyone has close to the same income. One would still wish to analyze the distribution across different groups of people, since equity is an important social goal regardless of income distribution.

While the distribution by income class is important because equity matters, the distribution by political jurisdiction has other reasons for being useful. Income class and political jurisdiction may often overlap of course. There may be rich towns or poor towns, and looking at the distribution by income class. It would be nice to find that analysis of the distribution of impacts in terms of political actors did give a good measure of the distribution by income classes, for then the analytical resources required would be less if one wanted both types of information about alternatives.11

3.52 Distribution by Political Jurisdiction or Actor

In the present process by which freeways are located in California, the State Division of Highways explicitly considers the distribution of impacts upon each town affected by a new freeway.12 Political jurisdictions such as towns are extremely relevant actors in freeway location in California, since the State Division of Highways must get the agreement of the town or
county in order to close any local streets affected by the construction of the freeway. The Division of Highways presents to each town data on the impacts of various alternative freeway locations on that town and upon other towns affected by the alternatives. This serves the purpose not only of giving the political actors information on the impacts to themselves but also information on the impacts to others. The political actors thus become aware of the tradeoffs involved in the choice among alternatives. Hopefully this information makes the decision process more rational and demonstrates to each actor the issues of equity.

The purpose of analysis by political jurisdiction or political actor is to increase each actor's perception of the impacts on himself and others, in the hope that this will increase the likelihood of rational negotiation upon the alternatives, and enable each actor to see the impacts from someone else's point of view. Information is thus seen as a catalyst in the political process.

The capability to organize the impact matrix by political actor or jurisdiction bases the analysis and the subjective negotiation between actors upon presumable more rational informational grounds. Thus it is concerned more with a subjective desire that the choice, or end state, be equitable. The distinction is only between degree of emphasis on process versus end state.

The political process may operate more rationally and equitably among all groups, even if they are of the same income, if information about distribution is available. Even if someone does not consider the impact on different income classes to be a problem in transportation, there may be
benefits to the decision making process from making the distribution of impacts known. Also, even if there is to be no political negotiation among the jurisdictions impacted, the analyst or decision maker might have a sense of equity such that he would wish to choose a system based upon its distribution of impacts. Thus, someone who feels analysis of distribution by income class is not necessary may still believe that analysis by political actor is useful, and vice versa.

It is recommended that for all system improvements, analysis always be made of the distribution of impacts from urban transportation systems by political jurisdiction and political actor. The distribution by political jurisdiction and actor could sometimes be used as a surrogate for distribution by income class. One would be assuming simply that there are usually identifiable interest groups of particular income classes who have political spokesmen. This seems like a reasonable assumption. Where it is not true, extra information about impacts on income groups should also be developed.
FOOTNOTES


2 Rotenberg (quoted from Kenneth Arrow), Ibid.

3 Strictly speaking there are of course, benefits and costs associated with the Null alternative. But this has been taken as the zero point, so that A and B are judged by their differences from the null alternative.

4 Rotenberg, op. cit., passim.

5 Except perhaps implicit in regard to people or groups with political power.

6 Much attention has, however, been paid to the question of the proper allocation of roadway costs between different kinds of user vehicles. U.S. House of Representatives Final Report of the Highway Cost Allocation Study 87th Congress, 1st Session, 1961, House Document No. 54.


8 Rotenberg, op. cit., passim.


10 Manheim, Ibid., passim.

11 Rotenberg, op. cit., passim.

12 See, for example, Case Study: The Century Freeway in Watts, or The Impacts of Highways upon Environmental Values, M.I.T., Urban Systems Laboratory for NCHRP Project 8-8, March 1969.
THE DISTRIBUTION OF BENEFITS AND COSTS FROM HIGHWAY AND AUTOMOBILE SYSTEMS
4. The Distribution of Benefits and Costs
From Highway and Automobile Systems

4.1 MEASURES OF BENEFITS FROM THE PRESENT AUTOMOBILE SYSTEM AND ITS OPERATING CHARACTERISTICS

This section adopts quite a modest tone for there do not seem to be any magic numbers which given an unambiguous measure of the distribution of benefits either by geographic area or by income group, from the operations of the present day urban highway system. There are only indications of whom the operations of automobiles and urban highways benefits in what degree, and these will be discussed.

This thesis does not attempt to discuss the distribution of the indirect economic impacts of urban area transportation, such as presumably lower prices of goods and services for all of society by making truck travel less expensive. Such a calculation would require a large and sophisticated model of the urban area and the outside world as well. Rather, the focus will be on person trip making in the urban area, and the claims to measuring the distribution of benefits and costs of even this are modest.

The discussion of three "indicators" of benefit follows. These are in order of discussion:

1. Trip opportunity ends within a certain amount of time, as a measure of access or mobility.
2. Auto ownership or auto availability as a measure of the ability to consume whatever highway service is offered.
3. Average vehicle speed or congestion as a measure of the quality of a trip, and as a measure of the contribution of transportation itself to access.
There are many possible measures of benefit that might be used in order to judge who is getting what from urban area highway systems. For instance, one could survey the attitudes of different people towards the service they are getting from highways, and compare the results by income class or by political jurisdiction. However, one would expect people's attitudes to be strongly dependent upon their aspiration level, and people who are getting better than average service may even have higher than average desires for improvements. While people's attitudes towards highway improvements are extremely important, it would be desirable to have a less subjective way of measuring what they are receiving.

4.11 Mobility or Accessibility

A good measure of some aspects of the quality of an urban location is the convenience with which one can get to other desired locations from that spot. There would be great difficulty in measuring the diversity of destination choices available to residents of a particular area. A measure which is reasonable to get however, and tells a lot about the convenience of a location, is the number of trip opportunity ends of a certain kind available from that location. For instance, Harland Bartholomew and Associates measured the number of low income jobs available within certain commuting times to residents of different places in the Memphis metropolitan area. They found that there were generally more low income jobs available within a certain time to residents of Memphis' South Side, an inner city neighborhood, particularly by public transportation, than were available from other locations. Most places in the Memphis area they found to be fairly accessible to most other places by auto, and
there were very large numbers of trip opportunity ends within either a half hour or an hour from all places within about fifteen miles of Memphis. The author of this thesis considers mobility within the Memphis area to be well and equitably distributed for those who have autos available, at least by these numerical measures. A study by Harland Bartholomew and Associates found that availability of an auto was the most significant determinant of mobility, and this author agrees with their conclusion.

While the number of moderate income jobs reachable by auto from the South Side is greater than those reachable from the suburban communities within twenty or thirty minutes, essentially the same number of moderate income jobs (72,700 vs. 76,600) were reachable by auto from both places in forty minutes.¹

The implication that is possible from this evidence is that mobility as measured by accessibility to jobs is really not a problem for people with autos available within a reasonable radius defining the urbanized area around Memphis, this radius being about twelve to fifteen miles at least. Changes in highway systems to bring about more job accessibility therefore does not appear to be a particularly important issue. Auto availability appears to be a much more important determinant of mobility, although it must be pointed out that cars are probably purchased because persons have a requirement for mobility. This qualification is important in judging "effects" of auto ownership on mobility.

4.12 Auto Ownership and Its Effects on Mobility

The effects of car ownership in terms of increasing mobility are striking. If one looks simply at total number of trips per person as a
function of cars per dwelling unit, there are great differences in trip making characteristics between those families owning zero, one, or two cars. The Wilbur Smith study presents the following data for selected urban areas.\(^2\)

<table>
<thead>
<tr>
<th>Total Trips per person</th>
<th>Cars per dwelling unit</th>
<th>all</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Chicago</td>
<td>0.78</td>
<td>1.76</td>
</tr>
<tr>
<td>Detroit</td>
<td>0.70</td>
<td>2.08</td>
</tr>
<tr>
<td>Pittsburgh</td>
<td>1.12</td>
<td>1.70</td>
</tr>
<tr>
<td>Puget Sound</td>
<td>0.90</td>
<td>2.60</td>
</tr>
<tr>
<td>San Juan</td>
<td>0.99</td>
<td>2.00</td>
</tr>
<tr>
<td>Knoxville</td>
<td>0.85</td>
<td>2.49</td>
</tr>
<tr>
<td>Lexington</td>
<td>0.76</td>
<td>2.06</td>
</tr>
</tbody>
</table>

For most cities, the effect of owning one car is to double the number of trips made per person. Of course, if zero car households live in high density areas, then many trips might be walking trips, for instance to the neighborhood grocery store, rather than a 2-mile drive to a supermarket shopping center.

Trip making by vehicle is no measure of quality of life in general. Ideally, auto ownership should be predicted by a trip generation model, rather than being treated as an exogenous variable, since otherwise, it may be too easy to overestimate the importance of vehicle ownership and to attach an unjustifiably low value to the lack of tripmaking by residents of higher density neighborhoods, or by households without a need for many trips.

We must also temper this discussion with the observation that there are presently many work trips made by low income workers as auto passengers in what is termed a "car pool".
In the lower density areas, most low income workers who do not own autos travel to work as auto passengers, as do higher income non-auto owners in the same area.\(^3\)

Thirteen percent of all auto owners in the entire Memphis metropolitan area traveled to work as auto passengers (non-drivers) while 28\% of all non-auto owners get to work as auto passengers. Thus, one of the most important sources of transportation for non-auto owners is the rides they receive from auto owners.\(^4\) One can hardly argue that these people receive no benefit from highway system improvements. Any improvement for drivers is likewise an improvement for passengers.

It has been suggested by Martin Wohl that car pooling should be considered as a separate mode of transportation, since its characteristics are different than those of single drivers. Car pooling may be the most restrictive of modes in terms of freedom for the passenger and the driver, but certainly the passenger receives high quality service in return for his lack of choice and flexibility in terms of time.

The automobile system has significant threshold levels at which it is possible to begin to receive the benefits offered by roadway construction or improvements. These income "bars" come about obviously because of the cost of owning and operating a motor vehicle. Even a strictly utilitarian car has significant costs associated with it. Meyer, Kain and Wohl estimate "the commuter should be able to buy and operate a satisfactory car at ownership costs of approximately 4 cents a vehicle mile".\(^5\)

Operating and maintenance charges are assumed to be about three cents per vehicle mile, not including user taxes, and insurance costs about $100 per year. These figures are for exclusive rush hour travel by passenger
Even with these assumed utilitarian costs, which do not include taxes, traveling 5000 miles per year by auto (one half the average use in miles per year) would still cost at least $450 per year and probably considerably more for the poor because the poor may live where insurance rates are higher.

Residents of ghetto areas are likely, of course, to be faced with higher insurance costs, higher interest rate charges on money borrowed (since they are "poor" credit risks) and probably greater likelihood of theft or vandalism.

Another significant level occurs at family ownership of two cars. If two cars are owned, not only are more trips possible but there is much more convenience and flexibility in the pattern of trip making, particularly if the first family car was used for commuting purposes.

The basic prerequisite for receiving direct benefits from highway investment is the ability to consume, as measured by income and trip availability, and this is true of most benefits received from private and public action. If some people are denied consumption because of the pattern of transportation system investments, however, then there may be reasons for altering investment choices. The trips of those unable to drive or own autos are definitely constrained by present system choices. The only logical way out of this dilemma would seem to be systems which have the omnipresence of the automobile, but do not require purchase, and do not require special skills to operate. Automated highway systems with publicly owned vehicles would be examples fulfilling these requirements.

For the cases of people with extremely low ability to pay because society does not see fit to provide them with adequate incomes, special
services or special privileges may be desirable. The Memphis Transit Authority provided the elderly with reduced fares in 1969. At the present time, subsidies to allow the poor to own autos might also be desirable in terms of increasing their mobility where it is lacking. Martin Wohl suggests the use of taxi "chits" for the poor, handicapped, aged and very young.

Auto availability by income groups is shown in the following table for all Standard Metropolitan Statistical areas in 1960

<table>
<thead>
<tr>
<th>Income Class of Family Unit</th>
<th>owner occupied</th>
<th>renter occupied</th>
<th>all</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than $2000</td>
<td>54.2</td>
<td>30.3</td>
<td>40.0</td>
</tr>
<tr>
<td>2,000-2,999</td>
<td>70.2</td>
<td>45.6</td>
<td>55.8</td>
</tr>
<tr>
<td>3,000-3,999</td>
<td>80.0</td>
<td>57.3</td>
<td>66.8</td>
</tr>
<tr>
<td>4,000-4,999</td>
<td>86.4</td>
<td>66.7</td>
<td>76.3</td>
</tr>
<tr>
<td>5,000-5,999</td>
<td>91.4</td>
<td>74.0</td>
<td>84.1</td>
</tr>
<tr>
<td>6,000-6,999</td>
<td>94.0</td>
<td>78.9</td>
<td>88.7</td>
</tr>
<tr>
<td>7,000-7,999</td>
<td>95.2</td>
<td>81.4</td>
<td>90.9</td>
</tr>
<tr>
<td>8,000-8,999</td>
<td>96.1</td>
<td>83.0</td>
<td>92.5</td>
</tr>
<tr>
<td>9,000-14,999</td>
<td>97.1</td>
<td>84.9</td>
<td>95.9</td>
</tr>
<tr>
<td>15,000+</td>
<td>98.2</td>
<td>84.6</td>
<td>95.9</td>
</tr>
<tr>
<td>TOTALS</td>
<td>87.8</td>
<td>61.5</td>
<td>77.0</td>
</tr>
</tbody>
</table>

Median Incomes:
- Owner Occupied, auto available: $7,100
- Owner Occupied, no auto available: $2,700
- Renter Occupied, auto available: $5,500
- Renter Occupied, no auto available: $2,800
Within the Memphis Metropolitan area there are substantial differences in the availability of automobiles, as can be seen from the following table. This table covers the innermost towns of the Memphis Standard Metropolitan Statistical Area. We are fairly certain that there are relatively few rural places in this innermost section. This area was chosen for this reason and because it is an interesting area in which to analyze the distribution of insurance and congestion costs. As can be seen, in "the inner ring", and especially in the central city, vehicle ownership rates are much lower than in the "outer ring".
<table>
<thead>
<tr>
<th></th>
<th>Vehicles (1)</th>
<th>People/Vehicles (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Inner Ring&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memphis</td>
<td>181,106</td>
<td>2.30</td>
</tr>
<tr>
<td>&quot;Outer Ring&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frayser</td>
<td>10,109</td>
<td>2.90</td>
</tr>
<tr>
<td>Millington</td>
<td>9,201</td>
<td>1.30</td>
</tr>
<tr>
<td>Raleigh</td>
<td>8,969</td>
<td>1.90</td>
</tr>
<tr>
<td>Martlett</td>
<td>3,101</td>
<td>2.03</td>
</tr>
<tr>
<td>Arlington</td>
<td>1,091</td>
<td>2.41</td>
</tr>
<tr>
<td>Shelby Farms</td>
<td>898</td>
<td>1.70</td>
</tr>
<tr>
<td>Germantown</td>
<td>5,811</td>
<td>2.01</td>
</tr>
<tr>
<td>Collierville</td>
<td>3,921</td>
<td>2.28</td>
</tr>
<tr>
<td>Capleville</td>
<td>1,212</td>
<td>2.86</td>
</tr>
<tr>
<td>Whitehaven</td>
<td>19,273</td>
<td>2.14</td>
</tr>
<tr>
<td>Southaven, Miss.</td>
<td>3,699</td>
<td>2.71</td>
</tr>
<tr>
<td>West Memphis, Ark.</td>
<td>9,023</td>
<td>2.15</td>
</tr>
</tbody>
</table>

(1) Reduce figures by 25% to eliminate transfers and trailers
(2) 1965 pop., 1967 vehicle registration
4.13 Speed or Congestion as an Indicator of Benefits

While benefits depend on trips made vs. trips not made (for whatever reason - income bars, etc.) I would also like some discussion of the differences in benefits provided by highway investment for the individual trip that is made.

There are two reasons why one might want to know more about the distribution of benefits from urban highway systems than is provided by either auto availability or by the number of trip opportunity ends of some type available within a given time. First, at some point there will be a declining marginal utility to having additional trip opportunity ends available, as in the categories of low income jobs, shopping centers nearby, and so forth. It seems certain that there is a significant difference between being within commuting distance of 400 jobs or 200,000 jobs, but not certain about the utility of being near 200,000 or 250,000 jobs.

Fleisher and Herr\textsuperscript{12} points out that different types of people have vastly different needs for the availability of new jobs. Some people are likely to be employed in the same spot all their lives, while others may have to shift work places frequently. Besides having a measure of the number of trip ends available, it would also be desirable to have a measure of the quality of the trips actually taken.

Second, one would like to be able to differentiate between the mobility differences provided by transportation investments and the mobility differences provided by various densities of development. Density, transportation investment, and access to other places are very closely intertwined. Some levels of density would be impossible without
certain transportation technologies or levels of transportation investment. For instance, some central business district densities could not be as high as they are if it were not for elevators and high rise building technology, and some suburban densities could not be as low as they are without automobile technology and investments in road ways.

Higher density of non-transportation land in and of itself provides more trip opportunity ends within a given time for some transportation technologies. It is easy to provide equal amounts of total roadway lane miles in two cities in which land uses other than roads are at different densities. The same number of lane miles provides the same transportation capacity for conceivable geometrics of location. It is then unambiguous that there are more trip ends within a certain amount of time in the higher density city than in the lower density city. Congestion in the higher density city would be the same or lower than in the low density city, since there is the same lane mile capacity and presumably fewer total lane miles driven.

In our urban areas, lower density developments have probably occurred at later dates than higher density areas, reflecting differences in transportation technologies as well as in other factors at the different times of development.

One cannot get any perfect measure that would separate the effects of density from the effects of transportation investments in terms of how they allow people to get to many different places. But some measure that differentiates transportation effects from density effects seems desirable, as does some measure of the quality of the individual trip.
Average vehicle operating speed is provided by transportation links, not by density, which influences the number of trip opportunities. Average vehicle operating speed is suggested as a qualitative measure also because that congestion, many stops and starts, a lot of vehicle conflict, and long times spent idling are particularly onerous when compared to free flow at constant speed. Average operating speed is the surrogate measure for the quality of the time spent in driving. If average operating speed is low, it is because there is a lot of time spent in stops and starts or idling.

There seems to be no studies which have separated the onerous aspects of urban auto driving into time spent in congestion and time spent in free flow. However, that time spent walking and waiting has more disutility for transit travelers than the same amount of time spent in motion, and likewise for auto travelers.

It seems a reasonable hypothesis that congestion itself operates to substantially decrease the utility or satisfaction of the time spent in driving. Average operating speed, rather than free flow speed, should give an approximation to how much of the time is spent in congestion.

Other measures, such as comfort of the ride, smoothness of flow, difficulties due to congestion, safety, and aesthetics probably does not necessarily have a negative correlation with speed either. Therefore, the use of speed, while not all inclusive as a surrogate measure for the other variables, at least may in most instances give a monotonic approximation to whatever might be a more comprehensive service index, thus, speed should be seen as a compromise index of the service measures which might
be more meaningful and is used as an index because of its simplicity. Because we are interested here in rough comparisons between service levels, speed is sufficient. It is not sufficient, of course, for analysis of the differences in quality of transportation service between modes.  

While speed has some merit, it also has many disadvantages and does not give an unambiguous measure of the quality or especially, the utility of an automobile trip. Vehicle operating speed can be misleading in that it does not necessarily correlate with having many and varied trip opportunity ends within a certain span of travel time, which is intuitively bothersome. If there are few cars and few places to go, speed may likely be quite high on all facilities, such as in the fringes of the urban area. Yet it may be very difficult in terms of time to get to many places in such areas even at high speed, and lack of an auto may be much more of a handicap in areas correlated with high speeds. Thus we cannot conclude that speed or lack of congestion is monotonically related to benefit, but since we do feel they have some merits as indicators of benefits and costs, let us examine their distribution. 

On a particular facility, congestion costs seem amusingly equitable, in that each driver is inflicting the same amount of trouble on each other driver as that other driver inflicts upon him, and what could be more equitable than that? However, if congestion is psychologically harmful and economically costly, it must be regarded as a serious matter. Herbert Mohring points out that the incremental user of a facility adds time costs to all other drivers, yet takes into account the time cost only to him when deciding to make a trip. The aggregate increase in trip times
for all drivers is greater than the trip time for that individual driver. The driver thus inflicts costs upon others, costs which are not part of his decision.

Some drivers, however, may spend more of their time on congestion free roads than do other drivers. This is the distribution of congestion in which we are most interested.

Examination of Memphis Urban Area Transportation Study (MUATS) maps color coded for average speed on highway facilities shows that speeds substantially increase with an increase in average distance from the center of the city of Memphis. The Comprehensive Traffic and Transportation Inventory of the Memphis Urban Area Transportation Study (MUATS) concludes that "speeds in rural portions of the metropolitan area generally exceed 25 miles per hour, those in central Memphis and other metropolitan centers are consistently less than 15 miles per hour".17

A Wilbur Smith and Associates Report generalized for all cities that "Highway traffic loads generally peak about three to four miles from downtown and then decrease gradually. While there are surpluses on the perimeter of the urban area, and sometimes in and near downtown, deficiencies are most critical in mid-town locations."18

Travel times from downtown Memphis during peak hour show that speeds become, in general, about twice as fast once the crowded core (perhaps 5 miles) is passed. This means of course, that there are relatively higher overall travel speeds for those who do most of their driving outside of the central area.

Starting from Union and Third Streets, Memphis, at peak hour, a vehicle can travel about two to two and one half miles in the first 20 minutes of
travel. This gives a speed of about 6 to 8 miles per hour, and the vehicle can in this time reach some nearby areas of Raleigh, Germantown, and Whitehaven, as well as the very inner neighborhoods of Memphis itself. In the next 20 minutes of travel at peak hour, a vehicle can reach a radius of about 10 miles to 12 miles. Thus, in that second 20 minutes, the vehicle would have traveled at an average speed of 23 to 30 miles per hour, or perhaps four times as fast as during the first 20 minutes. The 40 minute trip on the whole is thus made at an average speed of 15 to 18 miles an hour. Thus, this chosen measure quality of trip is twice as great for vehicles traveling twice as many minutes from the downtown.

By our measure, the suburbanite who chooses to drive from downtown to about the vicinity of Germantown is getting twice as good service on the average, as the inner neighborhood resident choosing to drive downtown.

The Pittsburgh Area Transportation Study (PATS) computed Travel to Capacity Ratios for each "ring" by distance from the center. This was a ratio of the vehicle miles actually travelled on roads in the ring to the computed capacity of that ring.

<table>
<thead>
<tr>
<th>Ring</th>
<th>Travel to Capacity Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.27</td>
</tr>
<tr>
<td>1</td>
<td>1.38</td>
</tr>
<tr>
<td>2</td>
<td>1.13</td>
</tr>
<tr>
<td>3</td>
<td>1.14</td>
</tr>
<tr>
<td>4</td>
<td>1.07</td>
</tr>
<tr>
<td>5</td>
<td>.97</td>
</tr>
<tr>
<td>6</td>
<td>.77</td>
</tr>
<tr>
<td>7</td>
<td>.66</td>
</tr>
</tbody>
</table>
PATS also computed the Persons per Mile of street type by ring, finding the following:

<table>
<thead>
<tr>
<th>Ring</th>
<th>Local Streets</th>
<th>Persons per Mile</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Arterials</td>
<td></td>
</tr>
<tr>
<td>0 and 1</td>
<td>761</td>
<td>1421</td>
<td>495</td>
</tr>
<tr>
<td>2</td>
<td>843</td>
<td>2725</td>
<td>644</td>
</tr>
<tr>
<td>3</td>
<td>917</td>
<td>2501</td>
<td>671</td>
</tr>
<tr>
<td>4</td>
<td>786</td>
<td>2433</td>
<td>594</td>
</tr>
<tr>
<td>5</td>
<td>550</td>
<td>1432</td>
<td>397</td>
</tr>
<tr>
<td>6</td>
<td>422</td>
<td>856</td>
<td>283</td>
</tr>
<tr>
<td>7</td>
<td>276</td>
<td>525</td>
<td>181</td>
</tr>
<tr>
<td>Average</td>
<td>573</td>
<td>1351</td>
<td>403</td>
</tr>
</tbody>
</table>

One of the difficulties of measuring benefit from present system operations is that it is a very sticky problem to choose a zero point from which to measure benefit. Benefit is a comparative word, and to what should we compare the present system in order to measure the benefits ascribable to transportation and their distribution? The calculation of benefits from new projects is relatively simple, since the zero point is taken at the present system.

Another serious criticism of any professed measure of benefits and costs from urban transportation systems is based on the concept of utility for particular households. If some household does not have much utility for better transportation, and has chosen a location where "good" transportation by whatever measure is unavailable, we are on very shaky ground in asserting that such a household is getting fewer benefits from transportation than another household. The key concept to understand is that transportation is not an end in itself, but is rather consumed along with many other goods and services which are dependent on location or income. People may choose poorer transportation (by any measure) in order to get
other things (e.g., better schools, a higher status neighborhood, a very dense neighborhood, a quiet neighborhood, and so forth). Perhaps not making vehicle trips is a benefit of living in a particular place, although this is blasphemy to the transportation planner. Therefore we should make an appropriate disclaimer here, that our measures of benefit are transportation oriented, and may have little to do with other people's ideas of the most important measures of the quality of life.

4.2 DIFFERENCES IN COSTS AND PRICES

1. Auto Insurance Costs and Their Distribution

2. The Distribution of Fuel Tax Costs

4.21 Insurance Costs and Their Distribution

One of the costs of which it is relatively easy to measure a distribution is insurance costs, since automobile insurance is bought and sold in a regulated market place. Insurance costs give some measure of a distribution of mutually inflicted prices which are paid as a result of the pattern of origins and destinations in urban areas. They are the easiest to measure component of a larger class in inflicted costs and benefits.

An important determinant of the distribution of the costs and benefits due to urban form is of course who drives to where? If one group of drivers uses facilities passing through the neighborhood of another, then usually some interference costs will be mutually inflicted.

It is hypothesized that the costs added to drivers in a particular zone from vehicles passing through or destined there from other zones,
can be termed "inflicted costs", since they are the resultant costs due to outside people operating on the facilities. The construction of facilities to serve these outside people might then be called an "inflicted benefit", since the facility serves the neighborhood too. Inflicted costs can be increased insurance costs, congestion costs, and immediate tax loss effects. Inflicted benefits can be increased accessibility to other parts of the urban area for drivers from that zone and less congestion.

(Such inflicted benefits for users may have associated with them other deleterious impacts on the neighborhood, which are discussed under the section on distribution of impacts from new facilities.)

Auto insurance rates are established for the principal place of garaging for the automobile, and are computed by town in Tennessee. Rates are based upon the average accident experience for different types of cars owned by different types of people. The fact that insurance rates are set by town has important consequences for the distribution of costs from accidents. In the abstract, some people may do a larger percentage of their driving in places where accidents are relatively more likely. Most probably, it is those who live where accidents are more likely who do a larger percentage of their driving in such places. For an abstract mode, let there be an urban area composed of two parts. There will be an inner core and a surrounding doughnut. Suppose trip patterns are fairly random and dispersed, yet at least relatively central directed. By a central directed trip pattern, it is meant that more driving is done in the core by drivers from the doughnut than is done in the doughnut by drivers from the core.
No relationship of accident frequencies follows directly from such a formulation. The nature of drivers to have accidents depends on more than the density of autos per unit area. The physical characteristics of the street system itself are likely to be extremely important. Age and other driver characteristics are also important and likely to be correlated with socio-economic status. All drivers cannot be assumed equal, even if it would be intellectually attractive to be able to explain their relative accident rates in terms of only the roadway characteristics and the time of day at which they drive.

No attempt is made here to formulate a general explanation of the causes of traffic accidents. We wish merely to describe the influence of urban form upon the distribution of insurance costs, and it is possible to put bounds upon these impacts.

It might be hypothesized that insurance rates are higher in the central city, partly because of less safe and outmoded roadways, but also because many people from outside the central city driving into it add to the accident risk. If a large percentage of the vehicle operation of a central city drivers is within the central city, but there are also large numbers of outsiders who spend just a small percentage of their time in the central city, then accident involvement of central city drivers may be high due to the large number of outside drivers there. Since the outside drivers do most of their driving in less congested areas, their insurance rates remain relatively low. A much larger per person amount may be added to the central city auto owner's insurance rates because of the accidents resulting from congestion caused by out of town vehicles. The out of towners costs are
shared by his townspeople who do not travel to the central city. Thus, urban form and the pattern of trip making may create larger insurance costs for those in the most congested areas.

If one is concerned about inequities for low income people, an obvious way out of this difficulty is to decrease the amount of residential segregation by income (and also by race of course)\textsuperscript{22} so that less total travel might occur and also so that lower income people could also get the benefit of lower insurance rates in better designed areas.

Insurance costs may contribute to the entry bar which keeps low income individuals from buying a car. One does not expect a poor central city youth in Memphis to take the cost of insurance lightly, since the price to him is likely to be $400 per year.

"Inflicted" insurance costs are the result of the use of an area's streets by many vehicles from other areas. This is apart from the fact that there may be higher insurance rates in the city if it has been discriminated against in terms of funds for improving or maintaining its road facilities.

It is illustrative to examine the number of accident involvements within the central city by place of registration of the vehicle. The Memphis Urban Area Transportation Study, 1969, gives the following figures for accident involvements within the city of Memphis by place of registration of the vehicle.
Registered In: | 1962 | 1964 | 1970  
---|---|---|---
Memphis | 9,740 | 11,111 | 15,426  
Tennessee-outside Memphis | 2,848 | 3,290 | 6,127  
Out of State | 1,119 | 1,677 | 2,216  

Total Vehicles Registered in Memphis\(^{23}\) | 164,000 | 208,000 | 246,000

On the average for these years, about 1/3 of the vehicles involved in accidents in the city of Memphis were from the outer ring. It might therefore be possible to attribute 1/3 of the accident costs occurring within the city of Memphis to these vehicles. In the sense of "inflicted costs", the accident involvement of Memphis registered drivers is likely to be higher because of the presence of these outside vehicles. However, the accident involvement and costs of drivers registered elsewhere is likely to be higher due to costs inflicted by vehicles registered in Memphis which travel in their towns. Thus, if distribution is of interest, the involvement of Memphis drivers in accidents outside the city must be compared with the involvement of outside vehicles in accidents within Memphis.

Drivers from the 12 towns closest to Memphis in 1965 had 7,062 bodily injury accident involvements in the city of Memphis, while cars garaged in the city of Memphis had 2,840 bodily injury accident involvements in those nine cities and towns.\(^{24}\) Among the 12 communities had more injury accidents in their towns by vehicles from the other towns than their vehicles had in the other towns. This gives a fair measure for the impact of urban trip making patterns on the congestion costs and insurance costs in particular areas. In fact, this evidence indicates that drivers from outside the central city inflict considerably more congestion and insurance costs on
central city residents than is inflicted in return by central city drivers on outside areas.

Looking at not just the central city but rather an inner ring of Memphis versus an outer ring, geographically drawn regardless of income, one finds the same results as for Memphis. Taking Memphis as the inner ring, and Frayser, Millington, Raleigh, Bartlett, Arlington, Shelby Farms, Germantown, Collierville, Capleveile, Southaven, and West Memphis as the outer ring, there were in 1965, 7,142 accidents by outer ring drivers in the inner ring, and only 2,254 accidents by inner ring drivers in the outer ring. For outer ring drivers, it meant that about 39% of their total accidents were in the inner ring, while inner ring drivers had 7% of their accidents in the outer ring.

The situation does not balance out, however, because inner ring drivers are involved in the same percentage of outer ring accidents as vice versa. The addition of accident hazard to the road is obviously not the same if 7,000 accidents as opposed to 2,000. The figures simply show that travel making and accident experience is relatively central directed for all the towns. People's accidents (and trips) are more likely on the average to be further toward the center than their residences.

There are several "transfers" operating here. The first occurs between residents of outlying towns who do a great deal of their driving in the "inner ring" and the residents of outlying towns who do not. Those who do not are helping to pay for the risks incurred by those who do, since insurance rates are set by town. Insurance rates also fluctuate depending on whether or not one drives to work (and depend as well upon several other features relating to driver characteristics). However, since accident
rates by time of day in Memphis show that most accidents are not at rush
hours, and since those who work elsewhere than Memphis drive to work,
the rates do not separate those in outer towns driving towards the center
from those not driving towards the center. Thus, there is an added incen-
tive for someone who works in the center to live further out; his auto
insurance savings *may* recompense him for added transportation costs due to
distance. His fellow townspeople help assume the "risk" he incurs by doing
so through their insurance rates.

The second insurance transfer involves people from the outer ring
driving into the center and people driving from the inner ring in outward
directions. These people add "accident" hazards, as well as congestion
costs to each other because they are using the same road space. A crucial
assumption must be made as to how traffic volume is related to accidents,
all other factors being equal. It is known that there are great differences
between relative accident frequencies at night and in the day even with the
same traffic volume. However, if at any given time and on any given road-
way system, volume increased, it is reasonable to assume that the number of
accidents will be greater. There may be a linear, logarithmic or exponential
relationship resulting in a simple monotonic approximation to the accident
and congestion hazard added by the marginal vehicle.

In order to compromise, for want of better approximations, it will be
assumed that accident and congestion hazards are linearly related to the
number of vehicles. Mathematically:

\[
P = Probability of car being involved in an accident for which he is liable
\]

\[
V = Traffic volume or cars present
\]

\[
K = The constant which gives the linear relationship
\]
Thus, for the inner zone driver, his probability of having an accident is 20% greater because of outer zone drivers being present. (Twenty percent of the accidents in the inner zone are those of outer zone drivers.) Thus, under the linear assumption, the inner zone drivers' insurance rates are 20% higher for coverage necessary for their accidents within the inner zone. Inner zone drivers still have accidents in other places too, of course, but 86% of their paid claim accidents were within the inner zone. Forty percent of the paid claim accidents of outer zone drivers were within the inner zone.\(^{27}\) Therefore, under the linear assumption, (.20) times (.86) or 17% of the insurance costs of inner zone drivers were due to the presence of outer zone drivers coming into their area. To be fair, one should use the same assumptions to calculate how much was added to outer zone driver's insurance premiums because inner zone drivers contributed to the accident probability in their zone. Since 38% of the accident hazard was contributed by inner zone drivers, then about (.20) times (.38) or 8% of the outer zone drivers accident costs were contributed by inner zone drivers traveling through the outer zone.

Importantly, the insurance rates of drivers in the inner zone are not the same as those of drivers in the outer zone. Thus, the relative contributions are .17I where I is the insurance premium assessed to inner zone drivers, and .08U, where U is the insurance premium paid by outer zone drivers. The roughness of the assumptions only permits order of magnitude estimates. For "average" kinds of drivers (over 25) purchasing "usual" sorts of insurance packages (about $300 in the inner zone, and $150 to $200 in the outer zone) the order of magnitude of inflicted insurance cost is: \(^{28}\)
(.17) (300) $50 is assessed to inner zone drivers because of outer zone drivers coming within the inner zone.

(.08) (150-200) $15 is assessed to outer zone drivers because of inner zone drivers coming into the outer zone.

This is a summary of the assumptions through which these figures were reached:

1. It was assumed that for any car, the probability of having an accident was linearly proportional to the number of other cars on the road.

2. It was assumed that other cars were present from different zones in the same percentage as the percentage of accidents by cars from different zones. This implies that all drivers were assumed equal in skill, no matter what their zone of origin.

3. The assumption is implicit that drivers from the various zones are operating their vehicles at the same time of day. That is, inner ring roads are not entirely occupied by outer ring drivers at one time, or inner ring drivers at another time.

4. There is also an implicit assumption that the average accident cost is about the same for accidents occurring in both zones. If accidents were, on the average, more severe if they occurred in the outer zone, the differences between inflicted costs would be less.

These assumptions with a possible exception of #4 do not seem doubtful and even if #4 is wrong it isn't likely to be so different that the
direction which the most costs are "inflicted" would be reversed. This point of view is supported by a MUATS report which states that the accident rate of Memphis is a result of great concentration of travel within the city by persons whose cars are registered in surrounding towns, compounded by consistently greater congestion than elsewhere within the planning area."^{29}

It is very difficult to attempt to describe what congestion and accident costs are inflicted on certain people by certain other people, so the formulations here are only what the author considers to be reasonable hypotheses. In fact, it is probable that no model of these interactions can ever be formulated with a high degree of certainty, simply because there are so many influences in traffic systems whose effects cannot be uncoupled from each other. Therefore, one can never expect agreement among experts on this formulation assigning some percentage of costs as inflicted by others. It will be argued by some that each driver is always "inflicting" the same amount of congestion and accident costs upon the car next to him as the car next to him is inflicting. This is of course true. However, some drivers will have more congestion costs inflicted on them (and will inflict more costs) than others because of the pattern of urban trip making, since some drivers will do a larger percentage of their travel in more congested areas. In terms of insurance, one can truly say that costs are inflicted, and inflicted differentially because of the pattern of urban travel and methods of setting insurance premiums.

It is indeed fortunate for purposes of analysis that where private markets do operate, such as in auto insurance, they provide some indication of the distribution of benefits and costs. It is also somewhat unfortunate
when those distributions may tend to be regressive or unfair, in the opinion of the author. The author feels this is not the fault of the private market alone but rather of public investment policies which have resulted in differential costs.

The class of facilities on which accidents occurred is shown in the following table. It is quite apparent that most accidents occur on city streets, suggesting perhaps that safety improvements to them or diversion of traffic from them deserve much more attention from state and federal agencies.

### MUATS Area Accidents 1965

<table>
<thead>
<tr>
<th>Number of Acc.</th>
<th>U.S. Routes</th>
<th>State Routes</th>
<th>M.D.C.</th>
<th>City Streets</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal</td>
<td>25</td>
<td>121</td>
<td>24</td>
<td>212</td>
<td>8</td>
<td>390</td>
</tr>
<tr>
<td>Non Fatal</td>
<td>1,120</td>
<td>5,817</td>
<td>4,614</td>
<td>38,768</td>
<td>316</td>
<td>50,635</td>
</tr>
<tr>
<td>Property Damage</td>
<td>405</td>
<td>2,290</td>
<td>983</td>
<td>10,689</td>
<td>136</td>
<td>14,503</td>
</tr>
<tr>
<td>Total</td>
<td>1,550</td>
<td>8,228</td>
<td>5,621</td>
<td>49,669</td>
<td>460</td>
<td>65,528</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of Vehicle Occ. Injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal</td>
</tr>
<tr>
<td>Non Fatal</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

4.22 The Distribution of Fuel Tax Costs

The manner in which funds for freeway construction and other roadway improvements are collected and allocated has a large influence upon the distribution of costs.
The major source of funds for freeway construction is taxes on motor vehicle fuel, with some funds added from taxes on other motor vehicles products and motor vehicle registrations. This tax has one rather peculiar property in terms of how much is collected depending upon the "quality" of service which is consumed, although the effect is quite weak. Under very slow, congested conditions, use of gasoline per mile is likely to be quite high. Under smooth flow conditions, 22-35 miles per hour, the use of gasoline per mile is likely to be at a minimum. Miles per gallon decline at high speeds due to the substantial wind and rolling friction resistance. However, most of the increases in speeds which we will be concerned with are in the 0-40 mph range, in which it probably can be said that as average speed becomes greater, tax per vehicle mile goes down, due almost entirely to the assumption that lower average speed is a reflection of many more stops and starts rather than lower nominal speed.31

This alone is hardly enough information on which to judge the distribution of costs for the system. The costs for the entire trip are what count, and service for the entire trip should be the measure of the distributional impact upon users. Nevertheless, it is a stange tax whose impact seems to fall most heavily on those who seem to be getting the smallest benefit from it. It must be pointed out that these differences in taxation are quite small. The tax might be considered more fair if more user tax was collected and more congestion was used as a rationing device on the highest cost facilities. Congestion, of course (and high resulting user taxes, if they are visible), operates to ration the use of high demand times. Congestion has serious problems as a rationing device, since it can
lead to extreme breakdowns in the performance of facilities, and the costs inflicted on others by the "marginal" car may be much higher than the costs to the driver, with a consequent loss of total benefits to the society.

Nationally, the gasoline tax has been an extremely regressive excise in relation to income. Philip Burch\(^{32}\) provides the following figures, which though old, are probably still correct if the income limits are moved up.

<table>
<thead>
<tr>
<th>RELATIVE TAX CONTRIBUTION TO NATIONAL ROAD PROGRAM BY AMOUNT OF FAMILY INCOME (%)</th>
<th>less than $5,000</th>
<th>$5-10,000</th>
<th>$10,000+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline Tax</td>
<td>47.3</td>
<td>38.4</td>
<td>14.3</td>
</tr>
<tr>
<td>General Revenues</td>
<td>26.5</td>
<td>34.8</td>
<td>38.7</td>
</tr>
</tbody>
</table>

Since most gasoline is used in urban states,\(^{33}\) these figures are not that way because farmers drive a lot. In fact, one logical explanation is that low income people do a lot of driving on congested facilities in stop and go conditions. The idea that highways should be paid for out of general revenues (taxes more proportional to income than gasoline tax) does not have much support. While it might be desirable to some people for the goal of income redistribution, one cannot argue objectively that it does (or does not) result in a "better redistribution of benefits and costs than a system of user taxes.

It is sometimes suggested\(^{34}\) that methods of assessing tolls for the use of congested facilities during rush hours would be a more desirable or equitable means for getting people to pay for the capacity they are using. Such a solution is quite undesirable, since it does not take account of the possibilities for relieving congestion by improving the facility in question.
or other facilities. In addition, it equates use of facilities with ability to pay through monetary outlays. Less well to do people may be willing to expend time, but may be totally incapable of expending money in order to make trips that may be essential for their livelihood. The distributive results of congestion pricing suggestions are therefore highly questionable. In addition, it has been demonstrated by Wohl\textsuperscript{35} that congestion toll pricing benefits neither those who are forced off the facility nor those who remain on the facility. He also finds\textsuperscript{36} that it is impossible to judge whether marginal cost congestion pricing is better on the whole for society than an average cost pricing scheme (such as fuel taxes) unless one knows the particulars of the given situation.
Paved level tangents
Costs of MV operation includes gas, oil, tires, maintenance, and mileage depreciation

<table>
<thead>
<tr>
<th>Avg. running speed</th>
<th>Passenger Cars</th>
<th>Single Unit Trucks</th>
<th>Combination Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 mph nominal</td>
<td>5  4.93</td>
<td>8.11</td>
<td>17.72</td>
</tr>
<tr>
<td></td>
<td>7  4.44</td>
<td>7.29</td>
<td>15.93</td>
</tr>
<tr>
<td></td>
<td>10 4.09</td>
<td>6.72</td>
<td>14.70</td>
</tr>
<tr>
<td>15 mph nominal</td>
<td>10 4.46</td>
<td>7.29</td>
<td>16.32</td>
</tr>
<tr>
<td></td>
<td>12 4.16</td>
<td>6.80</td>
<td>15.23</td>
</tr>
<tr>
<td></td>
<td>15 3.86</td>
<td>6.31</td>
<td>14.13</td>
</tr>
<tr>
<td>20 mph nominal</td>
<td>10 5.13</td>
<td>8.47</td>
<td>19.25</td>
</tr>
<tr>
<td></td>
<td>15 4.24</td>
<td>7.00</td>
<td>15.89</td>
</tr>
<tr>
<td></td>
<td>20 3.72</td>
<td>6.15</td>
<td>13.99</td>
</tr>
<tr>
<td>25 mph nominal</td>
<td>15 4.71</td>
<td>7.85</td>
<td>18.36</td>
</tr>
<tr>
<td></td>
<td>20 4.04</td>
<td>6.73</td>
<td>15.74</td>
</tr>
<tr>
<td></td>
<td>25 3.63</td>
<td>6.14</td>
<td>14.36</td>
</tr>
<tr>
<td>30 mph nominal</td>
<td>20 4.30</td>
<td>7.24</td>
<td>17.50</td>
</tr>
<tr>
<td></td>
<td>25 3.91</td>
<td>6.59</td>
<td>15.92</td>
</tr>
<tr>
<td></td>
<td>30 3.71</td>
<td>6.24</td>
<td>15.09</td>
</tr>
<tr>
<td>35 mph nominal</td>
<td>25 4.11</td>
<td>7.04</td>
<td>17.65</td>
</tr>
<tr>
<td></td>
<td>30 3.86</td>
<td>6.61</td>
<td>16.58</td>
</tr>
<tr>
<td></td>
<td>35 3.79</td>
<td>6.48</td>
<td>16.28</td>
</tr>
<tr>
<td>40 mph nominal</td>
<td>30 4.15</td>
<td>7.23</td>
<td>18.42</td>
</tr>
<tr>
<td></td>
<td>35 3.98</td>
<td>6.93</td>
<td>17.66</td>
</tr>
<tr>
<td></td>
<td>40 3.94</td>
<td>6.87</td>
<td>17.50</td>
</tr>
<tr>
<td>45 mph nominal</td>
<td>35 4.22</td>
<td>7.55</td>
<td>19.45</td>
</tr>
<tr>
<td></td>
<td>40 4.13</td>
<td>7.38</td>
<td>19.01</td>
</tr>
<tr>
<td></td>
<td>45 4.16</td>
<td>7.44</td>
<td>10.17</td>
</tr>
<tr>
<td>60 mph nominal</td>
<td>50 5.17</td>
<td>10.13</td>
<td>25.43</td>
</tr>
<tr>
<td></td>
<td>55 5.22</td>
<td>10.21</td>
<td>25.63</td>
</tr>
<tr>
<td></td>
<td>60 5.40</td>
<td>10.56</td>
<td>26.51</td>
</tr>
</tbody>
</table>
Additional Costs to stop and regain wanted speed (one stop, cents)\textsuperscript{38}

<table>
<thead>
<tr>
<th>Speed (mph)</th>
<th>Costs (cents)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0.345</td>
</tr>
<tr>
<td>15</td>
<td>0.318</td>
</tr>
<tr>
<td>20</td>
<td>0.314</td>
</tr>
<tr>
<td>25</td>
<td>0.328</td>
</tr>
<tr>
<td>30</td>
<td>0.383</td>
</tr>
<tr>
<td>35</td>
<td>0.487</td>
</tr>
<tr>
<td>40</td>
<td>0.636</td>
</tr>
<tr>
<td>45</td>
<td>0.835</td>
</tr>
<tr>
<td>50</td>
<td>1.108</td>
</tr>
<tr>
<td>55</td>
<td>1.477</td>
</tr>
<tr>
<td>60</td>
<td>1.952</td>
</tr>
<tr>
<td>65</td>
<td>2.574</td>
</tr>
<tr>
<td>70</td>
<td>3.410</td>
</tr>
</tbody>
</table>

4.3 THE DISTRIBUTION OF BENEFITS AND COSTS FROM NEW FACILITIES

This section covers briefly the distribution of benefits and costs from system improvements, focusing primarily on urban freeways. It is not possible with the present state of knowledge to get any general formulation relating the demographic characteristics of an area to the distribution of benefits and costs from a new facility, since the distribution is dependent on the specifics of the existing situation and the specifics of the location and design of the freeway. However, the distribution of user benefits and costs can be calculated either through the traffic assignment process or by simpler hand methods, and at least some of the non-user impacts can be dealt with. The general flow, through the entire national economy, of all benefits from a transportation investment is not treated here.

One important area of the distribution of benefits from new facilities is the distribution between users and non-users. The framework for the economics of user and non-user benefits and taxes is set up in a book by Herbert Mohring.\textsuperscript{39} It is important to realize that some user benefits
are passed on through the whole society and result also in patterns of non-user benefits. These can be increased land rental values, due either to increased accessibility or to the new locational decisions of other activities which locate near the facility, or decreases in the prices of goods and services. Many of the effects, of course, become quite far removed, making it an extremely difficult problem to formulate reasonably. For instance, it is easy to find the number of housing units to be displaced by a new freeway. However, in the long run that same freeway that initially destroyed housing units may perhaps allow new residential development to take place, and may even contribute to the filtering of housing to all income classes. "Filtering" is the often described mechanism through which a well-to-do household buys a new home, leaving increased and better housing stock for lower income classes. So it must be admitted that it is probably not possible to trace out the distribution of all the system effects of new transportation investments, without a general model of an urban area.

This section will largely concern itself with speculation upon the distributional effects which can be identified and which should fall within such a general model.

Mohring demonstrates that it is fallacious to add up user and non-user benefits in order to get some total value measure of benefits. This is an important point, since some non-user benefits represent user benefits passed on to others. However, for the purposes of the type of analysis proposed in this thesis, it is quite important to explicitly identify those user and non-user benefits for the various groups which can be presently identified. Evaluation proceeds on the basis of distribution of benefits,
and no analytical function is proposed which professes to trade off the impacts on different groups.

This chapter attempts to trace some of the user and non-user impacts of new facilities. First it presents cost figures for new expressways by density of area, and two methods for estimating user benefit distribution. As was mentioned, no general model for tracing the incidence of non-user benefits is presented. However, the section on long term effects of transportation impacts does suggest some speculative hypotheses about how "user benefits" enter into people's choices of locational patterns.

4.31 Costs and Benefits of New Expressways by Density of Area

While it is not contended that most new expressway projects might be unambiguously classed by the density of the areas to be served, making a distinction by density is useful for some comparisons between projects. These comparisons are either in judging the economic desirability of circumferential expressways at different distances (and presumably, densities) from the city center, or in judging whether new expressways were a "better" investment (higher total benefits minus costs) in higher density urban areas or in lower density urban areas.

This has implications for which investments will be chosen if traffic and transportation planners are inclined towards satisfying as much travel demand as possible through expenditure of a limited budget. Freeways may be more desirable investments on a benefit cost basis in some densities rather than others, although in general the pattern of activities, densities, and other facilities will be important determinants of benefits and costs.
The cost of property acquisition and demolition (preparation for construction) is greater in higher density areas. Meyer, Kain, and Wohl express such costs with the following equation:

\[ Y = 999,000 + 70,800X \]

where \( Y \) is the construction cost per mile for an eight lane facility and \( X \) is net residential density in thousands of persons per square mile.\(^{41}\)

When the figures were used by Meyer, Kain, and Wohl, vehicle operating costs were added in, and the total costs of automobile service to the CBD were compared with rail and bus transit service. Using the more familiar figures of gross population density rather than net residential density, Balkus and Srour \(^{42}\) found a relationship of \( \log Y = 2.2857 + 0.4055 \log D \), or \( Y/D = \) constant, where \( Y \) is the total cost per mile of road in thousands of dollars and \( D \) is population density in persons per square mile.

For the total cost per lane mile they found a relationship of \( \log X = 1.7753 + 0.3251 \log D \) or \( X/D = \) constant, where \( X \) is total cost per lane mile in thousands of dollars. This implies a total cost per lane mile of about $300,000 where population density is 200 persons per square mile, to about $1,000,000 per lane mile when the population density is 6,000 persons per square mile (about the equivalent of the suburbs in Memphis, to about $1,500,000 to $2,000,000 per lane mile when the population density is 20,000 to 40,000 (the "inner core").\(^{43}\) These figures are of course just estimates from curve fitting. Particular projects may have strikingly different estimates. However, it illustrates, as do other data, the very vast differences in costs depending on different densities.
Such cost figures are quite crucial in calculating the "economic" desirability of projects on the basis of total benefits minus costs. The traditional benefit cost analysis of the highway engineer compares these costs to the expected user benefits from the facility. The large differences in cost per lane mile by density mean that, unless new expressways in higher density areas have substantially more user benefits than those in lower density areas, then the new expressways in lower density areas will seem to better "economic" investments. That judgment would be assuming of course that it was net benefits minus costs which was important to the highway decision maker, regardless of distribution.

There are also different benefits available from roadways constructed in areas of different densities. For the benefits, however, there cannot be any general mathematical formulation, since the benefits generated are dependent on the characteristics of the particular roadway network existing and upon the location of the proposed link in relation to the rest of the existing network. The benefits realizable from any particular new link are also dependent on whether other new links are constructed or not. Some means of estimating the distribution of benefits already exist, however, and these will be noted here.

Two general ways are suggested for calculating the distribution of user benefits. The first uses a traffic assignment process to assign benefits to trips originating in particular zones. The trip makers could be tagged by income class if the purpose of the analysis were to get a distribution by income class as well as by geographic area. The second would be to make a simple geometrical approximation to the trip assignment
process by assigning benefits to all nearby travel desires sharing the direction of the link. These methods are further detailed later in this chapter.

4.32 Measures of Benefits from New Freeways

Highway improvements are usually evaluated economically by comparing the cost of construction with the so-called "user benefits". User benefits are the savings in vehicle operating costs, the savings in accident costs, and the savings in travel time resulting from assigning traffic to the new facility.

It seems quite reasonable to estimate a dollar value for savings in vehicle operating costs. The estimation of the dollar value of saving lives is an ethical problem, and is not a subject of this thesis. The dollar value of travel time savings is also quite a difficult figure to estimate analytically. Since most of the dollar value of benefits claimed for new freeways (and for Memphis Transportation Authority) is savings in travel time, it is worthwhile to explore the distribution of travel time savings and their value in some detail.

The first and most obvious difference in the distribution of travel time savings from a line haul facility such as a freeway or new transit system is that those who make the longest trips in the direction of the new facility are likely to get the greater benefits.

For example, a change in aircraft speed occurred when jet aircraft were substituted for piston aircraft. Suppose a traveler wishes to go from somewhere in New York City to Los Angeles and another traveler wishes to go from somewhere in New York City to Boston. Assume that throughout
the example, the time from when he leaves his origin to when the plane takes off is one hour, and likewise the time from when the plane touches down to when he reaches his destination is also one hour. Thus, for all trips, "access" time is two hours, and it is assumed that no improvements are being made in access time. By piston plane, New York City to Boston is two hours, and New York City to Los Angeles is 10 hours flight time, takeoff to landing. For jets, flight time is one hour to Boston and five hours to Los Angeles. (This is being generous to the improvement in the shorter trip; because of time spent in takeoff and landing, the shorter trip, even in line haul, would probably not decline in time by a proportionate amount.) Thus the change in line haul technology means that the New York City to Boston traveler now makes his total trip in three hours instead of four, while the New York City to Los Angeles traveler now makes his trip in seven hours instead of twelve. The longer distance traveler receives of course more benefit and more percentage reduction in travel time.

In this case of air travel, each trip maker is presumably charged a fare representing the cost of his trip. It is not in the interest of the airlines to build a cross subsidy into their fare structure. (In reality, of course, many routes do operate on a loss basis, with the hopes that they either will someday prove profitable, or that they will provide connections to profitable routes of the same airline.)

The situation in regard to urban freeway improvements seem to be similar in terms of the distribution of benefits, but dissimilar in terms of the mechanisms used to price trips of various lengths.
All other things being equal, a traveler gets more benefits from an improvement the more he uses that improvement as a proportion of his trip making. Thus, the driver making a ten mile trip on a freeway gets twice the benefit as the driver making a five mile trip on that freeway, assuming that the freeway was an exact locational replacement for an arterial street.

Improvements to collection and distribution facilities has approximately the opposite relative effect on the proportionate improvement in trip times. Suppose that collection and distribution services are about equal for both the longer distance traveler and the shorter distance traveler. We will assume an average of one half hour per round trip taken up with collection and distribution. Suppose through some improvements everywhere in collection and distribution systems that this was cut in half to one quarter hour. The short trip maker then would have a greater percentage decrease in his travel time, although, of course, the amount of time savings would be the same for both trip makers. Each would receive equal measured amounts of benefits.

The distribution of benefits due to line haul (freeway) improvements is more complex than this, however. Line haul improvements for one group may register as collection and distribution improvements for another group, since traffic is taken off local streets. This is part of the phenomenon we have termed "inflicted benefits". The other part of inflicted benefits is of course the increased performance on line haul facilities through the area, if these facilities wouldn't have been built except for the travel demand of non local people. Thus we must remember that there are "inflicted benefits" as well as "inflicted costs" due to urban spatial configuration and the pattern of trip making.
It is perhaps a characteristic of all transportation investment policies that projects which give most improvement to the line haul portion of the trip are easier to visualize and may be developed at the expense of collection and distribution. This is true of intercity improvements in air transportation as well as in urban area transportation itself. New types of propulsion (jet aircraft vs. piston) or of right of way (freeway vs. arterial) have easily measurable operating advantages. The line haul problem is probably the easiest problem in transportation to analyze, and it is relatively simple to demonstrate the differences in average line haul speed. Collection and distribution, or analysis of the total trip making pattern, is much more complex.

The result of this relative ease of line haul analysis and the possibly greater improvement in line haul has a simple and logically straightforward impact upon the distribution of benefits. Those who make the longest line haul trips get proportionately more benefits from solely line haul improvements. This is a short run analysis. Long term analysis of greater line haul speeds is covered later.

4.33 Methods of Calculating the Distribution of Benefits from Urban Freeways

Thomas N. Harvey has developed and illustrated a method for calculating user benefits from a new link by zone of origin. For each origin, Harvey calculates the user benefits accruing to that zone. Gunnar Hall of M.I.T. took this one step further, by setting up an objective function for choosing system improvements with one constraint that a certain percentage of benefits had to accrue to certain users.
The distribution of benefits from a new transportation system investment depends upon the system which is there already. This is because the value of the new investment is the savings which accrue to each group or area because of its implementation. There is an established pattern of trip-making dependent on the facilities already in existence. Therefore, one has to understand the operation of the present system in order to evaluate the distribution of impacts from new links. As in the evaluation of most housing proposals, the existing facilities are dominant in that they define the criteria (rents, or travel times and cost savings) which the new facility must match or better.

Thomas Harvey's simple model adds the new link to the old area, and recalculates the flows with a new traffic assignment run. He used just an example problem, but the method is generally applicable to much larger networks. In his example, as one might expect, not all groups gained time savings, since the redistribution of flows was complex and added to congestion for some trip makers. It is well known that new expressways are likely to increase congestion on some feeder or perpendicular streets, while decreasing congestion on parallel streets.

Thus, a method already exists for calculating the distribution of user benefits from a new link, given the facts that one already posses the data on flows and trip patterns in the existing network. Such a method can give information about the distribution of benefits if they are used during the overall network evaluation. However, the difficulty is that a major urban area transportation planning and network analysis involving home interview surveys is extremely expensive, and these studies have cost
from one to 15 million dollars. It would be nice to have a very simple and cheaper technique for looking at particular link improvements. Since the state of the art of traffic forecasting is such that 10 to 20 year estimates are often off by over 50%,\textsuperscript{46} it does not seem justifiable to get extremely sophisticated answers based on grossly speculative forecasts, especially at quite early stages of the design process.

Another method possible for estimations of the distribution of benefits from a new link is quite straightforward and geometric, and highway designers have long been using it. The analyst proceeds by taking a screen line count at several points along the proposed improved facility, and supplements it with a statistically valid sample of the users of the present facilities. He then assigns benefits to the users proportional to the length of trip they will make in the direction of the improved facility. If origin and destination data have already been collected, the sample of who is traveling through the corridor can be taken by computer. This assigns benefits also to those who travel on parallel streets.

Though not elegant, such a method would given an approximation to who benefits and by how much. It does not deal with who would receive the negative user benefits which Harvey's model illustrates. Though these dis-benefits could be decreased by complementary improvements in feeder and perpendicular streets, or good feeder ramp and interchange design, it would be extremely desirable at some stage in the design process to calculate such disbenefits.

It is suggested that both types of calculations of user benefits would have usefulness in the evaluation and design process, and would be utilized at different stages.
Calculating the user benefits from just one new facility is not a very complete problem though. Over some reasonable period of time many new facilities are likely to be constructed, so it would be preferable to analyze many different combinations of new facilities. The analysis of each proposed facility is then a sort of marginal analysis of the new system with or without that facility. The single new link analysis might also help to provide a staged programming strategy for implementing an entire set of improvements over a long period.

It is the opinion of the author that within the framework of the large urban area transportation studies of the late 1950's and the 1960's, analysis of major new expressway systems in terms of their distribution of benefits could have been done easily. These studies, however, looked solely at total benefits and costs, rather than tagging the user benefits by zone. Since the other methodological shortcomings of these studies were legion (but not a subject of this thesis), this is just one additional criticism, and should not be interpreted as suggesting that these studies would have been perfectly adequate if they had looked at distribution.

4.4 NON TRADITIONAL BENEFITS AND COSTS AND THEIR DISTRIBUTION

These are termed non traditional only because they have not typically been well analyzed by highway agencies. The following costs and benefits and their distributions are discussed in detail.

a. The distribution of residential displacements and impacts
   (1) Economic Costs of Being Moved
   (2) Psychological and social costs of being moved
b. Distribution of effects on tax bases
c. Results of long term activity and locational shifts

There are many other impacts which are important, yet are not dealt with here, because it is felt by the author that their impacts are even more specific than the above in regard to particular projects. These are things like business displacements, where impacts depend quite heavily on the individual business's size and health, on the particular type of business it is, impacts upon parks, historical sites, and questions of aesthetic design. This thesis doesn't discuss these things, not because of a judgment that they are unimportant in judging a distribution of impacts, but simply because the emphasis here is upon economic benefits and costs of a generalizable nature. In filling out the impact matrix of Topic 3, it is hoped that these and many other categories would be included.

4.41 The Economic Costs of Being Moved and Their Distribution

Some quite straightforward housing market effects have provided extremely great inequities in the distribution of costs from urban freeway projects. A current figure is that 45,000 to 50,000 households a year will be displaced by highway construction over the next three years. About three-fourths of this is expected to involve urban housing, but the distributive analysis of housing market supply effects would apply equally well to rural housing.

Lower income persons bear a very disproportionate share of the costs of being displaced, for two separate but related reasons.

1. They are more likely to be chosen to be displaced for highway projects. Two-thirds of highway project displaces have been
households with homes valued at less than $15,000 or rents less than $110 per month. Therefore, the poor have been more likely to be displaced.

2. The housing market is tighter for many of the poor than it is for many other groups. Low income Negroes, in particular, face an extremely restricted housing supply.

Adverse housing market supply effects occur when the quantity of housing in an area decreases but the demand does not. The price or rent of the remaining units then rises, since there are more people bidding for them. The 1962 Highway Act of the U.S. Congress provided that relocation assistance must be given to displacees. However, it was not until the 1968 Highway Act that implicit recognition was given to housing market effects.

"Fair market value" has been the basis for establishing what a government agency should pay a person whose property is taken by eminent domain. "Fair market value" is supposedly what a willing buyer would pay a willing seller in an open market exchange. However, in very large highway projects, "fair market value" has sometimes had little relation to either "fair" or "market". Its unfairness has been subject to criticism from both conservatives and liberals, since someone is being coerced to move and told how much he would be paid. Poorer people, with less knowledge of their legal rights, are certainly more apt to accept a lower price than a well-to-do person who could afford a legal battle. This differential cost has long been familiar.

The second criticism, that "fair market value" may not be established in relation to the housing market, is especially pertinent for larger
projects. If it is supposed that perhaps 3,000 lower income housing units are to be taken by a freeway project, market effects will be vastly different than if one family were displaced. This is because, due to the assessment practices of the appraisers, the value of the houses to be taken are set at the time that property acquisition begins. Thus, all 3,000 houses are assessed in accordance with the old market conditions. However, when the displacees take the old market value and try to purchase similar property, they find there is a new market price, established by the fact that supply is now 3,000 units less. The price of homes, or rents, rises to a new equilibrium.

In fact, there is a simple rule by which a public agency could make sure it was purchasing property at the market value. That is by purchasing similar property on an open market, and in effect making "trades" with displacees rather than monetary payments.

The reason, of course, for the use of eminent domain is the fear that some property owners in a highway's path would refuse to sell except at exorbitant prices. Thus, means of appraisal, and of setting a "fair market value" were applied to establish the price which the public agency should pay. No description of the different methods for arriving at fair market value will be given here. It should be noted that all techniques besides actual purchase of exactly similar property are only means of estimating the market. For each displacee, however, the agency could cooperate with him in actually buying a "similar" house on the open market. In this way, no one would be disbenefited economically, and the market would be constantly adjusting to a new equilibrium. The full costs of its
influence upon the housing market would then be borne by the public agency, not by the people displaced.

The Fifth Amendment of the United States Constitution provides an excellent guideline for payment of displacees. It reads:

"...nor shall any person be deprived of property, without due process of law; ...nor shall property be taken for public use, without just compensation."

Unfortunately, since "just compensation" was left undefined, it was possible for the courts to develop a body of practice which results in great inequity for people displaced by highways today.

Many expenses are not covered by the just compensation clause of the Constitution, according to the interpretation of the courts. John C. Vance, Highway Research Board Counsel for legal research lists the following losses and expenses for which courts have "consistently denied recovery".

1. The cost of moving personal property and the cost of disconnecting, dismantling, and reinstalling structures, machinery, and equipment.

2. Transportation costs and other expenses incurred in moving a displaced family to replacement housing and the expenses incurred in searching for replacement housing or other types of property.

3. Expenses incidental to the transfer of title to real property required by the Government, such as recording fees, clerk fees, transfer taxes, etc.; penalty costs for prepayment of a mortgage and real property taxes paid to a taxing entity which are allocable to a period subsequent to the transfer.
4. Loss of going concern value, goodwill, or livelihood, where a business cannot relocate without a substantial loss of its patronage; or the loss incurred due to business interruption.

5. Loss of employment due to the relocation or discontinuance of displaced business.

6. The increased cost necessary to acquire a substitute home, farm or business, or the increased cost of rent for a substitute dwelling or other property.

7. The loss of rental or other income between the time of announcement of a public improvement and the time of taking.

8. Loss of home ownership because of inability to obtain financing within the financial means of the displacee, or the loss of opportunity to continue in business.

9. Loss due to less favorable financing in acquisition of replacement housing.

In order to deal with these formerly uncompensated costs, Chapter Five of the 1968 Federal Aid Highway Act provides that homeowners may be reimbursed up to $5,000 by a supplementary payment in excess of fair market value and moving expenses. This is intended to help bring payment to the relocatee more in line with the true financial cost to the relocatee. Even this amount might not be enough in areas which suffer under depressed market conditions. Stuart Hill of the California State Division of Highways found that homes in Watts assessed at $13,000 cost between $18,000 and $22,000 to replace.

Chapter Five of the 1968 Federal Aid Highway Act is also intended to alleviate the housing market effects which face low income renters when
they are displaced by providing for a supplementary payment of up to $1500. Nothing is done for those other low income people not in the highway right of way who might also face higher rents because the supply of units has been diminished. 50

Interestingly enough, increased rents may lead to higher property values in the areas adjacent to the highway. Increased property values are generally cited as a benefit of highway construction. This may be a grotesque result in terms of the distribution of benefits and costs, and illustrates the need for great care in defining or measuring the benefits and costs, especially where one man's gain may be another man's loss.

In summary, the criteria upon which property owners and renters are reimbursed for the taking of their homes and their enforced moves are likely to profoundly influence the distribution of impacts. If property values are low because of the unwillingness of institutions to lend money or insure, then "fair market value" as a standard for reimbursement may not be fair in areas which are discriminated against. Ghetto areas are particularly vulnerable when "fair market value" is applied as a criterion. A ghetto resident will probably face great difficulty in relocation since he is the victim of housing market segregation. The removal of units from the restricted supply of ghetto housing drives rents and prices even higher and results in greater overcrowding. The 1968 Highway Act, by increasing payments beyond fair market value to a more realistic level of compensation, may alleviate this problem, and the Fair Housing Act may reduce housing segregation, but only if the laws are enforced strictly and equitably. Payments for housing show the importance that true costs be included in
the analysis. If very low and unfair prices are paid for property, then inequity receives a positive accounting in the benefit-cost framework. This is both socially and economically grotesque, yet has probably been a fairly common result of highway departments' efforts to keep costs down. It is this problem of poorly registered costs and benefits which, keeping track of distribution, will help alleviate.

4.42 Psychological and Sociological Impacts

In this field we never expect to have any numerical analysis of the distribution of impacts. But past research by Herbert Gans,\textsuperscript{51} Marc Fried,\textsuperscript{52} and others indicates that perhaps a typology of neighborhood could give a transportation designer indications of the kinds of psychological and social impacts to expect.

Marc Fried found that many low income people displaced from Boston's West End felt actual grief over their move for long periods of time. This he felt was partly due to the strength of working class orientations to the neighborhood, even if they had few close relationships there. If more of their close friends lived in the neighborhood, they were more likely to feel grief (67%) though 44% of even those with few neighborhood friends felt grief.

In dealing with this problem, perhaps the best method of analysis is one suggested by Professor Gordon Fellman of Brandeis. Fellman's suggestion is that if someone is planning change for a neighborhood, he ought to spend at least a year there getting to know the people, and out of this will perhaps come a gestalt which would enable him to understand the people, and how (or whether) to relocate them. Professor John Clarkeson of M.I.T.
has suggested many times that people impacted by highways be dealt with on a personal, individual basis. This approach is that no matter how many individuals are displaced (though it is desirable to displace as few as possible) enough effort should be expended to take care of both the economic and social impacts on that person because of a forced move.

These suggestions are a departure from the money and effort saving practices in present relocation, where people must largely fend for themselves. Current practice in the Memphis Redevelopment Authority, which handles relocation for families displaced by the North and Summer Ave. Expressways, assigns forty to fifty families to each relocation case worker. This is barely adequate to enable the case worker to discover and catalogue the social and psychological problems of relocatees, and certainly is not a level of effort necessary to ameliorate the deleterious impacts of relocation.

Another whole question of distribution of such impacts from urban expressway construction concerns the group of people whom Gordon Fellman calls "the survivors", those people in the affected neighborhoods whose homes are not quite taken but whose friends and associations have been removed. As with other psychological displacement impacts, the difficulties are likely to be most severe for lower class people quite attached to the neighborhood, rather than for middle income areas where visiting friends, relatives, or shops is done by car.

4.43 Tax Base Effects

Many communities are concerned about possible loss or gain of tax base, particularly from new freeway construction. Highway agencies usually attempt to impress upon communities the gains in taxable industrial real
estate and overall property values which will result from improved trans-
portation service. The Summer Expressway found that increases in taxable
industrial real estate in Bartlett-Arlington, due to the expressway were
sufficient to subtract $45 from each homeowner's tax bill. Most other
impact studies find a similar generation of such benefits for property
owners. Improvement of access is seen as desirable from an economic
point of view.

When much of a community's present tax base might be depleted, however,
there has usually been some concern over the effects. The California State
Division of Highways provides, in its impact studies of proposed freeways,
the immediate tax base lost for each community. The percentage loss also
has importance because it may be related to the community's ability to
continue operating the facilities in existence. For instance, a community
would find it suddenly had unused school capacity of 20% of its children
were displaced (though this would be a unique reversal of the school prob-
lems of most communities). In choosing which alternative alignment of a
new freeway to recommend, the state highway engineer may attempt to balance
the percentage impacts on each community. Thus, equity between communities
in regard to tax base impact is considered a valid goal by the California
Division of Highways.

There has been substantial political concern over tax base losses in
communities in higher density areas. Tax base losses have been a signifi-
cant issue in Cambridge, Massachusetts, and in San Francisco, California.
In each case, political opponents of the freeways were not convinced that
tax base gains would offset the losses.
The locations of residences and businesses are obviously influenced by transportation investments. The distribution of tax base effects on the various communities is a hard problem due to the difficulty of separating out the impacts of other factors on choice of location. Transport mode type is a determinant of industrial location. It used to be that heavy industry was always located on rail sidings or water. Trucking has made industry more mobile, as have autos for residents. Requirements of plant layout and technology may make suburban or new locations desirable to industry. Structures in the central parts of urban areas may be obsolete for modern plant technology. Therefore, it may not be correct to say that suburban highway construction (such as Interstate 240 around the Memphis area) causes industry to leave intown locations. To some extent that is where new plants have to locate anyway.

Industry and business may be simply following residential development. "Business and industry have pursued this population flight to the suburbs." The tax base effects upon central cities may be somewhat generalized. Many industries and residences which would be net tax contributors move out to suburban locations for a variety of reasons, one of which is to escape from higher taxes to where assessments may be lower. The process is self regenerating, for the more tax base contributors the city loses (and the suburbs gain), the more it is desirable for tax base contributors to move out, instead of bearing a larger burden of supporting city services for poor residential areas. The process will balance, however, if central city location rents fall and some location advantages remain. Not all relative advantages of intown locations are likely to be lost.
Here, the institutional arrangement of local property taxes works to
disadvantage the lower income residents, while transportation policy is
only one in a series of factors through which outmigration of the well-to-
do is made more attractive. A person who wishes to own a $75,000 or
$100,000 house would do well not to locate it in a low income community
where there is little industry and everyone else has $10,000 homes. He
will obviously pay much lower taxes in a community composed of similar
people, and with an industrial tax base as well. Policies of large lot
single family zoning and subdivision control effectively exclude low
income residents, preserving the tax shelter for the well-to-do resident.

It is often hypothesized that radial improvements in transportation
take the middle class out of the city. They are enabled to live further
from their jobs if radial transportation is improved, and the jobs then
follow to the suburbs once the labor market there is fairly well established.
But, lack of transportation improvement may mean that the urban growth
process will not occur at all in a metropolitan area.

Though there is no proof available as to the cause and effect rela-
tionships between transportation improvements and the relative tax bases
of jurisdictions, it is certainly a worthwhile area for speculation. Some-
day a general dynamic model of the urban area may be able to deal with tax
base-transportation interactions. Tax base differences may lead to political
pressures for certain types of transportation investments, and transporta-
tion investments may contribute to changes in relative tax bases among the
urban areas political jurisdictions.

Such base effects may occur for both highway investments and through
transit system financing, though the cause and effect relationship has not
been established.
The hypothesis we expect to be true is that the central city's tax base is declining relatively partly because of overall transportation policy. If this is true, there are likely to be secondary effects from the central city's loss of tax contributors. If the real estate tax rate in the city becomes very high, and commercial property is taxes at an even higher rate, stores may find it necessary to charge higher prices than do their suburban counterparts who pay lower rents because of lower taxes. (It is well known that ghetto stores may charge higher prices. This may be due to such costs as well as to the lack of competition, which may be due to a lack of mobility of many ghetto area shoppers.) Also, if the situation is like Boston, New York City, or Jersey City, New Jersey, real estate taxes may eat up between twenty and thirty percent of the gross income of office buildings or apartment buildings. The person who lives and shops in the high tax area is probably paying significantly for his "choice" of residence.

Tax base effects enter into the problem partially because travel patterns are across municipal boundaries. If nearly the entire urban area were one municipality, to which a close approximation is Houston, Oklahoma City, or Jacksonville, the dog-eat-dog competition for the right tax contributors would obviously be eliminated. Assessment practices could still favor the relatively well-to-do areas, or the areas with political power in the city.

Property tax assessment practices (and also means of setting auto insurance premiums) may provide an economic rationale for locational decisions and patterns of trip making that would not otherwise occur. They therefore cause some distortion in the distribution of transportation systems.
benefits and costs, making longer distances of travel acceptable to some trip makers. Most likely, it is the relatively well-to-do who will benefit from property tax assessment practices and automobile insurance assessment practices through paying lower prices for their suburban locations and for their long trips than they would otherwise pay.

4.44 Long Term Impacts

The demand for urban transportation is a derived demand, which means that it arises not because people want travel for its own sake, but that they wish to travel in order to secure income, goods, or services, or other opportunities. Because of this, transportation expenditures, in terms of time and effort as well as money, might be looked upon as a cost of getting other things.

The traditional analyses of user benefits would lead one to believe that within the urban area, the result of transportation improvements is to lower persons' travel times. Some dollar value is then attached to the savings in travel time, and persons are expected to use those travel time savings for other purposes, such as leisure. If travel time is considered a cost, however, it seems reasonable that savings in travel time will be used by some persons to broaden their locational choices. If they can travel at higher speeds to work, they may live further from the job in a more preferred community. The benefit of time savings is thus partly used as a benefit of increase in locational choice.

As urban areas become larger trip length becomes longer, from about three miles in urban areas of 250,000 or less to about 6 miles in urban areas of over 7 million people. The average work trip length in the
Baltimore area increased from 2.6 miles in 1926 to about 4 miles in 1946 to over 5 miles in 1961. Persons in larger urban areas, with choices of more places in which to locate and more places to which to travel, apparently choose to travel further as part of an increase in those choices.

Some part of the increased distances and travel times experienced in larger urban areas is likely due to externalities inflicted by others through their locational and trip choices. Firms which move may inflict longer travel times or distances on their own employees, who have an investment in their jobs, as well as upon other firm's employees, who battle more congestion and compete in a more competitive land market for housing locations closer to work. For instance if A is the location of a firm and B the location of some of its workers' residences, a new firm at C will inflict some external travel time costs on employees from B if some of C's employees come from that direction. If residents of both firms have similar preferences for rent and travel time, at least some persons

A       C       B       D

will be forced through increased rents to live further out than B, perhaps at D. But as long as there are substantial moving costs for residences, some increased trip lengths will result from this process of new firm location or more intense development.

However, there seems to be little possibility that trip lengths increase simply because of reduced efficiency in locational patterns when urban areas become larger. Part of the trip length increase is due to the availability of amenities further away from workplaces, such as better schools, larger
lots, higher class neighborhoods, and so forth, and importantly, to individual preferences for particular towns. Sometimes the well-to-do have the longest travel times, suggesting that "travel time savings" is an inferior good\(^{62}\) in relation to other factors influencing locational choices.

If savings in travel time gets converted into benefits of increased locational choice, the distribution of benefits may be different. More benefits would go to those who can most easily change old locations in order to consume the newly available locations. Such persons are likely to be the upwardly mobile. A study in the Memphis area found that persons desired to locate in zones containing those with somewhat higher status.\(^{63}\) Thus, for the analysis of long term impacts, one must carefully predict a resulting development pattern, and the kinds of people who will relocate due to changes in accessibility and the pattern of land uses. The professional understanding of this aspect is presently fairly rudimentary, and much work remains to be done to improve on the results.

4.5 INTERMODAL IMPACTS AND IMPACTS ON NON DRIVERS

System improvements for any mode benefit mostly those who can make use of the facilities. Those who are unable to do so receive only indirect benefits and costs or direct costs. Currently, about one half of all 200 million American citizens have licenses to drive a car. The other half are either too young, physically incapable, do not have access to an auto, or choose not to drive. The trip making characteristics of non drivers are quite different from those of drivers. Non auto drivers are the portion of the population for whom transportation investments are small.
In effect, the supply of transportation is geared to those who have the ability to register demand for transportation in a certain way (as for instance, by owning and operating a motor vehicle). The demand characteristics to be measured for urban area transportation should be independent of this kind of supply limitation. Most are not, for trip making models are based on things like automobile ownership, net residential density, income, etc. Therefore, although the transport planner can deal with present trip generation rates, very little is known about what will happen when there is a change in the supply and quality characteristics of the modes of transportation offered. A system which would serve anybody, not just drivers or auto owners, may have much greater trip generation rates. Benefits and costs may then be distributed over the society in a different manner.

At present, investments in the capacity of one mode, such as auto, may have adverse effects upon the finances of the operations of other modes, or on the level of service offered by other modes. Conceivably, a net decrease in transportation capacity could occur if the financially troubled modes were to curtail or cease operations. Under these circumstances, a subsidy to the financially impacted mode might be justified in order to keep it in operation.

The effects of declining transit ridership due to increased automobile usage may mean that service by transit is decreased. Schedule frequency may be cut, or lines may be abandoned. When this happens, those persons who were relying upon the transit system for most of their service may find that other people's choice of the automobile has curtailed their service by transit. They may even be constrained to travel by auto as
the only realizable way of making the journey. Of course, the auto
system may also be the cheapest overall, if investments decrease auto
travel time and cost, as demonstrated in some conditions by Meyer, Kain,
and Wohl. However, in terms of distribution, those who cannot drive
may be receiving poorer transit service because those who can drive, do
drive. The long term effects in this situation may be the most substan-
tial. The auto mode, besides being likely to offer superior service to
start with, has an added advantage in that long term increases in service
by auto lead to actual, not just relative, decreases in service by transit
and new patterns of development which transit cannot serve profitably.
This may be a general rule for one superior mode in competition with
another (e.g., airplanes and passenger trains, and much earlier, railroads
and turnpikes). The competition is asymmetrical, and the distribution of
impacts resulting from gains in competitive position does not fall equally
upon the urban area population. Those who own cars show large gains in
mobility, while those who do not have autos available may show actual as
well as relative losses in mobility. There may thus be a "feedback" to
measures of increased accessibility to some parts of urban areas, in that
increased accessibility by one mode may be partially (perhaps even wholly)
offset by decreased accessibility by another mode.
FOOTNOTES


3 Aaron Fleisher and Philip Herr, "The Mobility of the Urban Poor," prepared for the Department of Housing and Urban Development by the Joint Center for Urban Studies of M.I.T. and Harvard, 1968, Tables 5b, 5c.

4 Likewise for two or more auto owners who share expenses by car pool.


6 Ibid., p. 218-219.

7 There has also been some debate as to whether new or used cars are more expensive to "own." It seems unresolved.


10 Wilbur Smith and Associates, op. cit.

11 Harland, Bartholomew and Associates, op. cit.

12 Fleisher and Herr, op. cit.

13 D. A. Quarmby, Transport Planning and the Choice of Travel Mode, Summary Report, Department of Management Studies (University of Leeds, December 1966). Quarmby found that two minutes of walking or waiting time seemed to have as much disutility as five minutes of time spent in motion.


15 The concept of utility, as used in economics or decision theories, tells what the value of some particular goods are in relation to other goods. The utility of a trip is measured by what someone is willing to sacrifice for it, in terms of money, time, effort, and so forth. Utility is not
necessarily equal to out of pocket cost to the traveler (the present "price" of the trip). The utility of a trip is measured by that point at which a person is indifferent (in terms of money, time, effort and so forth) between making the trip and not making the trip. It is a measure of the deprivation of not making a trip.

16Herbert Mohring, Highway Benefits: An Analytical Framework (Northwestern University Press), p. 79. Pricing policies suggested by Mohring, such as "marginal cost" pricing, are briefly touched upon in the next section.

17Harland, Bartholomew and Associates, Comprehensive Traffic and Transportation Inventory, Memphis/Shelby County Planning Project, p. 33.


20The difficulty is not just in getting out of the downtown since travel speeds are low on almost all roads in the inner area.

21Pittsburgh Area Transportation Study, Vol. 1, p. 69.


23Reduce figures by 25 percent to eliminate transfers and trailers. Memphis/Shelby County Redevelopment Authority, 1967.


25Accident rates per hour, by time of day computed from 1969, Transportation Facts for the Memphis/Shelby County Region.

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Accident Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 midnight - 7 a.m.</td>
<td>440</td>
</tr>
<tr>
<td>7 a.m. - 9 a.m.</td>
<td>360</td>
</tr>
<tr>
<td>9 a.m. - 4 p.m.</td>
<td>240</td>
</tr>
<tr>
<td>4 p.m. - 7 p.m.</td>
<td>1050</td>
</tr>
<tr>
<td>7 p.m. - midnight</td>
<td>730</td>
</tr>
</tbody>
</table>


27Based upon an informal interview and unpublished report, United States Fidelity and Guarantee Insurance Company Mid-South Region.

28Ibid.

29Comprehensive, Traffic and Transportation Inventory, Memphis/Shelby County Planning Project, 1969, p. 33.
30 Ibid.

31 See tables, which reflect total operating costs. Much more detailed information on driving conditions would be necessary in order to prove this assertion.


36 Ibid.


38 Ibid., p. 67.


40 Ibid.

41 Joseph Hyman, "Construction Cost of Urban Expressways," *CATS Research News* (Volume 4, No. 1, December 19, 1960). These were developed from Chicago data. The above figures do not include right of way costs, which were not used by Meyer. Right of way costs are z=$5,850,000 – $5,050,000.


43 Inflation is likely to raise all cost estimates considerably and it is not considered likely that construction costs will rise so much more rapidly than land costs that these differentials would be wiped out.


48 This does not, of course, pay a particular person for his special attachment to a particular piece of property. Psychic attachments, apart from economics, are also quite real; Professor Ralph Gakenheimer Lecture, N. Y. C., 1969.

49 Research Results Digest, National Cooperative Highway Research Program, Digest 3-March 1969, p. 2.

50 California also developed its own program to deal with the problem. According to Stuart L. Hill, Supervising Right of Way Agent, California State Division of Highways, homes in the Watts Area assessed at "fair market value" of $13,000 by appraisers could not be bought anywhere else in the Los Angeles area for less than $18,000 to $22,000. A program of replacement housing will be utilized to overcome the inequity which would have been introduced if fair market value were used.


54 Highways and Economic and Social Changes, 1964, U. S. Bureau of Public Roads, analyzed 100 impact studies. Most impacts were beneficial.

55 Case Study: Route 42 Freeway, unpublished research material, Civil Engineering Department, U.C.L.A., California.

56 Meyer, Kain, and Wohl, op. cit., Chapters 2 and 3.


60 Wilbur Smith and Associates, op. cit., p. 97.
An inferior good is one whose consumption goes down as income goes up. The rich, of course, have ways of making their travel time less onerous, by traveling, for example, in a luxurious car with stereo tape deck and air conditioning, or on a commuter railroad with a bar or opportunities to play bridge.

Models which describe modes by their service characteristics have been developed. The so-called abstract mode model or Baumol-Quandt model is one. Richard E. Quandt and William J. Baumol, "The Demand for Abstract Modes: Theory and Measure," *Journal of Regional Science*, Vol. 6, No. 2 (1966).

Ibid.
THE DISTRIBUTION OF BENEFITS AND COSTS FROM RAPID TRANSIT SYSTEMS
5. The Distribution of Benefits and Costs from Rapid Transit Systems

This chapter sets a framework for analysis of the distribution of benefits and costs from public transportation systems. The major factors felt to be important in defining the distribution of benefits and costs are identified. These include:

A. to whom transit is available;

B. the fare structures and cross subsidies within the system;

C. the manner in which deficits are financed, if fares do not pay for all the costs of the system.

A few examples of existing and future transit systems are analyzed for their distribution of costs and benefits. Most of the figures are drawn from the MTA (Memphis Transportation Authority) operations in the Memphis metropolitan area, and from the San Francisco area's Bay Area Rapid Transit District (BARTD).

5.1 THE DISTRIBUTION OF AVAILABILITY OF TRANSIT

Trips by rapid transit, or by public transportation systems of any kind, are focused on the central business district to a much greater extent than are trips by automobile. Transit systems and transit service are much less present everywhere than are automobile and highway systems. As a practical matter, many more people are actually "captive" to the automobile for their essential trips than are "captive" to mass transportation. "Captive" is the word usually used by highway planners to describe those people who have no car and therefore must travel by public transportation.
The table on the next page comes from the U.S. Census of Transportation and indicates that public transit availability is not very widespread but does seem to be distributed evenly over income groups.


DISTANCE FROM HOME TO AVAILABLE TRANSPORTATION

Percentage of U.S. workers living at distance shown from public transportation, or not having such transportation available:

<table>
<thead>
<tr>
<th>Family Income</th>
<th>Less than 1/4 Mile</th>
<th>1/4 to 1/2 Mile</th>
<th>Over 1/2 to 1 Mile</th>
<th>Over 1 Mile</th>
<th>Public Transit Not Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than $2,000</td>
<td>30</td>
<td>9</td>
<td>2</td>
<td>3</td>
<td>56</td>
</tr>
<tr>
<td>$2,000-3,999</td>
<td>35</td>
<td>11</td>
<td>2</td>
<td>3</td>
<td>49</td>
</tr>
<tr>
<td>$4,000-5,999</td>
<td>39</td>
<td>12</td>
<td>4</td>
<td>4</td>
<td>41</td>
</tr>
<tr>
<td>$6,000-7,499</td>
<td>34</td>
<td>14</td>
<td>5</td>
<td>3</td>
<td>44</td>
</tr>
<tr>
<td>$7,500-9,999</td>
<td>35</td>
<td>15</td>
<td>4</td>
<td>6</td>
<td>40</td>
</tr>
<tr>
<td>$10,000-14,999</td>
<td>32</td>
<td>16</td>
<td>5</td>
<td>9</td>
<td>38</td>
</tr>
<tr>
<td>$15,000 and over</td>
<td>31</td>
<td>17</td>
<td>6</td>
<td>5</td>
<td>41</td>
</tr>
</tbody>
</table>

* 1963 Census of Transportation, *op.cit.*
The conventional wisdom is that public transportation serves the poor in urban areas, and that the well to do make their way by car. This seems to be largely a myth, as studies by Fleisher and Herr\(^2\) and Martin Wohl\(^3\) indicate that transit riders do not tend to be poor, and that poor people make their trips largely by auto, as do those who are better off. Fleisher and Herr defined residence zones in which there was a differing degree of service by public transportation.

Rz 0 or residential zone zero is the inner area of the central city, Rz 1 the locations within twenty eight minutes of the central business district by MTA (Memphis Transportation Authority), Rz 2 all other locations within the MTA system, Rz 3 the locations outside the MTA system where other means of public transport is available, Rz 4 where no public transportation is available, and Rz 5 the outer towns. Rz 1 corresponds very roughly to 2 to 5 miles from the center of the area.

They found the following distribution of household income by percent in each residential zone (Rz).

<table>
<thead>
<tr>
<th>Rz</th>
<th>$0-3,999</th>
<th>$4,000-4,999</th>
<th>$5,000-9,999</th>
<th>$6,000-9,999</th>
<th>Over $10,000</th>
<th>% of Entire Pop. in This Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>29</td>
<td>16.0</td>
<td>11</td>
<td>22</td>
<td>22.0</td>
<td>2.9</td>
</tr>
<tr>
<td>1</td>
<td>29</td>
<td>14.0</td>
<td>16</td>
<td>29</td>
<td>12.0</td>
<td>24.0</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td>10.0</td>
<td>14</td>
<td>37</td>
<td>20.0</td>
<td>16.0</td>
</tr>
<tr>
<td>3</td>
<td>17</td>
<td>9.9</td>
<td>14</td>
<td>40</td>
<td>19.0</td>
<td>40.0</td>
</tr>
<tr>
<td>4</td>
<td>17</td>
<td>9.5</td>
<td>14</td>
<td>40</td>
<td>17.0</td>
<td>8.8</td>
</tr>
<tr>
<td>5</td>
<td>29</td>
<td>14.0</td>
<td>15</td>
<td>32</td>
<td>9.7</td>
<td>8.3</td>
</tr>
</tbody>
</table>

% of entire population in this income group:

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>11.0</td>
<td>14</td>
<td>35</td>
<td>18.0</td>
<td></td>
</tr>
</tbody>
</table>

As can be seen from the table, the poor were certainly more scattered about the urban area than the conventional wisdom would indicate. They
also tended to use automobiles as frequently as possible. Of all the low income workers in the Memphis area in 1963 (defined as those with incomes less than $5,000), fifty five percent commuted as auto drivers, nineteen percent commuted as auto passengers, and only twenty-four percent commuted by public transportation. This was a total of only 37,000 poor workers using public transport to commute.\(^4\)

The distribution of work trips by income is remarkably similar for auto owners. No matter what someone's income, the same percentage of workers (about 76%) commuted by auto if they were auto owners. About thirteen percent of auto owners in all income groups commuted as auto passengers, while only ten percent of workers who owned autos, independent of income group, commuted by public transportation.\(^5\)

As might be expected, non-auto owners had vastly different modal usage for their work trip than did auto owners. However, even among non-auto owners, 36 percent of lower income workers managed to commute by car, and this figure is higher than for non-auto owners of other incomes.\(^6\)

Transit does, however, provide some benefits in terms of making trips available. According to figures prepared by Herr and Fleisher, those non-auto owners who do have transit available (those who reside in zones 0, 1, and 2) do make on the average substantially more trips than those non-auto owners without public transit (who reside in zones 3 and 4) and non-auto owners in the outer cities (zone 5). This seems like a logical result.\(^7\)

National data in Wohl's study tend to collaborate the findings of Fleisher and Herr for Memphis' metropolitan area. The following table gives the national distribution of work trips by mode and income:
DISTRIBUTION OF WORK TRIPS BY MODE

Percentage of Workers in Each Income Group Using the Mode Shown:*

<table>
<thead>
<tr>
<th>Family Income**</th>
<th>Percent</th>
<th>Auto Driver Only</th>
<th>Car Pooler</th>
<th>Public Transit</th>
<th>Other Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than $2,000</td>
<td>(7)</td>
<td>36</td>
<td>36</td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td>$2,000-3,999</td>
<td>(14)</td>
<td>47</td>
<td>29</td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td>$4,999-5,999</td>
<td>(24)</td>
<td>59</td>
<td>23</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>$6,000-7,499</td>
<td>(16)</td>
<td>57</td>
<td>27</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>$7,500-9,999</td>
<td>(16)</td>
<td>63</td>
<td>22</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>$10,000-14,999</td>
<td>(12)</td>
<td>60</td>
<td>24</td>
<td>13</td>
<td>3</td>
</tr>
<tr>
<td>$15,000 and over</td>
<td>(4)</td>
<td>67</td>
<td>25</td>
<td>6</td>
<td>2</td>
</tr>
</tbody>
</table>

* 1963 Census of Transportation, op. cit.
**The percentage of workers falling within each income group are shown in parenthesis; for 7 percent, income was not reported.

While those served by public transportation do tend to be predominantly in core areas, they are not predominantly poor. Neither do the poor in the Memphis area tend to be solely concentrated where there is public transportation. The poor in other metropolitan areas may not tend to be so relatively scattered as those in the Memphis area. Poor blacks may tend to be much less scattered than poor whites. Wohl's article indicated that 60 percent of the poor in metropolitan areas do reside in central cities.8

New York City's poor are not the principal users of the city's subways; most of the passengers have above-average incomes. This was one of the findings of a study of transportation in the city by the Tri-State Regional Planning Commission. Among the other conclusions were the following:

A. There exists no large proportion of commuters by automobile to Manhattan who could be lured to mass transit.
B. Of all vehicles entering Manhattan, excluding buses, private cars constitute only 25 percent.

C. Auto drivers to Manhattan come from families with incomes 50 percent higher than average, so that higher tolls are unlikely to affect their driving patterns.

Nearly 90 percent of all subway riders are city residents, and they have family incomes slightly above average for the city. The other 10 percent of subway riders are almost all middle-income and upper-income suburbanites. "Subways are not primarily the vehicle of the poor; rather the poor of the region simply do not, or cannot, travel extensively." The report did not give specific percentage figures for low-income riders.

Concerning a possible increase in the subway fare, the report asserted: "Current riders can afford, both in terms of money and time, to use the subway if service is good." The commission's investigators found that 80 percent of the 4.3 million riders either start to end their subway trips in Manhattan and that the subways themselves account for 43 percent of all mass-transit.9

**HOW PEOPLE GET TO MANHATTAN EACH DAY**10

<table>
<thead>
<tr>
<th>Mode</th>
<th>Trips</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass Transit</td>
<td>3,269,000</td>
<td>79.0%</td>
</tr>
<tr>
<td>Subway</td>
<td>2,253,000</td>
<td>54.4%</td>
</tr>
<tr>
<td>Commercial Bus</td>
<td>782,000</td>
<td>18.9%</td>
</tr>
<tr>
<td>Railroad</td>
<td>149,000</td>
<td>3.6%</td>
</tr>
<tr>
<td>Other</td>
<td>85,000</td>
<td>2.1%</td>
</tr>
<tr>
<td>Private Transport</td>
<td>870,000</td>
<td>21.0%</td>
</tr>
<tr>
<td>Auto Driver</td>
<td>374,000</td>
<td>9.0%</td>
</tr>
<tr>
<td>Auto Passenger</td>
<td>166,000</td>
<td>4.0%</td>
</tr>
<tr>
<td>Taxi</td>
<td>330,000</td>
<td>8.0%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>4,139,000</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>
5.2 FARE STRUCTURES AND CROSS SUBSIDY WITHIN THE SYSTEM

This is probably the most important factor in influencing the distribution of benefits and costs as it is the most important source of funds for the existing transit system. The different types of fare structures in different transit systems cause very different distributions of impacts.

A flat fare system, regardless of distance traveled, probably makes the least sense in terms of rational economics, and its distributive aspects are more likely regressive, so long as those people making the longest trips are of the highest income. For instance, on the Massachusetts Bay Transportation Authority (MBTA) system in the Boston metropolitan area, most of the rail rapid transit system operates on a flat fare basis, with transfer privileges, and many fairly long bus lines charge the same fee as do shorter lines. On bus lines, if there are no transfer privileges, it is the system configuration which defines the costs of going from one point to another, rather than just the distance between the two points. The New York City transit system operates on a similar flat fare basis, with transfer privileges on the rail lines. Since the subway system in New York City is so extensive the flat fare means that the money cost of very long trips (or those with several transfers) will be relatively low; yet the time costs may be quite significant for long trips by subway, especially if many transfers are necessary.

Express trains tend to make line haul service better and to decrease the per mile time costs of the longer trips. Express buses have similar effects. (It is interesting how many operational variations devoted to
efficiency do so with greatest incidence of benefit to those taking the longest trips.)

Zone fare structures enable benefits and costs to the individual travelers to be more equitably balanced. They also provide a more economically rational pricing structure, since the consumer is closer to paying the cost of what he gets. Zone fare structures could also be used as a policy to redistribute benefits and costs in what is felt to be a socially desirable way.

For a whole transit system, some lines may be more profitable than others, or under present day circumstances, simply lost less money than others. When this happens, there is obviously some redistribution being provided to benefit the less profitable lines.

Some regressive redistributions may occur today. Transit operators may find that their most profitable lines are in high density, lower income areas or in ghettoes, an unsurprising circumstance, since travel demand there is unfulfilled by automobile systems because of the costs of ownership and operation of autos.\textsuperscript{12} The case of "captive"\textsuperscript{13} transit riders, or those who must travel but do not have automobiles, occurs most often in low income areas. Transit operators may have profitable or low loss lines in these areas of high transit demand. But the number of route miles of bus transit systems has not declined in the post war United States, it has increased.\textsuperscript{14} The increase might be seen as a result of extending bus service to outlying areas, in an attempt to regain lost patronage. The consequence of extensions has probably been that not enough patronage has been regained to make up for the costs of extending service into areas of less demand. Some specific instances of this will be cited later.
There may thus be a cross-subsidization within the transit industry, with some people, perhaps lower income people, paying so that unprofitable service may be offered to others, perhaps higher income people. The reasons for this subsidy are political. The transit industry can operate as a regressive form of benefit distribution if fare structures and cross subsidies are structured to do so.

5.3 PUBLIC TRANSIT DEFICITS AND THE RESULTING DISTRIBUTION OF BENEFITS AND COSTS

Most public transit systems in the United States operate at a deficit. Therefore, much of the costs of operating the system comes from tax levies rather than the fare box. Taking the Memphis area as an example, during the 12 month fiscal year ending 1970, total operating revenues for the MTA amounted to 9.8 million, and total expenses to 11 million, leaving after some other deductions, a net deficit of 1.2 million to be paid for by the communities served.

Thus, a substantial proportion of money to run the system came from taxes, and the distribution of benefits and costs from the system is influenced substantially by how the taxes are collected and on whom they are incident.

This is a very difficult problem to analyze, for there are many long-term distributional impacts which result from the existence of concentrations of activity such as a central business district dependent on public transportation. It is possible to set up a framework for analysis and to utilize the data available to answer some questions, but a disclaimer here is appropriate. Only a general model of an urban area can answer such questions.
The central business district is a place of high property values, and it is generally believed, generates more tax dollars than it requires in expenditures for public services. In the conventional wisdom, the central business district, or commercial and industrial properties in general, are thought to be revenue generators for a city. Therefore, maintenance of high property taxes in the central business district is in the financial interest of the residents of the central city. If inner-city residents do pay a public transit subsidy to other inner-city residents or to suburbanites, it may in fact be to the financial advantage of that inner-city resident if the extra taxes received from activity occurring in the central business district are large enough to offset the subsidies. The same argument applies to the provision of automobile access to employment in the central city. If jobs are income generators for a city, then it may even be profitable for the city to subsidize parking, collector and distributor streets (and even line haul facilities) for outsiders.

However, the evidence on tax rates in the Memphis area suggests that no matter by what mechanism local tax bases are being generated, it does not seem to be advantageous to be a central-city resident.

The next page shows the comparative tax rates in 1967 on full value for communities in the Memphis area. It should be kept in mind that many factors contribute to the tax rates of cities like Memphis, including substantial amounts of tax free government properties, swollen bureaucracies and so forth. The table only indicates that the MTA deficit is a significant factor in the tax levy, not that it causes the distribution of tax rates.
<table>
<thead>
<tr>
<th>Location</th>
<th>Rate On Full Value</th>
<th>Due To MTA Deficit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memphis</td>
<td>57.80</td>
<td>9.41</td>
</tr>
<tr>
<td>Frayser</td>
<td>57.80</td>
<td>2.75</td>
</tr>
<tr>
<td>Millington</td>
<td>24.70</td>
<td>4.29</td>
</tr>
<tr>
<td>Raleigh</td>
<td>57.80</td>
<td>3.78</td>
</tr>
<tr>
<td>Bartlett</td>
<td>24.70</td>
<td>1.34</td>
</tr>
<tr>
<td>Arlington</td>
<td>24.70</td>
<td>0.49</td>
</tr>
<tr>
<td>Shelby Farms</td>
<td>57.80</td>
<td>0.08</td>
</tr>
<tr>
<td>Germantown</td>
<td>57.80</td>
<td>5.16</td>
</tr>
<tr>
<td>Collierville</td>
<td>24.70</td>
<td>1.12</td>
</tr>
<tr>
<td>Capleville</td>
<td>24.70</td>
<td>0.86</td>
</tr>
<tr>
<td>Whitehaven</td>
<td>57.80</td>
<td>3.27</td>
</tr>
<tr>
<td>Southhaven, Miss.</td>
<td>22.70</td>
<td>1.86</td>
</tr>
<tr>
<td>West Memphis, Ark.</td>
<td>33.90</td>
<td>2.75</td>
</tr>
</tbody>
</table>

The tax rate on full value is the rate which is most comparable across communities. It depends on many other things besides transit subsidies, though as can be seen, the transit subsidies are a substantial portion of expenditures. It will perhaps be more illustrative of what will happen in the future if newer lines in Memphis or systems are considered, and the subsidies to those lines analyzed.
It seems that some new and proposed transit systems may be providing subsidies to very high income suburbanites traveling to the central city. In Wohl's article, a few examples are given of the subsidy per trip provided on some specific facilities. For instance, Wohl found that downtown destined riders on the Skokie Swift, a new service provided to connect the village of Skokie with the Chicago Transit Authority system, were subsidized to the extent of $0.14 per passenger trip. The median income of the riders was $12,900 per year as compared to a median income for the entire Chicago SMSA of $7,342. Likewise, the Highland Branch of the MBTA in Boston was opened to the western suburbs in 1959, and provided service to riders with a median income of $9,400 (compared with a median income for the SMSA of $6,687), at a net subsidy of $0.16 per passenger trip. Wohl concludes that on the surface, "A perverse income transfer is implied." 

The net subsidy per passenger trip for the entire Bay Area Rapid Transit system in the San Francisco area makes these subsidies look quite minor. Using the original BARTD Composite Report of May 1962, the figures presented by BARTD were that about 81,000,000 riders would use the system annually. Only 56,000,000 of these would be on the actual BARTD system, with the remainder on the San Francisco streetcars which the BARTD system will put in its subway. During the years of 1972 to 1999 when the BARTD system is in operation, the average subsidy per year is somewhat over $50 million. This works out to an average subsidy of about $0.62 for each and every trip on BARTD in those years. About $140 million will be paid out as subsidy to BARTD before a single passenger is served. Even using a small discount factor, this results in an additional subsidy of about $0.10
per passenger trip. BARTD passengers are thus subsidized at the rate of over $.70 per passenger trip. The subsidy is even greater if the BARTD system is analyzed by itself apart from the improvement to the streetcar lines. The subsidy for BARTD trips themselves is somewhat over $.90 per passenger trip. These figures are based on initial BARTD cost estimates, which proved to be very low once actual construction started, so that the actual subsidies are likely to be substantially higher than these calculations estimate.

These figures are, however, in line with some of the subsidies currently provided to commuter railroad patrons, and the BARTD system does have the configuration of a commuter railroad. One could expect similar new systems proposed for other urban areas to have similar subsidies involved.

Most of the subsidy of the BARTD operation will be paid out of local property taxes. The rest will come from toll bridge revenues. Since so much of the expense of the BARTD system is to be borne by taxes on local property, it is desirable to ask what income transfers may occur for that reason.

First those persons living in the suburbs and not commuting to the central city on the BARTD system are paying at least part of the costs of the work trips of other households, since only one third of the money to operate the BARTD system will come out of the fare box. This transfer between suburbanites is quite analogous to the transfer through insurance premiums of those suburbanites not making trips to high accident areas to those suburbanites who do. BARTD estimates the cost to the average household in the average single family house of $27 per year in property taxes.
The tax rate position of the central-city resident who does not use the system is more ambiguous. He may or may not benefit depending upon the tax revenues stimulated in his city by some presumed growth of the central business district, which is apparently what rapid transit is intended to do.

The issue of increased tax base for the central city is not easy to resolve, but a few simple calculations in regard to San Francisco serve to indicate the ranges within which it might be profitable for central-city property owners to subsidize the work trips of suburbanites and thus increase the central-city tax base. The city and county of San Francisco had an assessed valuation of $1,225,167,000, of which 43 percent was the assessed valuations of commercial and industrial properties. Payments from property taxes in San Francisco in 1966 totaled about $141,000,000, of which about $61 million was paid by commercial and industrial properties. There were about 476,000 jobs in the city of San Francisco, so it might be estimated that each job was generating about $128 in tax revenue per year. Assuming that business property taxes are pure profit for the city (the city also collects other taxes on business, of less than half of this amount, so other revenues may cover business costs to the city), then local residential property owners in the city of San Francisco should be willing to subsidize the jobs of commuters at a level of about $128 per year.

If the BARTD system brings 10,000 extra jobs into the city of San Francisco, the gain for residential taxpayers of the city is about $1,300,000 per year. Twenty-five thousand jobs would be worth $3.2 million per year in tax revenues. This is a range of jobs which might be
FOOTNOTES


3 Wohl, op. cit., passim.

4 Ibid., passim.

5 Ibid., Table 5c.

6 Loc. cit.

7 Ibid., Figure 3.

8 Ibid., p. 28.


10 Loc. cit.

11 With some exceptions, such as Far Rockaway, where twice the normal fare is charged. There are no free transfers between bus and subway.

12 Informal interview with officials of the bus company of Houston, Texas, September, 1970.


16 Ibid.

17 Ibid.


SUMMARY AND CONCLUSIONS
6. Summary and Conclusions

1. It is possible to deal more carefully with the distribution of benefits and costs in urban area transportation than has been done in the past.

2. It is desirable to look at the distribution of impacts upon both income groups and political actors.

3. Present travel patterns and system operations, on a daily or yearly basis, inflict some differential benefits and costs.

4. Accessibility and travel opportunities seem to be quite high for persons who have autos available regardless of location, and nearly regardless of income.

5. Auto ownership does depend on income however, and poor people may be unable to afford autos.

6. Average operating speed gives some measure of the level of service provided by transportation itself, though far from perfect. Speeds are higher farther from the center of the urban area.

7. Higher auto insurance costs are inflicted by suburbanities who drive towards the center onto fellow suburbanities who do not and also onto drivers in the central city.

8. New highways can be analyzed for their distribution of benefits using presently available techniques, but it is more appropriate to analyze whole new programs of highways together.

9. Analysis of the economic impacts on relocatees should inclue consideration of the changes housing market, in which housing prices or rents have been forced up by the highway agency.
10. The long term benefits of highway investment may be distributed differently than the short term benefits.

11. Rapid transit systems being presently proposed do not seem to be aimed predominantly at providing transportation service for the poor.

12. Increases in central city tax bases, in San Francisco at least, may not be substantial enough to offset the increases in property taxes in order to subsidize the system.
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