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I am submitting herewith a dissertation written by David P. Middendorf, entitled "An Analysis of the Demand for Bus and Shared-Ride Taxi Service in Two Smaller Urban Areas." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Civil Engineering.

Kenneth W. Heathington

Kenneth W. Heathington, Major Professor

We have read this dissertation
and recommend its acceptance:

James A. Spencer

William L. Grecco

Robert A. McLean

Accepted for the Council:

Hilton A. Smith

Vice Chancellor
Graduate Studies and Research

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AN ANALYSIS OF THE DEMAND FOR BUS AND SHARED-RIDE TAXI SERVICE IN TWO SMALLER URBAN AREAS

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee

David P. Middendorf

June 1975

1228015

TO MY PARENTS

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ABSTRACT

A study was made of the demand for the publicly owned, fixed-route, fixed-schedule bus service and the privately owned, demand-responsive transportation service in two smaller urban areas--Davenport, Iowa, and Hicksville, New York. The demand-responsive transportation systems were innovative taxicab enterprises which, in their manner of operation, resembled many of the current publicly owned dial-a-ride systems; that is, the taxi systems provided on-call, door-to-door public transportation on a shared-ride basis, pooling unrelated trips into the same cab when practicable by deviating the vehicle from the direct route. The objectives of the study were to compare the travel patterns and markets of the bus and shared-ride taxi systems, to compare the travel patterns and markets of the shared-ride taxi system in each study area, to analyze the factors and circumstances underlying the choice of either the bus or the shared-ride taxi, and to measure the public sentiment toward each form of public transportation.

Several sources of data were utilized in the study. Information on the usage of the bus and shared-ride taxi systems was gathered through on-board surveys, mail surveys, and home interviews. Additional information on the characteristics of the demand for shared-ride taxi service was provided by dispatching records and drivers' logs maintained by the two taxicab companies. Finally, the users as well as the non-users of public transportation were interviewed in their homes to determine their attitudes toward each mode of public transportation.

In many respects, the bus and shared-ride taxi systems were

competitive. Both forms of public carriage attracted similar types of people. Except for the movement of masses of commuters during the peak hours, the two modes also performed many of the same functions although not to the same degree. The shared-ride taxis, for example, were particularly useful for trips between widely scattered origins and destinations. The shared-ride taxi system in Hicksville provided an important feeder service to the Long Island Railroad commuter rail network. The bus was usually chosen because of its lower fare by persons who were generally more dependent upon public transportation. The shared-ride cab, on the other hand, was selected for reasons related to its flexibility of movement and door-to-door service by persons with virtually the same socioeconomic characteristics as the bus users. The bus system was generally regarded as the more important mode; however, there was no consensus among nonusers of public transportation that the bus service should be subsidized and publicly owned. On the other hand, it was strongly felt by the public that the financing and provision of taxicab service was strictly the responsibility of private enterprise. Nevertheless, in communities with a population less than at least 100,000 and possibly up to 250,000, local planners and policy makers should consider a shared-ride taxi system or some other variation of a privately owned demand-responsive transportation system as a replacement for fixed-route, fixed-schedule bus service during off-peak periods.

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CHAPTER 1

INTRODUCTION

This report presents the results of a study of the usage of two alternative forms of public transportation--fixed-route, fixed-schedule bus service and demand-responsive transportation service--in two smaller urban communities. The present state of urban public transportation, the expanding role of government at all levels in public transportation, the search for more readily obtainable, less capital-intensive solutions to pressing urban transportation problems--these and other existing circumstances enhance the timeliness of this research and the pertinence of its findings. The purposes of this introductory chapter are to describe these circumstances which underscore the importance of this research and to outline the scope and objectives of the project.

Basis for the Research

Present State of the Urban Mass Transit Industry

Planners, transportation engineers, carrier managers, political leaders, environmentalists, and many mass transit patrons themselves have been viewing the decline of urban public transportation services with mounting concern. The problem has affected urban areas of all sizes (and some rural areas as well), although its precise effects vary from one locality to another, depending on the size of the community, the roles which the local public transportation systems perform, and an assortment of other endemic conditions. The effects of this decline are experienced by both users and nonusers of mass transit systems because of the

complexity of the total transportation system and the intricacy of its relationships with the economic, social, political, and natural systems comprising its environment. A change in the transportation system tends to produce manifold and extensive changes in the latter systems. Since many modes of mass transportation, particularly those which operate on fixed routes and schedules, do not always provide a suitable alternative to the automobile for many trips within an urban area, there is an undesirably high level of dependence on the automobile in both large and small American cities. Thus, while it is true that many urban residents depend upon public transportation as their primary mode of travel, it is also true that many other urban dwellers are totally dependent upon their automobiles for most if not all of their transportation needs. During periods of critical fuel shortages, the latter directly experience the consequences of an inadequate public transportation system.

For several decades the conventional transit industry, defined in this report to include only rail rapid transit, trolley coach, and motor bus systems, has been confronted with a plethora of problems including rising capital and operating costs, deteriorated equipment, inadequate private investment, and antiquated regulations. However, the problem which has compounded the above problems and even created some of them is the insufficient demand for the industry's product. According to statistics compiled by the American Transit Association (ATA), between 1945 and 1973 rail transit ridership plummeted 84 percent and motor bus ridership 53 percent. Similarly, between 1950 and 1973 trolley coach ridership underwent a 94 percent decline, although many of these systems were replaced by motor bus operations. Altogether, in 1973 the total number of passengers carried by the three forms of mass transit combined was only

approximately 29 percent of the corresponding total in 1945 when the resurgence in mass transit ridership during the war years was approaching its peak.

Table 1-1 provides evidence that the problem of decreasing transit ridership is not peculiar to only the systems in large metropolitan areas. In fact, transit systems operating in central cities with a population of 250,000 or less have experienced a relatively greater decline in patronage than their counterparts in the major metropolitan centers. In the smallest urban areas, the large decline in ridership has often culminated in the discontinuance and, consequently, the complete loss of transit service.

The decrease in transit ridership has been accompanied by an increase in operating expenses which have gradually eclipsed operating revenue. Based on the ATA's published statistics, for the transit industry as a whole (that is, for all rail rapid transit, trolley coach, and motor bus systems combined), between 1945 and 1973 operating costs increased by approximately 120 percent, whereas operating revenue advanced by only 30 percent. The ATA's preliminary assessment of the industry's economic condition in 1973 shows that, while transit operations were receiving $1.798 billion from 5.345 billion passengers, their operating expenses totaled $2.362 billion. After $0.116 billion in taxes had been deducted from gross revenue, the industry was operating with a collective deficit of approximately $0.681 billion. The severe financial difficulties encountered by the conventional modes of mass transportation have had an unfortunate consequence; namely, efforts to revive the industry have concentrated in many instances on methods of financing transit systems rather than on an analysis of the changing markets for mass transit

TABLE 1-1

CHANGES IN THE NUMBER OF REVENUE PASSENGERS ON SURFACE TRANSIT LINES BETWEEN 1945 AND 1973 BY POPULATION SIZE

Population Size	Millions of Passengers		Percent Change
	1945	1973[a]	
500,000 and above	6,969	2,406	-65.5
250,000 - 500,000	2,920	689	-76.4
100,000 - 250,000	2,359	230	-90.3
50,000 - 100,000	1,899	176	-90.7
Less than 50,000	932	107	-88.5
Suburban and other	1,348	299	-77.8

SOURCE: American Transit Association, 1973-1974 Transit Fact Book (Washington: American Transit Association), p. 7.

[a]Figures for 1973 are preliminary.

services and the development of innovative public transportation enterprises which meet the needs of the emerging markets.

Transit's ills are the product of the complex interaction of many social, economic, political, technological, and other factors both within and external to the transit industry. Of these factors, the combination of widespread automobile usage and low-density development has had a devastating impact upon transit ridership. Conventional mass transit systems operate most economically and efficiently along densely traveled corridors where large numbers of trips between common origins and destinations can

be pooled into a relatively small number of vehicles. Because the Central Business District (CBD) of a town or city historically produced and attracted considerably more trips than any other subarea, transit routes have tended to be oriented towards this zone and have remained firmly fixed in this orientation since they were originally established. Urban change, however, has occurred in a manner which is indifferent to these rigid transit routes. Since World War II the predominant trend in urban growth and development has been one of decentralization of the urban population. According to the 1970 Census, between 1960 and 1970 over 95 percent of the population growth in metropolitan areas occurred outside the older, more densely developed central cities. New housing developments have been characterized by low population densities because of the preference for detached single-family homes, government policies favoring this type of housing, and, of course, the ubiquitous automobile whose presence enabled widely scattered areas to be developed in the first place. Accompanying this low-density residential expansion has been the scattered development of new factories, office buildings, shopping centers, schools, churches, and recreational centers to serve the surrounding population. The automobile helped to spur this pattern of growth and is well-suited to it; in such an environment, however, scheduled transit services operating on fixed routes have been unable to provide an economical level of service comparable to that of the automobile.

The transit industry has contributed to its own demise by its inability and often displayed unwillingness to adapt to its rapidly changing environment. With few exceptions transit managers have tended to emphasize their <u>product</u> rather than their <u>market</u>. It is not too difficult to understand why an enterprise which often subjects its customers to

such inconveniences as a stringent schedule, waiting while unprotected from adverse weather, uncomfortable physical and psychological conditions, exact fares, poor informational services, uncleanliness, inconvenient transfers, and sometimes unreliable service should be encountering difficulties in attracting new customers much less retaining its present users.

A characteristic of transit management which has contributed much to the industry's problems is the notable lack of innovativeness. In fact, the history of mass transit in the United States is one of opposition to innovation (Eckert and Hilton, 1972; Solomon and Saltzman, 1971, pp. 1.7-1.13, 2.1-2.17); during the second decade of this century, the electric streetcar companies were especially active in causing the legislated demise of jitney operations, and in the early 1920's, many of the same enfranchised street railway firms were also opposed to the introduction of the motor bus. Thus, in the past transit managers often reacted to original approaches to providing common-carrier passenger transportation by acting to regulate the newer concepts out of existence. In addition, as ridership continued to decline, rather than redevelop their service in tune with the changing transportation needs and preferences of urban residents, many in the industry adopted the practice of raising fares and reducing the frequency and extent of their service; in other words, as the demand for their product diminished, management made it even more difficult and inconvenient to use.

The transit industry itself has not been solely to blame for the absence of innovation: the implementation of novel systems and changes in existing systems has often been thwarted by over-regulation of the industry. Either in indifference to or in unawareness of the social,

economic, and technological forces which were inexorably changing urban travel patterns to the detriment of public transit, regulatory agencies and municipalities have continued to apply the set of regulations developed prior to World War I when electric streetcar companies and rapid transit railways were truly prosperous monopolies. Transit enterprises have had to seek public approval in order to change routes, fares, equipment, and service standards. Nevertheless, the transit industry itself has been responsible for many of the ordinances which have served to stifle innovation and constructive change in public transportation.

In summation, the present picture of conventional mass transit is bleak. Many of the institutional obstacles which have consistently hampered the industry have yet to be removed; likewise, most of the social, economic, and technological forces, which have led to the obsolescence of many transit services, continue to operate unabatedly. One consequence of the troubled state of public transit has been the extended involvement of local, state, and Federal government in matters concerning public transportation.

The Expanded Role of Government in Public Transportation

Prior to World War II, public transportation was a matter of public interest primarily to local governments (and, in some cases, state agencies) whose involvement was limited mainly to the regulation of privately owned transit systems. Since the late 1940's, first in the major metropolitan areas and more recently in smaller urbanized areas, municipal governments in increasing numbers have assumed a direct role in the provision of transit services. Table 1-2 shows the extent of public ownership of mass transit systems in 1973. Although only 18 percent of the

TABLE 1-2

THE EXTENT OF PUBLIC OWNERSHIP OF TRANSIT SYSTEMS IN 1973

	Preliminary Estimate	Percent of Industry
Number of systems	185	18
Operating revenue (Millions)	$1,581	88
Vehicle miles operated (Millions)	1,431	78
Revenue passengers (Millions)	4,864	91
Number of employees (Average)	126,000	90
Passenger vehicles	47,508	79
Motor buses	35,732	74
Subway and elevated	9,276	100
Surface railway	1,037	96
Trolley coaches	1,013	100

SOURCE: American Transit Association, 1973-1974 Transit Fact Book (Washington: American Transit Association), p. 3.

systems were publicly owned, these included all subway and elevated rail transit systems and most large motor bus systems. Consequently, the remaining private bus companies tended to be relatively small and operated in smaller central cities and suburban areas.

Public ownership has not always been accompanied by public subsidization. There have been instances in which total reliance was initially placed upon passenger revenue in order to finance the system; for example, in Cleveland and Boston the responsible public entities were

required to "fix fares at a level to keep the system on a self-sustaining basis" (Owen, 1966, pp. 102-110). In most of these cases, however, this policy subsequently had to be abandoned in favor of at least partial subsidization.

More importantly, public ownership has not halted the overall downward trend in transit ridership, nor has it resolved the problems associated with the increasing costs of operation (if anything, public ownership has induced the cost of providing transit service to go higher, particularly in the area of labor). In many cases, public ownership has not even improved the service: all too often the public entity responsible for operating and maintaining the system simply perpetuated the practice of raising fares and making reductions in the extent and quality of the service in a vain effort to meet financial obligations.

Early in the era of public acquisition of transit operations, it became apparent that, in order to maintain adequate levels of service at "reasonable" fares, an external source of funding was needed. The obvious choice for this source was the Federal government. Federal involvement in transportation was well-established in the highway field; in fact, a major argument for federal financial aid to mass transportation was that the Federal government was partially responsible for urban transportation problems by appropriating funds only for freeway development (Hilton, 1974, p. 4). Nevertheless, mass transit was considered by many to be a local issue, and federal assistance in the area was slow to evolve.

The first federal effort to provide aid for local mass transit systems was contained in the Housing Act of 1961 (Smerk, 1972, p. 501; Hilton, 1974, p. 5). This Act provided funds for urban transportation demonstration projects; loans to finance the acquisition, construction,

and improvement of transit facilities; and planning grants for the preparation of comprehensive plans. The $42.5 million appropriated to execute the provisions of this Act were administered by the Housing and Home Finance Agency.

The foundation of present transit aid programs was laid in 1964 with the passage of the Urban Mass Transportation Act. For the first time capital grants were available for the purchase of land, right-of-way, parking facilities, rolling stock, signal equipment, and stations and terminal facilities. These provisions were extended by the Urban Mass Transportation Act of 1966 which provided grants for the planning, engineering, and design of capital improvements. In addition, this Act initiated the management training, research and development, and university research and training programs.

Prior to the creation of the U. S. Department of Transportation (DOT) in October 1966, federal mass transit aid programs were administered by the Housing and Home Finance Agency and, subsequently, by an agency of the U. S. Department of Housing and Urban Development (HUD). There was considerable dissatisfaction with the manner in which these programs were being handled within HUD, but following the establishment of DOT, a controversy arose over whether the programs should be shifted from the older to the newer cabinet-level agency. By 1968 the decision was reached to make the transfer, and consequently, the Urban Mass Transportation Administration (UMTA) was created within DOT (Hilton, 1974, p. 9).

Among the major criticisms of these early federal efforts in mass transportation were the inadequate levels of funding and the absence of a mechanism for long-range financing (Smerk, 1972, p. 502, 507; Hilton,

1974, pp. 9-11). The lack of any long-term commitment in particular was considered by transit spokesmen, urban planners, and local public administrators to be a major deterrent to the formulation and implementation of long-range, capital-intensive mass transit plans. The Public Transportation Assistance Act of 1970 sought to remedy this problem by providing $3.1 billion for capital improvements through 1976 and a proposed total of $12 billion through 1980. These levels of expenditure were still considered to be paltry in terms of apparent needs.

The Federal government's role in mass transportation remained a controversial one as the search for a continuous, adequate funding source continued. A major target of this search was the Highway Trust Fund, established in 1956 to finance the construction of the Interstate system. Following years of intensive lobbying and bitter debate in Congress, transit interests won some important concessions on this issue with the signing of the Federal Aid Highway Act of 1973. Under the bill's provisions, beginning in the fiscal year of 1975, cities were permitted to use up to $200 million of the $800 million allotted to urban areas from the Highway Trust Fund for the purchase of buses, and in the fiscal year of 1976, municipalities would be allowed to spend the entire amount of their $800 million share on capital improvements in their bus and rail transit systems.

Another issue which surrounded federal efforts to aid mass transit involved subsidies for the operation of transit systems. Proponents of federal operating subsidies favored them as a means of holding down the rising transit fares and thereby increasing ridership. Opponents argued that such funds would only be used to brace obsolete, deteriorating transit systems rather than redevelop or improve them. After several

unsuccessful attempts, on November 22, 1974, Congress passed a measure which authorized the use of up to $3.9 billion of the funds provided by the bill for the subsidization of transit operating costs.

In conclusion, the public sector is currently involved in mass transportation through regulation, ownership and management, and subsidization. Unfortunately, expanded public involvement has not contained the problems which have historically confronted the transit industry. Furthermore, federal mass transit programs have tended to sustain the status quo, offering little incentive to transit managers or to public administrators with responsibilities in public transportation to adopt new ideas, concepts, or techniques (Smerk, 1972, pp. 507-510; Hilton, 1974, pp. 97-117). Fortunately, some transportation planners have begun to infuse the principles of marketing and other business concepts into the public transportation planning process, and recent experimentation with several low-cost transportation alternatives has produced some promising results.

The Changing Public Transportation Planning Process

Until recently, in formulating solutions to urban transportation problems, planning efforts tended to focus on the supply of transportation facilities. Having had its roots in highway planning and engineering, the urban transportation planning process initially had as one of its primary functions the determination of the number and types of improvements needed in the street and highway network in order to accommodate the burgeoning automobile traffic. The chief purpose of modal split analysis was to segregate the demand for public transportation from the demand for street and highway facilities in order to obtain a better estimate of the latter.

When it became evident that providing new facilities to accommodate the automobile would never adequately satisfy the total transportation needs of a community and when the impact of urban freeway development on the social, economic, and physical environment began to be felt, transportation planners turned their attention to public transportation and its potential for solving certain critical urban transportation and environmental problems. Most of the early and many contemporary transportation plans, in the tradition of conventional highway planning, have recommended increasing the supply of public transportation facilities through the expansion of existing services and the construction of entirely new systems. There are, however, some very basic differences between highway planning and public transportation planning (Heathington, 1974, pp. 2-14).

A major distinction between highway planning and public transportation planning resides in the fact that a highway is a facility whereas a public transportation system is a product or service. A highway is planned, designed, and evaluated on the basis of sound, established engineering standards and criteria; that is, highway planning is principally an engineering function, although the process receives inputs from numerous other disciplines which are concerned with the many systems in the highway's environment which may be affected by the facility. The highway user is by no means excluded from consideration by the highway planner: the mental, physical, and psychological characteristics of the driver are a major factor in the geometric design of the highway facility, and the trip-making characteristics of the urban populace are a principal consideration in the location and capacity of a facility. Nevertheless, it is not the intent of the highway planner to modify human behavior but rather

to accommodate expected travel behavior. Public transportation, however, is a business, and, as a business, its sole purpose is to satisfy consumers' needs through marketing and innovation (Drucker, 1968, pp. 3-4). Thus, public transportation planning is essentially an entrepreneurial function. Unlike the highway planner, the public transportation planner is very much concerned with modifying human behavior. The former is interested in accommodating automobile users, the latter in attracting customers. From the standpoint of the interaction of supply and demand, a highway is a relatively fixed facility in that the supply of highway space is virtually constant regardless of the demand for it. In contrast, a well-designed public transportation service is a flexible product in that the supply or extent of the service and, indeed, the nature of the service itself can change in consonance with changes in the magnitude and nature of the demand. In view of the considerable length of time required to plan, design, and construct a highway system, highway planning is long-range in its orientation. However, since the markets for public transportation services may change in considerably shorter periods of time, public transportation planning must be more dynamic and sensitive to change. Additionally, unlike highway planning, public transportation planning, to be effective, must be market-oriented; that is, it must start with the wants and needs of a market segment or defined group of consumers and culminate in a service which satisfies these needs and is therefore attractive to individuals in the group. Attracting users is certainly not a consideration in highway planning.

It would be incorrect to state that past and present public transportation planning efforts have ignored the passenger and have instead focused solely on system characteristics such as headways, routes, fleet

size, vehicle capacity, fare structure, etc. However, these planning exercises have tended to be product-oriented rather than consumer or market-oriented. The common procedure has been to design the system first and, based on the characteristics of the system, to then estimate the demand for the resulting service. Normally, no attempt is made to evaluate the proposed system in terms of its ability to meet the special wants and needs of specific submarkets for public transportation; that is, the concept of market stratification is overlooked.

Among some transportation practitioners, there has been a gradual awareness of the need for a new approach to the planning of public transportation services -- a marketing or consumer-oriented approach. This approach requires the planner to identify the transportation needs of each of a large number of market target groups in the urban area and to design a system or several systems to satisfy these needs within the limits imposed by available resources. Cravens and Woodruff have proposed a framework or descriptive model of the public transportation planning process which allows for the infusion of marketing concepts and techniques. The process, as they perceive it, consists of the following six stages (Cravens and Woodruff, 1974, pp. 11-15):

1. Community inventory or audit -- an analysis of the community to identify opportunities and constraints;
2. Description of community goals;
3. Identification of feasible transportation system alternatives;
4. Determination of operational objectives to serve as guidelines and standards for the evaluation and control of existing and new systems;
5. Systems design and testing; and

6. Implementation, evaluation, and control.

It should be noted that the marketing task itself is not a separate stage of the planning process; rather, it spans the entire process, making important contributions at each stage. For example, an important marketing task in the community inventory stage is the analysis of the market environment "to identify and evaluate those factors that will influence the market performance of transportation systems" (Cravens and Woodruff, 1974, p. 15). To assist in establishing community goals, determining operational objectives, and setting priorities, an analysis of market needs and a description of the market segments are essential. Another major marketing task within the proposed framework involves the testing of concepts on selected target groups or market segments in order to provide guidelines for the systems design stage of the process. Finally, market strategy guidelines must be developed, encompassing not only the physical and service characteristics of the system but also the promotion of the service, pricing policies, and management control policies (Cravens and Woodruff, 1974, pp. 14-19).

The Shift Toward Low-Cost Transportation Alternatives

The output of the conventional urban transportation planning process consists of recommended improvements in the local transportation system to be implemented over a period of time which typically spans 20-25 years. Particularly in large metropolitan areas, new transportation facilities, predominantly highways, comprise the major portion of the recommended improvements. However, in addition to the extensive environmental impact, huge capital requirements, and long lead time associated with large-scale, fixed transportation facilities, the mounting public opposition

to new freeway construction in urban areas has induced some transportation researchers and practitioners to devote more attention to the consideration of a wide variety of low-cost methods of improving urban transportation. These low-cost alternatives are being examined especially for their potential for solving more immediate transportation problems and for effecting a more efficient utilization of the existing transportation infrastructure.

Low-cost transportation alternatives may be classified in several ways. Some of these solutions are technological, while others, such as regulations, incentives, pricing or taxing schemes, and policies, are non-technological in nature. The latter may also be subcategorized as being either positive or negative according to whether they attempt to encourage or discourage certain forms of travel behavior. Depending on whether they are used to improve the efficiency of some element of the transportation system or are implemented to reduce the demand or need for transportation, low-cost alternatives may also be either curative or preventive. Among the wide variety of options being studied are various regulations, incentives, and pricing schemes such as peak hour tolls, zone pricing, higher downtown parking fees, and preferred parking for car pools; traffic engineering techniques such as computerized traffic signal networks, freeway surveillance and ramp metering, and bus priority systems; express bus service or exclusive lanes for buses and other multi-occupant vehicles; and para-transit, including rental cars, taxis, dial-a-ride systems, jitney service, car pools, and subscription bus service.

Demand-Responsive Transportation

The low-cost transportation alternative relevant to this research was the concept of demand-responsive transportation. Interestingly,

although demand-responsive transportation services were available to the general public in the United States as early as 1914, it was only a decade ago that transportation researchers began to seriously consider their potential (Kirby et al., 1974, pp. 14-15). Demand-responsive transportation is a nonscheduled service activated by the customer by either hailing the vehicle or telephoning for service. This form of public conveyance is normally associated with the notion of low-capacity vehicles -- automobiles, vans, and mini-buses -- providing on-call, door-to-door service. Depending on the method of operation employed, a passenger or a group of passengers traveling together may either have exclusive use of the vehicle or have to share it with passengers who have different origins and destinations. Examples of demand-responsive transportation systems are dial-a-ride (also commonly known as "dial-a-bus"); exclusive or single-fare taxi; shared-ride taxi; livery, a form of taxi service which accommodates only prearranged trips; and public limousine, a more expensive form of taxi service usually characterized by a large, prestigious automobile.

Demand-responsive transportation appears to be a promising solution to some of the problems confronting conventional modes of transit. As a more personalized form of public conveyance which offers door-to-door service without many of the inconveniences often imposed on the passenger by systems operating on fixed routes and schedules, the concept may be more attractive and marketable to a wide segment of the population than a conventional bus service. In areas with population densities of up to 8000 persons per square mile, a demand-responsive transportation system may be more suitable, attractive, and economical than a fixed-route, fixed-schedule bus system (Roos, 1970, p. 123). Perhaps the most attractive feature of the concept, in addition to its simplicity (from the user's standpoint),

is its flexibility: the system can be used to transport persons from many origins to one destination such as a line-haul transit station as in Bay Ridges, Ontario (Bonsall, 1973) and Haddonfield, New Jersey (Gwynn and Simpson, 1973; Medville, 1973); from many origins to a few destinations such as downtown, shopping centers, schools, and hospitals as in Ann Arbor, Michigan (Urbanik, 1973); and from many origins to many destinations as in Haddonfield, New Jersey (Gwynn and Simpson, 1973; Medville, 1973).

Much of the present knowledge of the economic, operational, and market characteristics of demand-responsive transportation systems has been gained through "laboratory" research: computer simulation, preliminary market analyses, and feasibility studies. Experience with actual operations, although accumulating, is still somewhat limited. In the United States and Canada during the past decade, more than 50 publicly owned and operated versions of demand-responsive transportation have been implemented with varying degrees of success. Among the more extensively evaluated operations are those in Bay Ridges, Ontario; Haddonfield, New Jersey; Ann Arbor, Michigan; and La Habra, California. However, the most common form of demand-responsive transportation, the taxicab, has not received the attention which has been devoted to dial-a-ride systems and to fixed-route, fixed-schedule bus systems. In many communities, buses and taxicabs operate within the same areas, conceivably in competition with each other. A study of such a situation could provide answers to an array of interesting and significant questions concerning the travel patterns and market characteristics of each of the two types of public transportation. The research described in this report took advantage of two such opportunities.

Outline of the Research

Distinctive Features of the Project

The study whose findings are presented in this report was part of a much larger project involving a comprehensive analysis of the markets, economic characteristics, and operation of two privately owned demand-responsive transportation systems, located in Davenport, Iowa, and Hicksville, New York. Several features of the overall project distinguished it from much of the previous research on demand-responsive transportation. First, in addition to being privately owned, the two demand-responsive transportation systems under investigation consisted of taxicab fleets; moreover, in their manner of operation, these taxi systems resembled many of the publicly owned dial-a-bus or dial-a-ride systems. Specifically, the two private firms provided on-call, door-to-door transportation on a shared-ride basis, pooling unrelated trips with different origins and destinations into the same cab when practicable by deviating the cab from the direct route; for this reason, these systems were given the designation "shared-ride taxi." Also in operation in each study area, possibly competing with the shared-ride taxi service for many of the same types of trips, was a conventional, fixed-route, fixed-schedule bus system; the demand for this service was likewise analyzed. Finally, because the shared-ride taxi system in Hicksville had come into existence in 1961 and the one in Davenport in 1967, this study was not a demonstration project. In view of the high costs involved in conducting a sufficient number of full-scale demonstration projects in order to evaluate all aspects of demand-responsive transportation, this feature of the overall project constituted an important advantage. For example, the federally funded

dial-a-ride demonstration project in Haddonfield, New Jersey, was originally designed to cost $1.7 million (Gwynn and Simpson, 1973, p. 38); however, according to UMTA, $4.8 million in federal funds was ultimately expended on the project. The longevity of the shared-ride taxi systems also made it possible to determine the markets and economic viability of two firmly established demand-responsive transportation systems.

Objectives

As part of a much broader study, the scope of the research reported herein was limited to an analysis of the demand aspects of the bus and shared-ride taxi operations in the two study areas. The specific objectives of this research were the following:

1. Determine the characteristics of the demand for and utilization of the fixed-route, fixed-schedule bus and shared-ride taxi systems;
    a. Measure the demand as a function of level of service and pricing scheme;
    b. Analyze the temporal and spatial patterns of bus and shared-ride taxi trips and the purposes for which the trips were made;
    c. Analyze the contribution of each type of public transportation to the mobility of specific segments of the study area population;
    d. Analyze the market for each level of service offered;
    e. Determine the extent of utilization of each system by individual users;

2. Compare the demand characteristics of the shared-ride taxi system in Davenport with those of the shared-ride taxi system in Hicksville;
3. Determine the factors and circumstances which influence the selection of either the bus or the shared-ride taxi as a means of travel;
4. Determine the public sentiment toward the bus and shared-ride taxi systems.

The scope of the overall project also encompassed the organizational, operational, and economic characteristics of the two shared-ride taxi systems. The results of these analyses and additional information regarding the systems under investigation may be found in the following project reports which are also referenced in the Bibliography:

1. A Preliminary Analysis of Two Shared-Ride Taxi Systems, August 1973;
2. An Organizational and Environmental Review of Two Privately Owned Shared-Ride Taxi Systems, October 1974;
3. Economic Characteristics of Privately Owned Shared-Ride Taxi Systems, October 1974.

Synopsis of the Report

Chapters 2, 3, and 4, containing supplementary and explanatory information, lay the groundwork for the remainder of the report, which discusses the results of the analyses performed in this study. Chapter 2 consists of a review of available literature on the characteristics of the demand for taxicab service in the United States. The taxicab industry is compared with the mass transit industry in terms of the supply of and the

demand for their services. Although perhaps not representative of a true cross section of the taxicab industry, the findings of previous research into the characteristics of taxicab usage suggest the roles which taxicab systems perform and the nature of the markets which they serve. In Chapter 3 the two study areas, Davenport, Iowa, and Hicksville, New York, are described along with the bus and shared-ride taxi systems which operate within them. The design of the research and the manner in which it was conducted are discussed in Chapter 4, along with an evaluation of the data collected.

Chapter 5 begins the presentation of the findings of this study. In this chapter the demand for shared-ride taxi service in each study area is examined at a macroanalytic level. The breakdown of the overall demand according to the levels and types of service offered by the shared-ride taxi systems is shown. Also included is an analysis of the extent of group riding (not to be confused with ride-sharing), which has definite advantages for shared-ride taxi users in Davenport.

The performance of the shared-ride taxi systems is evaluated in Chapter 6, including the promptness with which the systems respond to requests for service and the celerity with which shared-ride taxi trips are completed. In the latter area, the duration of shared-ride taxi trips is compared with that of bus trips in the study areas.

Chapters 7 through 10 are concerned with a microanalysis of the demand for bus and shared-ride taxi service. The nature of bus and shared-ride taxi trips is the subject of Chapter 7, including their spatial orientation, their distribution over time, and the purposes for which they are made. Chapters 8, 9, and 10 are focused upon the individual users of

mode are analyzed, and a discriminant model of bus and shared-ride taxi users is developed. Chapter 9 is concerned with the extent to which individuals utilize each type of public transportation, including users' dependence upon each mode and the frequency with which each service is utilized. Finally, in Chapter 10 the factors which influence the selection of either the bus or the shared-ride taxi are analyzed.

Chapters 11 through 14 are directed toward the fourth major objective of the study, which is to measure the public sentiment toward each mode of public transportation under investigation. The preferences of nonusers of public transportation for either the bus or the shared-ride taxi are analyzed in Chapter 11. Chapter 12 discusses users' and nonusers' perceptions of the direction of changes in the quality of each mode's service and the quality of the present service. In Chapter 13 the perceived importance of each mode to various population groups and to the environment of the community is examined. Chapter 14 concludes this portion of the study with a timely analysis of users' and nonusers' attitudes toward alternative methods of financing and providing bus and shared-ride taxi service.

Finally, in Chapter 15 the implications of the major findings of the research are discussed.

CHAPTER 2

A REVIEW OF EXISTING INFORMATION ON THE CHARACTERISTICS OF THE DEMAND FOR TAXICAB SERVICE

A large body of information on the concept of demand-responsive transportation has been accumulated through computer simulation, preliminary market analyses, feasibility studies, and experience with several actual dial-a-ride systems. Since this acquired knowledge has been amply documented in various technical journals, it will not be reproduced here. However, the taxicab, one of the most prevalent forms of intraurban common carriage in the United States, has received relatively little attention both as a subject of research and as a major element of comprehensive transportation plans. Because this research involves an analysis of the demand for taxicab service in two smaller communities, it is appropriate and instructive to examine the somewhat limited available information on the utilization of this mode in other urban areas. The purpose of this chapter is to emphasize the importance of the taxi through a comparison of the taxi and mass transit industries in terms of size, supply, and demand and through a review of previous research on taxicab usage.

Comparison of the Taxi and Mass Transit Industries

The International Taxicab Association (ITA), the national trade association of the fully licensed cab fleet operators, estimates that, in 1970, there were approximately 7200 taxi fleets in operation in more than 3300 communities (Institute for Defense Analyses, 1972, p. 8.5). The

number of fleet operations becomes more significant when compared with the estimated size of the entire transit industry. The fact that 185 publicly owned transit systems constituted only 18 percent of the industry in 1973 (see Table 1-2, page 8) implies that, at that time, there were altogether at least 1028 individual motor bus, rail rapid transit, and trolley coach systems; thus, taxi fleets outnumbered transit systems by a ratio of approximately 7:1. Moreover, to the total number of fleets must be added an unknown quantity of independent owner-operator cab services, thereby enlarging the above ratio. In some suburban areas and smaller urban communities, the taxicab is the only form of public transportation.

Table 2-1 compares several other dimensions of the taxicab and mass transit industries, along with the commuter railroad. In 1970 taxi fleets transported more people than all the rail rapid transit, trolley coach, and commuter railroad systems combined and nearly 60 percent as many passengers as all the bus systems while generating almost $400 million more revenue than the entire mass transit industry and commuter railroads together. Since the table does not include estimates of the number of persons carried by independent owner-operator taxi enterprises or by unlicensed "gypsy" cab operations, the actual level of taxicab patronage had to be much higher than indicated. From the ratio of passenger revenue to revenue passengers, the average taxi fare was 93 cents compared to 28 cents for mass transit as a whole and 83 cents for commuter railroads. While traveling a total of 1.8 times as many revenue miles as all the mass transit vehicles and 2.4 times as many miles as all the buses, taxis carried 0.70 passengers per revenue mile, compared to 2.88 for buses, 3.96 for rail transit vehicles, and 3.88 for trolley coaches, reflecting the fact that the taxi is a more personalized form of public

TABLE 2-1

RELATIVE SIZE AND PERFORMANCE OF THE TAXICAB AND MASS TRANSIT INDUSTRIES, 1970

Mode	Revenue Passengers (Millions)	Passenger Revenue ($ Million)	Revenue Miles Traveled (Millions)	Number of Vehicles (Thousands)
Taxicab (Fleet)	2,378	2,221	3,417	170
Mass transit	5,932	1,639	1,884	62
Bus	4,058	1,194	1,409	50
Rail[a]	1,746	415	441	11
Trolley coach	128	30	33	1
Commuter rail[b]	247	205	c	c

SOURCE: Institute for Defense Analyses, Economic Characteristics of the Urban Public Transportation Industry (Washington: U. S. Government Printing Office, 1972), p. 8.6.

[a]Includes elevated and subway rail rapid transit, grade-separated surface rail, and streetcar operations.

[b]Urban passenger rail service provided by railroad companies.

[c]Not available.

conveyance and, therefore, is not involved in the movement of large aggregations of people in a single vehicle. Finally, Table 2-1 indicates that the number of taxicabs in fleets was 2.7 times the number of mass transit vehicles and 3.4 times the number of buses. From the standpoints of size and patronage, therefore, the taxicab appears to be an important component of the total public transportation system.

Characteristics of Taxicab Usage

Before delving into previous research on taxicab usage, a few comments should be made concerning the location and data base of these other studies. In most cases the sole or principal source of information was the origin-destination survey or travel inventory conducted by the local transportation planning agency as a part of the comprehensive transportation planning process. One exception was a special study of taxicab usage in a small impoverished section of Brooklyn. More importantly, each of the studies cited herein was conducted in a major metropolitan area. Although the findings of these studies were fairly consistent, they may not be indicative of taxicab usage in smaller urban areas such as Davenport, Iowa, and Hicksville, New York. Nevertheless, the results are relevant to this study, since they may serve to disprove some preconceptions regarding the markets for taxicab service and the functions which this mode performs.

One additional caveat should also be given. As the discussion of the distinctive features of this research intimated in Chapter 1, the two taxicab systems under investigation were rather unique in the industry. One may recall that their method of operation involved combining separate fares, very probably with different trip origins and destinations, into the same cab whenever expedient. In many urban areas this practice is either strictly prohibited by ordinance or is permitted only upon the consent of the first passenger. In other communities ride-sharing is precluded by the requirement that a taximeter be used to calculate fares. The shared-ride taxi systems of Davenport and Hicksville are not the only operations of their kind in the United States: the actual number of such

systems has not been pinpointed but appears to be fairly small. More important, however, is the point that the characteristics of the demand for shared-ride taxi service may differ from that of the more conventional single-fare or exclusive cab service. As far as is known, the studies included in this section involved taxicab systems belonging to the latter category of operation.

Taxi Users

Table 2-2 shows that the majority of taxicab users in both Chicago and Pittsburgh were female. In the former metropolitan area, however, a relationship was found between the sex of the passenger and the destination of the trip, implying the existence of several distinct markets for taxi service. Thus, whereas two-thirds of the taxi trips to noncentral destinations were made by women, taxi trips to the Central Business District (CBD) were more frequently made by men.

Taxi users in Chicago were predominantly from the middle age groups: approximately 79 percent of them were at least 30 years old. More than one-fourth of the taxi trips to Chicago's CBD were made by persons in the 35-44 age group (Beimborn, 1968, p. 93). The 1969 study of taxicab usage in the Tri-State area (including New York City) reported similar findings: approximately two-thirds of the users in that region were between 25 and 64 years of age (Institute for Defense Analyses, 1972, p. 8.14).

Only the Chicago study furnished information on the racial characteristics of taxi patrons (Beimborn, 1968, p. 94). In that city, nonwhites made slightly less than ten percent of all cab trips, but as was true with regard to the passenger's sex, the proportion of nonwhites

TABLE 2-2

DISTRIBUTION OF TAXI PASSENGERS BY SEX IN CHICAGO (1956) AND PITTSBURGH (1963)

	Male	Female
Chicago		
Central area destination	52.5%	47.5%
Noncentral destination	32.9	67.1
All trips	41.2	58.8
Pittsburgh	39.0	61.0

SOURCE: Institute for Defense Analyses, Economic Characteristics of the Urban Public Transportation Industry (Washington: U. S. Government Printing Office, 1972), p. 8.13.

varied with the destination of the trip. For trips terminating outside the CBD, approximately 14 percent of the passengers were nonwhite.

Nondrivers constituted a large share of taxicab ridership in Chicago and Pittsburgh. In the former city 45 percent of the taxi trips were made by persons who did not possess a driver's license (Beimborn, 1968, p. 94), while in the latter study area the corresponding proportion was 42 percent (Kirby et al., 1974, p. 165). As Table 2-3 indicates, women were much more likely to be nondrivers. For Chicago, however, the table also shows a sizeable difference in the proportion of male nondrivers taking a cab to central and noncentral destinations, respectively, suggesting that more than one market segment was involved.

The study of taxicab usage in Pittsburgh furnished detailed information on the availability of a private automobile to certain groups of

TABLE 2-3

DISTRIBUTION OF DRIVERS AND NONDRIVERS AMONG TAXI USERS BY SEX IN CHICAGO (1956) AND PITTSBURGH (1963)

	Male		Female	
	Drivers	Nondrivers	Drivers	Nondrivers
Chicago				
Central area destination	80.4%	19.6%	39.5%	60.5%
Noncentral destination	53.8	46.2	22.4	76.6
All trips	68.1	31.9	28.8	71.2
Pittsburgh	51.8	48.2	24.8	75.2

SOURCE: Institute for Defense Analyses, Economic Characteristics of the Urban Public Transportation Industry (Washington: U. S. Government Printing Office, 1972), p. 8.13.

taxi users (Kirby et al., 1974, p. 165). Of the passengers who were over 55 years old, 56 percent had no driver's permit, and likewise, 56 percent were from households which had no car. With respect to nonwhites, 69 percent were without a license, and 85 percent were from autoless households. Finally, 70 percent of the users belonging to households with a total annual income under $7500 were nondrivers, and in 85 percent of these cases, the family did not own an automobile.

The occupations of taxi riders in Chicago, Pittsburgh, and New York City (Tri-State area) are displayed in Table 2-4. Despite the large periods of time between the three studies, the results of each were quite similar. Professional, managerial, clerical, and sales workers constituted

TABLE 2-4

DISTRIBUTION OF TAXICAB PASSENGERS IN CHICAGO, PITTSBURGH, AND TRI-STATE AREA BY OCCUPATIONAL GROUP

Occupational Group	Chicago 1956	Pittsburgh 1963	New York City (Tri-State) 1969
Professional, technical and kindred workers	28.2%	22.5%	26.5%
Managers, officials, and proprietors	20.2	22.3	21.8
Clerical	15.8	a	18.7
Sales	14.4	11.5	15.4
Service workers	9.0	12.5	7.1
Craftsmen, foremen, and kindred workers	3.5	7.5	5.2
Operatives and kindred workers	5.7	0.5	3.4
Private household workers	1.8	3.2	1.0
Laborers	1.3	3.0	0.0
Other	a	17.0	a

SOURCE: Institute for Defense Analyses, Economic Characteristics of the Urban Public Transportation Industry (Washington: U. S. Government Printing Office, 1972), p. 8.12.

[a]Not specified.

between 73 and 82 percent of the employed passengers. The economically inactive, however, also comprised a large market for taxicab service. In Pittsburgh housewives, students, and unemployed, retired, and handicapped persons together accounted for nearly 60 percent of all taxi trips (Institute for Defense Analyses, 1972, p. 8.12). In Chicago 45 percent of all taxi trips and over 54 percent of the taxi trips with destinations in noncentral zones were completed by housewives (Beimborn, 1968, p. 94).

With respect to income, available evidence seems to indicate that taxi service is important to both high-income and low-income groups. In the New York City study area, 45 percent of the taxi riders were from households having an annual income in excess of $10,000, while in Pittsburgh 43 percent of the taxi patrons belonged to households with annual incomes greater than $10,000 (Kirby et al., 1974, p. 162). At the lower end of the income spectrum, however, a study of Boston's taxi ridership discovered that households with annual earnings under $4000 accounted for one-fifth of all cab revenue in that city. A detailed analysis of taxi usage among residents of a poverty area in Brooklyn revealed that 43 percent of the cab trips in that area were made by members of households with incomes under $4000; moreover, almost three-fourths of the taxi users came from households which had no auto. The residents used the taxi primarily for shopping, social-recreation, and personal business trips. One-third of their taxi trips were made within the immediate community (Kirby et al., 1974, p. 166). In conclusion, it appears that, although a large proportion of cab trips are made by persons in the higher income brackets, within low-income areas, the taxi is a useful and frequently utilized mode of transportation.

Trip Purpose

In the Chicago study, the distribution of trip purposes for taxi trips with destinations in the CBD differed from that for trips with destinations outside the CBD, as shown by Table 2-5. The most salient differences were the greater proportion of work trips and the lesser proportion of trips to the passenger's home in the distribution of trips to central destinations. Among the noncentral taxi trips, there were a moderately larger percentage of social-recreation trips and a smaller percentage of business trips.

Table 2-5 also reveals some very interesting differences between the usage of the bus and the taxi in the Chicago area. The buses were used much more extensively for work trips and for school trips. Conversely, the taxis transported more business-related trips and more social-recreation trips than work trips. Although both modes may have performed many similar functions, the bus system's role of moving masses of commuters is clearly depicted in these results.

Relative to trip purpose, the findings of the Tri-State study were generally congruous with those for Chicago (Institute for Defense Analyses, 1972, p. 8.10). Approximately 36 percent of all taxi trips were to the passenger's home, while 24 percent were to his or her place of work. Within Manhattan, the proportions of work trips and residential trips were nearly equal, indicating that, outside this district, the home was the predominant destination. Personal business and social-recreation trips accounted for 17 percent and 12 percent of all taxi trips, respectively; hence, as in Chicago, taxis were used more often for social-recreation and business purposes than for traveling to work.

TABLE 2-5

DISTRIBUTION OF BUS AND TAXI TRIPS BY TRIP PURPOSE IN CHICAGO (1956)

Trip Purpose	Taxi			Bus
	Central Destination	Noncentral Destination	All Trips	
Home	27.9%	52.9%	42.4%	46.5%
Work	23.2	6.4	13.4	23.5
Shop	4.2	2.3	3.1	4.6
School	0.4	1.1	0.8	6.3
Social-recreation	13.6	18.5	16.5	8.4
Meal	7.1	1.6	3.9	0.7
Personal business	23.6	17.2	19.9	10.0

SOURCE: Edward A. Beimborn, "Characteristics of Taxicab Usage," Highway Research Record 250, Transportation Research Board, 1968, p. 86.

Land Use at Trip Ends

In Chicago land use at the origins and destinations of taxi trips was also analyzed. The results are summarized in Table 2-6. A high percentage of the taxi trips taken by residents of Chicago were home-based. Of the nonresidential origins and destinations, service and retail establishments produced and attracted the largest share of taxi trips. The exceptionally low percentage of trips oriented toward manufacturing areas implies that the taxi firms had not tapped the blue-collar worker market to any considerable extent.

TABLE 2-6

DISTRIBUTION OF TAXI PERSON TRIPS BY TYPE OF LAND USE AT ORIGIN AND DESTINATION IN CHICAGO (1956)

Land Use	Origins	Destinations
Residential	50.4%	55.1%
Agriculture, forestry, and fisheries	0.1	0.1
Manufacturing	2.5	2.5
Transportation, communications, and utilities	6.9	3.9
Retail	12.3	10.0
Services	17.1	16.4
Wholesale trade and commerce	1.0	1.4
Public buildings	7.5	8.5
Public open space	2.2	2.1

SOURCE: Edward A. Beimborn, "Characteristics of Taxicab Usage," Highway Research Record 250, Transportation Research Board, 1968, p. 91.

Linkage with Other Modes

The taxicab was used as the primary mode of transportation in 86 percent of all trips involving the use of a cab in Chicago. For trips requiring the use of an additional mode as the major link in the trip, the suburban or commuter railroad was most often involved (Beimborn, 1968, p. 92). In Chicago, therefore, taxis appear to have performed a very minor role as a feeder system to the bus and rail rapid transit systems.

Spatial and Temporal Characteristics

In both the New York City and Chicago metropolitan areas, the density of taxi trip origins and destinations was greatest in the Central Business District but decreased rapidly as radial distance from the center of the city increased. In New York City, the Borough of Manhattan accounted for nearly one-half of all taxi trip ends in the region. Within a circular area of one-half mile radius centered in Manhattan, the density of taxi trip destinations exceeded 40,000 per square mile, and there were five times more taxi trip origins than auto trip origins. Excluding major airports, the density of taxi trip destinations exceeded 5000 per square mile in only a few areas outside a five-mile radius of Manhattan (Kirby et al., 1974, p. 169). Similarly in Chicago, the densities of taxi trip origins and destinations within the 4.5 square mile central area were approximately 9600 and 9400 trips per square mile. In contrast, the density of cab destinations within the ring immediately adjacent to the central area was less than 400 per square mile. Chicago's CBD accounted for 43 percent of all taxi trip origins, 42 percent of all cab destinations, and 58 percent of all cab trips (Beimborn, 1968, p. 86).

One of the most salient characteristics of taxicab movements was the absence of distinct morning and late afternoon peak periods of demand which are common to most other modes of urban transportation; rather, the demand for cab service tended to be fairly uniform during the day, according to observations made in several major cities. In Chicago, the heaviest concentration of demand for taxis occurred during the noon hour (Beimborn, 1968, p. 87), and a similar pattern was observed in Washington, D. C. (Kirby et al., 1974, p. 169). In New York City, a slight peaking of cab trips occurred around 8 a.m. and 5 p.m. in addition to the same minor

peaking around noon noted in Chicago and Washington (Kirby et al., 1974, p. 169). These observations regarding the temporal distribution of taxi trips are consistent with previous findings pertaining to the purposes for which the taxi is used. In general, in major metropolitan areas taxis were utilized less often than other modes for the daily journey to and from work.

Trip Length

In the Chicago and New York City regions, taxi trips tended to be shorter in length than trips made by any other mode, as indicated in Table 2-7. The actual distributions of the length of cab trips were bi-modal since a large number of journeys by taxi were made to destinations (particularly airports) external to the central city.

Summary

In terms of its size and scope of operations, the taxicab industry is an important subsystem of the total urban public transportation system. There are at least seven times as many individual taxicab enterprises as there are mass transit systems in the United States. More significantly, while transporting more passengers annually than all rail rapid transit, trolley coach, and commuter railroad systems combined and over half as many passengers as all intraurban buses, taxis collectively generate more revenue annually than the entire mass transit industry including commuter railroads.

In several major northeastern and midwestern metropolitan areas, taxis were found to attract a diversity of submarkets. In addition to wealthier residents and male white-collar workers, who utilize the taxi

TABLE 2-7

AVERAGE TRIP LENGTHS IN AIRLINE MILES FOR SEVERAL MODES IN CHICAGO (1956) AND TRI-STATE AREA (1969)

Mode	Average Trip Length (Airline Miles)	
	Chicago	Tri-State
Taxicab	2.9	2.1
Bus	3.6	2.5
Auto -- driver	3.5	3.9[a]
Auto -- passenger	3.9	b
Subway-elevated	7.2	5.8
Commuter railroad	13.3	b

SOURCES: Edward A. Beimborn, "Characteristics of Taxicab Usage," Highway Research Record 250, Transportation Research Board, 1968, p. 89; Ronald F. Kirby et al., Para-Transit: Neglected Options for Urban Mobility (Washington: U. S. Department of Transportation, 1974), p. 172.

[a]Average trip length for all auto trips

[b]Not specified.

for work and business-related trips to and within the Central Business District, the taxis also served large numbers of housewives and other economically inactive individuals and, in economically depressed areas, low-income persons. To residents without a driver's license or from households which owned no automobile, the taxi was also a useful means of transportation.

Taxis were engaged more often for short social-recreation and personal business trips than for the daily journey to work. Consequently,

the demand for taxi service was fairly uniform during the day in several major cities. This latter characteristic is an extremely important one in view of the fact that, whereas many mass transit systems in major metropolitan areas are often overcrowded during peak periods, they have been unable to attract an economical level of ridership during the off-peak periods.

Although information on the characteristics of taxicab usage is limited and is biased toward a few of the older, large metropolitan areas, the findings of previous research indicate the attractiveness and versatility of the taxi mode. Furthermore, the results of these studies intimate that the taxi may be more suitable than the bus for many trips during the off-peak periods.

CHAPTER 3

DESCRIPTION OF THE STUDY AREAS AND THEIR BUS AND SHARED-RIDE TAXI SYSTEMS

In this chapter some of the distinctive characteristics of the two study areas are pointed out, and a sketch of the bus and shared-ride taxi systems under investigation is presented. Davenport, Iowa, and Hicksville, New York, were chosen as sites for this study not because they appeared to be representative of a large number of American cities of similar size and character; rather, they were selected because of the unique taxi systems which operate within them. Nevertheless, due to the smaller size and population of these two communities, the results and conclusions of this research are likely to be more widely applicable than the findings reported in the previous chapter for several of the nation's largest metropolitan areas.

The Study Areas

Davenport, Iowa, is one in a cluster of four incorporated communities collectively known as the Quad Cities, a metropolitan area embracing a population of approximately 300,000. With a 1970 population of nearly 98,500, almost 11 percent more than in 1960, Davenport itself is the largest of the four communities. Situated along the Mississippi River, this municipality and its neighbors constitute an important midwestern trade and industrial center.

Located within Nassau County on Long Island, Hicksville is an unincorporated community whose boundaries define a taxing district for fire

protection, water, parks, schools, and libraries. With a 1970 population of 48,100, not only is Hicksville the smaller of the two study areas, but during the period from 1960 to 1970, it experienced a 4.6 percent decrease in population. Although it, too, is the site for a large number of diverse industries, this community is a major transportation hub with one of the most heavily used commuter railroad stations in the Long Island Railroad network located near its center.

The composition of Davenport's population differed moderately from that of Hicksville's in certain respects. These differences are worth mentioning since the socioeconomic characteristics involved are often linked to the demand for public transportation. Relative to age, Davenport contained a higher percentage of elderly citizens: in 1970, 10.6 percent of Davenport's residents were over 64 years of age, while only 5.6 percent of the inhabitants of Hicksville were in this age group. Another distinguishing characteristic was household income, which tended to be higher in Hicksville. According to the 1970 Census, the median family income was $13,900 in Hicksville and $10,400 in Davenport. Whereas 42.1 percent of the households in Hicksville had annual earnings exceeding $15,000, only 21.5 percent of the families in Davenport had surpassed this level. At the opposite end of the income scale, 7.4 percent of Davenport's households, but only 2.4 percent of Hicksville's, had incomes below the poverty level. The higher household incomes in Hicksville were reflected in the greater percentage of multi-car families in that community; thus, 54.7 percent of the households in Hicksville had at least two automobiles, compared to only 37.2 percent in Davenport. In the latter community, 15.2 percent of the households had no automobile, while in Hicksville the proportion of autoless families was only 4.6 percent. Determining the extent

to which these differences in the characteristics of the study area populations are reflected in the composition of the markets for each shared-ride taxi system was one of the major objectives of this study.

Traffic Zones

In order to analyze the spatial dispersion of bus and shared-ride taxi trips, both study areas were partitioned into zones. In Davenport these zones consisted of the traffic zones which had been established previously for land use and transportation planning purposes. A network of traffic zones had not been delineated in the Hicksville area; consequently, trip origins and destinations in that community were coded by census tract. Altogether, a total of 110 zones in Davenport and 85 census tracts in Hicksville were identified.

In both Davenport and Hicksville, the area subdivided into zones had to be expanded to coincide with each shared-ride taxi system's service area, which extended beyond the boundaries of the principal community. Thus, in Davenport the zoned area also included the small neighboring community of Bettendorf, Iowa. Likewise, in Hicksville the actual study area encompassed several of the surrounding small villages from which requests for shared-ride taxi service were frequently received.

Public Transportation in Davenport and Hicksville

Bus Service

Davenport. The publicly owned and operated bus system in Davenport exemplified the same characteristics which typify many intraurban bus systems throughout the United States. Using vehicles with seating capacities ranging between 32 and 36 passengers, the system operated on

half-hour headways along six established routes which converged in the downtown area. The level of service offered on Saturdays had been slightly lowered; Sunday service had been completely curtailed. For the use of this mode, a fare of 30 cents was charged all passengers except senior citizens, to whom a fare of 15 cents was applied.

Prior to the commencement of this study in 1973, bus service in Davenport was provided by a private company. The system, however, had not been immune to the same ruinous problems of rising costs and declining patronage which have plagued much of the transit industry. By 1970 the private bus service was operating with a sizeable deficit, and in 1972 the buses transported only 30 percent of the number of passengers carried in 1960. Typically, the management's response to the spiraling decline in ridership was to reduce the level of service, which resulted in a huge loss of revenue.

Because of the severity of the private firm's financial difficulties, the City of Davenport began subsidizing the operation in 1969 at a maximum tax rate of two mills. In that same year, the Davenport City Transit Authority was created. One of the first actions of the Authority was to request a technical study of public transportation in the Quad Cities area. As a consequence of this study, the Authority prepared an application for a capital grant from UMTA to aid in the acquisition of the assets of the private bus company and the purchase of new buses and radio equipment. Subsequent to the approval of the grant application, the public assumed complete control of the bus service in Davenport.

Hicksville. In Hicksville there existed no strictly local bus service circulating solely within the community. At the commencement of this study, ten private companies provided bus transportation along 67

routes connecting various activity centers in Nassau County. Of the ten routes serving portions of Hicksville, most converged at the regional shopping center located near the center of the community and provided access to the commuter railroad station. Levels of service on these routes varied considerably with rush hour headways ranging between 15 and 70 minutes and non-rush hour headways ranging between 20 minutes and two hours. Depending on which route and which company's service was used, the base fare varied from 20 cents to 40 cents. Because of the orientation of the routes and the lack of coordination between each company's schedule, trips between many origin-destination pairs within Hicksville had to have been difficult to make by bus.

The privately owned bus operations in Nassau County also experienced the common problems of rising costs and diminishing demand. Although revenue had increased over the long run, expenses had mounted more steadily and steeply; consequently, since 1968, the bus companies as a group were operating at a deficit. Between 1964 and 1971, the privately owned transit systems collectively had lost one-third of their ridership and had reduced their total revenue mileage by one-fourth. While data was being collected for this study, the Metropolitan Suburban Bus Authority purchased the ten private firms and began implementing plans to consolidate, coordinate, and improve the bus service in the county.

Shared-Ride Taxi Service

The following is intended as background material to provide only a brief sketch of the two shared-ride taxi systems. Additional information on each system's organizational structure, labor-management relations, market strategy, method of operation, and regulatory environment can be

found in the project report An Organizational and Environmental Review of Two Privately Owned Shared-Ride Taxi Systems. Another report, Economic Characteristics of Privately Owned Shared-Ride Taxi Systems, contains detailed information on the economic aspects of the two systems, including costs, revenue, and productivity.

Both shared-ride taxi systems operated in a similar fashion. For each telephoned request for service, the origin and destination of the trip, the number of passengers involved, and the time of the request were recorded by the company's telephone operator and transmitted to the dispatcher. In assigning cabs to specific requests for service, the dispatchers attempted to pool separate trips into the same vehicle, provided that such a maneuver did not unduly inconvenience the customers already in the vehicle. Accordingly, cabs were seldom diverted more than four blocks from the direct route in order to serve additional passengers, and never was an occupied vehicle assigned to an additional trip which necessitated backtracking in order to be accommodated. The "shared-ride" mode of operation described above constituted the standard level of service. For those customers who preferred not to share a cab with other users, each taxi system offered a direct origin-to-destination exclusive cab service, the level of service conventionally provided by other cab systems, for a considerably higher fare and only upon request.

In several important respects, the two shared-ride taxi systems differed from each other. The Davenport firm, for example, maintained a smaller fleet--approximately 20 Checker cabs, compared to approximately 30 Dodge passenger cars in Hicksville--to cover a much larger service area. Although the fare schedule in each community was based on a network of zones (distinct from the set of zones used for coding trip origins

and destinations), the Davenport system's fares were considerably lower. For the shared-ride level of service, the base fare in Davenport was 75 cents with an incremental charge of 25 cents per zone, whereas in Hicksville the minimum fare for shared-ride service was $1.00 with an additive charge of 50 cents per mile. This disparity in the fare levels reflected the distinctive market strategy of each firm. The management of the shared-ride taxi system in Davenport was more concerned with increasing its share of the market and maintaining high volumes through relatively low fares. In Hicksville the adopted strategy involved levying higher rates and carefully controlling the fleet size in order to maintain a wide profit margin. The above differences, which are discussed more fully in the other reports, are mentioned here in view of their possible effects on the level of performance and the market composition of each system.

CHAPTER 4

STUDY DESIGN

Because of the paucity of basic data on taxicab usage in small and medium-sized urban areas, the overall goal of this study was to conduct as comprehensive an analysis of the demand for shared-ride taxi service in Davenport and Hicksville as possible under the time and budgetary constraints imposed upon the project. Such a broad scope necessitated collecting a wide assortment of data to fulfill the diverse objectives of the research. Moreover, a variety of data collecting instruments had to be designed and several methods of obtaining the needed information had to be employed to meet specific requirements for data. These aspects of the project are the topics for discussion in this chapter, which also includes an evaluation of the several samples of data collected.

Data Requirements and Sources

Because of their breadth, the first two objectives of this study dictated the need for a large array of varied items of information. One major requirement was to obtain data suitable for answering the question of how much each level of service is used. In addition to ridership totals, which indicate the magnitude of the demand for each level of service or mode, information which measures the extent to which each mode is patronized by individual users was also needed. The latter requirement ultimately reveals the relative importance of the bus and shared-ride taxi as a primary and as an

auxiliary mode of transportation.

The first two objectives also necessitated collecting data which serve to characterize the demand for the bus and the shared-ride taxi. Essentially, such information had to address the questions of who uses each mode and how is each mode used. To determine the relative size of various markets for bus and shared-ride taxi service, a variety of personal data had to be gathered for individual passengers, including age, sex, physical handicap, employment status, household income, number of automobiles available to household members, possession of a driver's license, etc. User characteristics, however, are not the only factors which identify each mode's markets and functions. Equally important are the characteristics of the bus or taxi trip such as its purpose, its spatial orientation (to or from the community's center, or between noncentral points), and the time at which it is made (peak or off-peak period). Using items of data pertaining to the characteristics of individual trips and individual passengers, the ultimate aim was to develop a statistical model which would either accurately discriminate the markets for each mode or, more fundamentally, indicate the degree to which these markets can be discriminated.

Another data requirement, related to the third objective, involved gathering information which would aid in establishing the basis for the choice of mode of public transportation. The most difficult tasks associated with this requirement were identifying all of the factors which might influence an individual to select either the bus or the shared-ride taxi over its alternate and designing a device by which the relative importance of these factors could be measured. Trip and user characteristics can provide some useful clues toward a

better understanding of the modal choice process; however, the actual reasons for initially selecting the bus or the shared-ride taxi and for persistently using it were considered more requisite. Moreover, in view of the sharp decline in bus ridership and the simultaneous increase in taxi ridership that has occurred in Davenport, information was needed to determine the extent to which bus users had switched to the shared-ride taxi and the basis for the switch.

A final general requirement, imposed by the study's fourth objective, involved obtaining data of an attitudinal nature. Specifically, there existed a need to quantify the attitudes, preconceptions, and preferences of not only bus and shared-ride taxi users but nonusers of public transportation as well relative to several aspects of bus and shared-ride taxi service. These aspects included the direction of recent changes in the quality of each mode's service, the present quality of service, the importance of the bus and the shared-ride taxi to various segments of the population and to the economic and physical environment of the community, and the acceptability of alternative methods of financing and providing bus and shared-ride taxi service.

Because of the nature of the required data, the most appropriate sources for much of it were the bus and taxi users themselves. Three devices were utilized for interrogating the public transportation users in each study area -- on-board surveys, mail surveys, and home interviews. For additional data on shared-ride taxi usage, other major sources were the dispatching tickets and the drivers' logs kept by the cab companies. The following section will describe the forms which were employed to gather the necessary information from these sources. Finally, the 1970 Census of Population and Housing and the

local planning agencies and transit authorities were secondary, but nonetheless important, sources of data.

The Instruments for Data Collection

Customer and Vehicle Data Records

The dispatch tickets and drivers' logs maintained by the shared-ride taxi companies were valuable sources for an abundance of data on the daily operations of the shared-ride taxi systems. Two data collection forms, designated the Customer Data Record and the Vehicle Data Record, were designed to record the information contained on these company records. A Customer Data Record, a copy of which is shown in Appendix A, was completed for each request for taxi service, including requests for goods item pickup and delivery. Among the data items contained on this form were the following: the time at which the request for service was made, the time at which a cab was dispatched to handle the request, the origin and destination of the trip, the cab's arrival time at the origin and the destination, the number of passengers involved, the level of service requested (shared-ride or exclusive taxi), and the fare. The file of Customer Data Records enabled a variety of analyses to be performed including a determination of the daily fluctuation of the demand, the magnitude of the demand for shared-ride and exclusive cab service, the spatial and temporal patterns of taxi trips, the distribution of fares, and the quality of the service in terms of wait times and travel times. On the Vehicle Data Record, shown in Appendix B, operating statistics for each combination of vehicle and driver were summarized, including the number of hours the vehicle was in operation, the number of miles

traveled during the driver's shift, and the total receipts for both passenger and goods movements. Both forms were useful not only to the study described in this report but to the economic study as well.

Passenger Survey Questionnaires

A dual questionnaire, consisting of a form to be completed while traveling in the bus or the cab and a form to be completed later and returned by mail, was developed to survey bus and shared-ride taxi users, with a separate questionnaire having been designed for each group. Appendices C and D contain copies of the questionnaire distributed to bus passengers and taxi passengers, respectively, in Hicksville (Nassau County). Except for references to the commuter railroad in Question 1 of the mail survey form, the questionnaires distributed in Davenport were identical.

The on-board survey forms were designed to gather information about the characteristics of the bus and shared-ride taxi users and the trips which they make via these two modes. Basically, this information was used to perform many of the analyses prescribed by the first two objectives of this research. From the data collected by these forms, a discriminant model of the demand for bus and shared-ride taxi service in each study area was developed, tested, and interpreted.

The mail survey forms were also employed to secure information pertinent to the first two objectives of the study. Question 1, a table of all trips taken during the previous week by mode and by trip purpose, measured the intensity of bus and shared-ride taxi usage. From this tabulation of trips, it was possible to test hypotheses on the degree to which bus and shared-ride taxi users were dependent

upon their respective modes, the frequency with which each mode of public transportation was used, and the relative propensity of persons in each group to travel. Ultimately, the responses to this question determined the nature of the role of the bus and shared-ride taxi systems as primary and auxiliary modes of transportation.

The remainder of the second portion of the bus and taxi passenger questionnaires was directed toward the third objective of the study, an inquiry into the factors underlying the observed travel patterns and market characteristics. Responses to questions 3 through 6 of both questionnaires, question 7 of the bus questionnaire, and question 9 of the taxi questionnaire established the time at which the individual user began to utilize the bus or the shared-ride taxi and the conditions and reasons which formed the basis for the initial decision. In question 9 of the bus survey form and question 10 of the taxi survey form, respondents indicated their reasons for preferring the bus or the shared-ride taxi over its alternate. The intent of these questions was to determine the extent to which such factors as cost, proximity of the service, perceived safety, comfort, speed of service, and ease of carrying packages influence the choice of mode of public transportation. Many of the choices enumerated in these questions were gleaned from bus and taxi users during extemporaneous interviews and pretests of earlier drafts of the questionnaires. For those cases in which the respondent used both modes, question 11 of the bus questionnaire elicited the circumstances or occasions under which the taxi was chosen instead of the bus.

The fact that annual ridership on the shared-ride taxi system in Davenport had been increasing while, simultaneously, bus ridership

had been declining prompted the inclusion of items into the taxi questionnaire which would aid in determining the impact of the improved taxi service upon usage of the bus system. In question 7, taxi users indicated whether or not they had been regular customers of the bus service prior to using the taxi. In addition, question 9, listing alternative reasons for starting to use the taxi, contained items which imply dissatisfaction with the bus service or which denote circumstances resulting in the bus system's becoming inconvenient or otherwise undesirable as a mode of transportation.

Household Survey Questionnaire

A copy of the questionnaire administered in the homes of selected residents of Hicksville is included as Appendix E. Except for references to the commuter railroad in Question 1, the questionnaire used in Davenport was identical.

The household survey questionnaire was designed to cover all four objectives of the study. Questions 1 through 4 were essentially the same as some of those appearing on the mail survey forms, although questions 1 and 4 were also intended for the nonusers of public transportation. The remainder of the questionnaire was directed toward the fourth research objective. Employing the technique of semantic differentials, questions 5 and 6 measured users' and nonusers' perceptions of the direction of changes in the quality of the bus and shared-ride taxi services over a five-year period. In questions 7 and 8, the respondents expressed their general opinions of the present quality of the bus and shared-ride taxi systems. Questions 9 through 14 quantified the perceived importance of both modes of public transportation to various population groups and to the community in

general. By means of the method of pair comparisons, the responses to question 15 were used to ascertain the priorities which users' and nonusers' attached to public transportation and other areas of public investment for additional tax support. Finally, questions 16 and 17 employed Likert scales to measure attitudes toward alternative methods of financing and providing bus and shared-ride taxi service.

Administration of the Data Collecting Instruments

Customer and Vehicle Data Records

On preselected dates, listed in Table 4-1, data contained on dispatch tickets and drivers' logs were coded onto the Customer Data Records and the Vehicle Data Records by cab company personnel. Although complete information on each trip was not always obtainable, an almost 100 percent sample of taxi trips made during the 24-hour period was collected for each day. An effort was made to procure the data on a schedule of once every eight days in Davenport and once every fifteen days in Hicksville. As indicated in Table 4-1, between April 1973 and January 1974, information on the operation of the shared-ride taxi systems was collected for 20 days in Davenport and 17 days in Hicksville.

Passenger Surveys

Prior to conducting the actual surveys, both the bus and the taxi passenger questionnaires were pretested. The latter form was pretested by distributing approximately 100 questionnaires to shared-ride taxi users in Davenport and examining the completed forms returned

TABLE 4-1

DATES OF DATA COLLECTION ON SHARED-RIDE TAXI OPERATIONS

Davenport		Hicksville	
Day of Week	Date	Day of Week	Date
Tuesday	April 10, 1973	Wednesday	April 18, 1973
Wednesday	April 18, 1973	Thursday	May 3, 1973
Thursday	April 26, 1973	Friday	May 18, 1973
Friday	May 4, 1973	Saturday	June 2, 1973
Saturday	May 12, 1973	Wednesday	June 20, 1973
Sunday	May 20, 1973	Sunday	July 8, 1973
Thursday	June 28, 1973	Monday	July 30, 1973
Monday	August 27, 1973	Tuesday	August 21, 1973
Tuesday	September 11, 1973	Wednesday	September 5, 1973
Wednesday	September 19, 1973	Thursday	September 20, 1973
Thursday	September 27, 1973	Friday	October 5, 1973
Saturday	October 6, 1973	Saturday	October 20, 1973
Sunday	October 14, 1973	Tuesday	November 8, 1973
Tuesday	October 23, 1973	Sunday	November 25, 1973
Wednesday	October 31, 1973	Tuesday	December 11, 1973
Thursday	November 8, 1973	Thursday	January 3, 1974
Saturday	November 17, 1973	Friday	January 18, 1974
Friday	November 23, 1973		
Sunday	December 16, 1973		
Monday	December 24, 1973		

by mail. The pretest of the bus survey form was conducted in Knoxville, Tennessee, by personally administering the questionnaire to a small sample of bus riders. As previously mentioned, some additional input into the design of these questionnaires was gained through extemporaneous interviews with several shared-ride taxi users in Davenport.

Two surveys of bus and shared-ride taxi passengers were conducted in each study area. On June 28 and October 23, 1973, in Davenport and on June 20 and November 8, 1973, in Hicksville, bus and shared-ride taxi passengers, upon entering a bus or taxi, were given a dual questionnaire by the driver. The top sheet of the survey form was completed while traveling in the bus or cab and submitted to the driver upon leaving the vehicle. The remainder of the questionnaire was to be completed at the respondents' earliest convenience and forwarded by mail. Since the bus system in Hicksville actually served all of Nassau County, a cordon line was established around the study area, and only passengers boarding the buses within the bounded area received a questionnaire. Due to budgetary constraints, it was not possible to station interviewers in the buses and taxis to assist passengers in completing the on-board portion of the survey form.

In Davenport, off-duty bus drivers were employed to monitor the bus passenger surveys to insure that each bus was supplied with an adequate quantity of questionnaires, and to collect the completed survey forms. In Hicksville, the bus passenger surveys were supervised by the Metropolitan Suburban Bus Authority. The taxi passenger surveys were monitored by the two cab companies.

Home Interviews

In each study area, the goal of the household survey, begun in December 1973 and completed in April 1974, was to conduct interviews in approximately 500 homes, using a stratified sample comprised of 125 bus users, 125 taxi users, and 250 nonusers of public transportation. Households belonging to the last of these categories were selected at random from city directories. The samples of taxi users were generated by randomly selecting dispatch tickets and noting the address of the trip origin or destination, depending on which trip end was the passenger's home. The bus users were screened from telephone calls to residents randomly selected from the city directories.

The household survey in Davenport was initially monitored by the cab company's management, who hired local citizens to conduct the interviews. The supervisory function was ultimately transferred to the local branch of a large market research firm in an effort to expedite the survey. In Hicksville, members of a private group conducted the survey, supervised by two field coordinators.

A program to adequately inform the public about the survey was implemented in each study area. Local police departments and elected officials were contacted and provided with information concerning the survey to enable them to respond to queries from citizens, particularly those selected to be interviewed. In an effort to generate pre-survey publicity and to inform residents of the nature and purposes of the survey, a session was held before members of the local news media. Finally, a pre-interview letter was sent to the households chosen for the interviews, requesting the cooperation of household members.

The home interview questionnaire was pretested by administering

it to a small sample of residents of Knoxville. After the questionnaire had been satisfactorily revised, intensive training seminars were scheduled in each study area at which the interviewers were instructed on the correct procedure for conducting the interviews. Each household member at least 16 years of age was to be given a questionnaire to complete with the assistance of the interviewer. Before leaving the home, the interviewer was required to inspect each completed questionnaire to insure that it had been filled out properly and to rectify any inconsistencies.

Despite the pre-survey publicity, the pre-interview letter, and other precautions, many citizens refused to permit an interviewer to enter the home, particularly in Hicksville. Initially, these interviews were simply cancelled, but it soon became apparent that modifications to the survey procedure were required in order to complete the surveys in a reasonable period of time and obtain an acceptable sample size. Consequently, in the event of a refusal, the interviewers were instructed to leave a sufficient number of questionnaires at the home and to return at a later date to collect the completed forms. Any inconsistencies, improperly supplied responses, and missing data were to be corrected by calling the household and finishing the interview over the phone.

Evaluation of the Survey Samples

Passenger Surveys

Table 4-2 displays the number of respondents in each of the passenger surveys. In both study areas, shared-ride taxi users as a group were less responsive to each survey than the bus users. In

TABLE 4-2

NUMBER OF RESPONDENTS IN THE PASSENGER SURVEYS

	Davenport		Hicksville	
	On-Board Survey	Mail Survey	On-Board Survey	Mail Survey
First survey				
Bus	683	409	531	276
Shared-ride taxi	268	100	180	37
Total	951	509	711	313
Second survey				
Bus	555	314	748	328
Shared-ride taxi	180	43	50	18
Total	735	357	798	346

Davenport, for example, the ratio of bus respondents to taxi respondents was 2.5:1 for the first on-board survey and 3.1:1 for the second; in comparison, the ratio of daily bus ridership to daily shared-ride taxi ridership varied between 1.8:1 and 2.3:1. For the mail surveys in Davenport, the disparity in the degree of responsiveness of each group was even more pronounced: the ratio of bus respondents to taxi respondents was 4.1:1 for the first survey and 7.6:1 for the second. The greater disinclination of shared-ride taxi passengers to participate in such a survey while traveling in the cab may be an indication that these individuals place a higher value upon their time and privacy; that

is, taxi users may be less willing than bus users to tolerate intrusions upon their time and privacy while making short and relatively fast trips by public transportation.

Patrons of the shared-ride taxi service in Hicksville were less inclined to complete the questionnaires than their counterparts in Davenport. Whereas the Davenport shared-ride taxi system transported approximately 45 percent more passengers than the Hicksville system on the dates of corresponding surveys, the number of taxi users responding to the on-board surveys in Davenport exceeded that in Hicksville by 48 percent for the first survey and 260 percent for the second. Likewise, in each mail survey, over twice as many completed questionnaires were received from taxi users in Davenport.

Since the actual number of bus trips made within the cordoned area encompassing Hicksville was not known, the proportion of the total trips represented by the on-board survey samples could not be estimated. In Davenport, however, the two samples of bus trips represented approximately 26 and 21 percent, respectively, of the estimated average total trips per weekday made on the bus system. As indicated in Table 4-3 for both on-board surveys in Davenport and for the second in Hicksville, a large majority of the sampled bus trips occurred during the morning. This was very likely the result of a tendency among bus passengers to complete a questionnaire only for one segment of their round trip, one consequence of the absence of interviewers in the buses.

Of the total number of shared-ride taxi trips taken on each survey date in Davenport, 23.0 percent and 18.4 percent, respectively, were sampled. In the case of the shared-ride taxi, the actual distribution of the demand during the day was known from information gathered

TABLE 4-3

DISTRIBUTION OF RESPONDENTS IN THE BUS PASSENGER ON-BOARD SURVEYS BY PERIOD OF THE DAY

Period	Davenport		Hicksville	
	Number	Percent	Number	Percent
First survey				
Before 6 a.m.	7	1.2	1	0.2
6 a.m. - 9 a.m.	221	37.0	126	25.4
9 a.m. - noon	191	32.0	119	23.9
Noon - 3 p.m.	91	15.2	99	19.9
3 p.m. - 6 p.m.	86	14.4	124	24.9
After 6 p.m.	1	0.2	28	5.6
Total	597	100.0	497	100.0
Second survey				
Before 6 a.m.	9	1.6	9	1.2
6 a.m. - 9 a.m.	251	46.0	392	53.3
9 a.m. - noon	178	32.6	176	23.9
Noon - 3 p.m.	48	8.8	73	9.9
3 p.m. - 6 p.m.	59	10.8	75	10.2
After 6 p.m.	1	0.2	11	1.5
Total	546	100.0	736	100.0

by the Customer Data Records. Table 4-4 shows that trips taken during the morning periods were oversampled, whereas trips made during the evening period were undersampled.

In Hicksville, 22.3 percent of the total number of shared-ride taxi trips made on the day of the first survey but only 7.5 percent of the trips made on the day of the second were included in the on-board samples. Table 4-5 shows that, as in Davenport, trips completed in the morning were slightly over-represented, whereas those completed in the late afternoon and evening were under-represented.

Since the characteristics of the respective populations of bus and shared-ride taxi users were unknown, no direct tests of the representativeness of the on-board survey samples could be performed. Using the data contained on the Customer Data Records, several indirect tests for bias were possible, such as the one previously discussed concerning the distribution of sampled trips over periods of the day. These tests, however, were inappropriate for determining the presence and direction of bias in the social, demographic, economic, and other characteristics of the sampled bus and shared-ride taxi users. Consequently, any statistically significant differences discovered in the data may only reflect differences between samples and not necessarily between populations. To assume that the nature and extent of bias is the same in each sample may seem reasonable, but this assumption cannot be proven with absolute certainty.

Home Interviews

Table 4-6 displays the number of home interviews completed in each study area. The goal of completing interviews in 500 households

TABLE 4-4

DISTRIBUTION OF RESPONDENTS IN THE TAXI PASSENGER ON-BOARD SURVEYS IN DAVENPORT BY PERIOD OF THE DAY

Period	Customer Data Records		Passenger Survey	
	Number of Trips	Percent	Number of Respondents	Percent
First survey				
Before 6 a.m.	136	11.7	8	3.1
6 a.m. - 9 a.m.	146	12.6	53	20.6
9 a.m. - noon	181	15.6	57	22.2
Noon - 3 p.m.	219	18.8	44	17.1
3 p.m. - 6 p.m.	181	15.6	49	19.1
After 6 p.m.	299	25.7	46	17.9
Total	1162	100.0	257	100.0
Second survey				
Before 6 a.m.	82	8.5	12	7.5
6 a.m. - 9 a.m.	150	15.5	47	29.4
9 a.m. - noon	179	18.5	50	31.3
Noon - 3 p.m.	162	16.7	26	16.2
3 p.m. - 6 p.m.	165	17.0	12	7.5
After 6 p.m.	230	23.8	13	8.1
Total	968	100.0	160	100.0

TABLE 4-5

DISTRIBUTION OF RESPONDENTS IN THE TAXI PASSENGER ON-BOARD SURVEYS IN HICKSVILLE BY PERIOD OF THE DAY

Period	Customer Data Records		Passenger Survey	
	Number of Trips	Percent	Number of Respondents	Percent
First Survey				
Before 6 a.m.	19	2.4	2	1.2
6 a.m. - 9 a.m.	187	23.1	48	29.1
9 a.m. - noon	171	21.2	40	24.2
Noon - 3 p.m.	129	16.0	31	18.8
3 p.m. - 6 p.m.	160	19.8	27	16.4
After 6 p.m.	142	17.6	17	10.3
Total	808	100.0	165	100.0
Second survey				
Before 6 a.m.	5	0.7	0	0.0
6 a.m. - 9 a.m.	125	18.7	9	18.4
9 a.m. - noon	180	26.9	21	42.9
Noon - 3 p.m.	183	27.4	15	30.6
3 p.m. - 6 p.m.	108	16.1	3	6.1
After 6 p.m.	68	10.2	1	2.0
Total	669	100.0	49	100.0

TABLE 4-6

NUMBER OF HOME INTERVIEWS CONDUCTED

	Davenport	Hicksville
Total households	455	289
Total respondents[a]	578	449
Shared-ride taxi users	117	92
Bus users	139	47
Nonusers of public transportation	374	328

[a]The total number of respondents does not equal the sum of respondents in the three groups since some individuals were users of both the bus and the shared-ride taxi service.

was almost reached in Davenport but not in Hicksville. As noted in the table, several persons interviewed were users of both modes of public transportation. Since there was no basis upon which to classify these individuals in one of the two groups of public transportation users, they were included in both and represented a complicating factor in subsequent tests of hypotheses.

The characteristics of the respondents in the household surveys are presented in Table 4-7 for Davenport and Table 4-8 for Hicksville.

TABLE 4-7

CHARACTERISTICS OF THE RESPONDENTS IN THE DAVENPORT HOUSEHOLD SURVEY

	Nonusers of Public Transportation		Bus Users		Taxi Users	
	Number	Percent	Number	Percent	Number	Percent
Sex						
Male	166	44.4	25	18.0	26	22.2
Female	208	55.6	114	82.0	91	77.8
Age						
Under 16	4	1.1	3	2.2	0	0.0
16 - 21	36	9.6	12	8.6	6	5.2
22 - 44	178	47.6	38	27.3	39	33.6
45 - 64	119	31.8	56	40.3	46	39.7
Over 64	37	9.9	30	21.6	25	21.6
Unspecified	0	...	0	...	1	...
Employment status						
Employed	193	51.9	72	52.2	64	55.2
Unemployed	179	48.1	66	47.8	52	44.8
Unspecified	2	...	1	...	1	...
Marital status						
Married	284	75.9	73	52.5	57	48.7
Single	58	15.5	40	28.8	27	23.1
Other	32	8.6	26	18.7	33	28.2
Physical handicap						
Handicapped	4	1.1	8	5.8	9	7.8

TABLE 4-7 (Continued)

	Nonusers of Public Transportation		Bus Users		Taxi Users	
	Number	Percent	Number	Percent	Number	Percent
Not handicapped	370	98.9	129	94.2	106	92.2
Unspecified	0	....	2	....	2	....
Household size						
One	31	8.3	25	18.1	25	21.7
Two	90	24.2	46	33.3	42	36.5
Three	55	14.8	22	15.9	15	13.0
Four	84	22.6	19	13.8	16	13.9
Five	50	13.4	9	6.5	4	3.5
Six	29	7.8	8	5.8	8	7.0
Seven and above	33	8.9	9	6.5	5	4.3
Unspecified	2	....	1	....	2	....
Ability to drive						
Licensed	334	89.3	60	43.5	43	37.1
Unlicensed	40	10.7	78	56.5	73	62.9
Unspecified	0	....	1	....	1	....
Household members with driver's license						
None	13	3.5	41	29.7	39	33.6
One	68	18.2	35	25.4	36	31.0
Two	183	48.9	34	24.6	28	24.1
Three	66	17.6	21	15.2	10	8.6
Four	36	9.6	6	4.3	3	2.6
Five or more	8	2.1	1	0.7	0	0.0
Unspecified	0	....	1	....	1	....

TABLE 4-7 (Continued)

	Nonusers of Public Transportation		Bus Users		Taxi Users	
	Number	Percent	Number	Percent	Number	Percent
Household autos						
None	12	3.2	44	31.9	49	42.2
One	137	36.6	51	37.0	38	32.8
Two	157	42.0	32	23.2	22	19.0
Three or more	68	18.2	11	8.0	7	6.0
Unspecified	0	....	1	....	1	....
Length of residence in Davenport						
Less than 1 year	2	0.5	2	1.4	2	1.7
1 - 5 years	23	6.2	7	5.0	7	6.0
6 - 10 years	48	12.9	12	8.6	16	13.7
11 - 20 years	72	19.3	27	19.4	20	17.1
21 - 40 years	142	38.1	39	28.1	31	26.5
Over 40 years	86	23.1	52	37.4	41	35.0
Unspecified	1	....	0	....	0	....

TABLE 4-8

CHARACTERISTICS OF THE RESPONDENTS IN THE HICKSVILLE HOUSEHOLD SURVEY

	Nonusers of Public Transportation		Bus Users		Taxi Users	
	Number	Percent	Number	Percent	Number	Percent
Sex						
Male	177	54.3	17	37.0	22	24.4
Female	149	45.7	29	63.0	68	75.6
Unspecified	2	....	1	....	2	....
Age						
Under 16	4	1.2	1	2.2	0	0.0
16 - 21	37	11.4	10	22.2	8	8.9
22 - 44	136	42.0	15	33.3	26	28.9
45 - 64	131	40.4	14	31.1	53	58.9
Over 64	16	4.9	5	11.1	3	3.3
Unspecified	4	....	2	....	2	....
Employment status						
Employed	220	69.4	17	38.6	46	52.9
Unemployed	97	30.6	27	61.4	41	47.1
Unspecified	11	....	3	....	5	....
Marital status						
Married	240	73.8	26	56.5	70	76.9
Single	69	21.2	15	32.6	9	9.9
Other	16	4.9	5	10.9	12	13.2
Unspecified	3	....	1	....	1	....

TABLE 4-8 (Continued)

	Nonusers of Public Transportation		Bus Users		Taxi Users	
	Number	Percent	Number	Percent	Number	Percent
Physical handicap						
Handicapped	3	0.9	1	2.2	7	7.7
Not handicapped	323	99.1	45	97.8	84	92.3
Unspecified	2	....	1	....	1	....
Household size						
One	9	2.8	3	6.5	3	3.4
Two	55	16.9	10	21.7	22	24.7
Three	50	15.3	11	23.9	26	29.2
Four	91	27.9	9	19.6	18	20.2
Five	70	21.5	6	13.0	11	12.4
Six	23	7.1	2	4.3	6	6.7
Seven and above	28	8.6	5	10.9	3	3.4
Unspecified	2	....	1	....	3	....
Ability to drive						
Licensed	293	90.2	15	32.6	43	47.3
Unlicensed	32	9.8	31	67.4	48	52.7
Unspecified	3	....	1	....	1	....
Household members with driver's license						
None	5	1.5	5	10.9	5	5.5
One	32	9.8	14	30.4	32	35.2
Two	145	44.5	18	39.1	40	44.0
Three	85	26.1	7	15.2	12	13.2

TABLE 4-8 (Continued)

	Nonusers of Public Transportation		Bus Users		Taxi Users	
	Number	Percent	Number	Percent	Number	Percent
Four	49	15.0	2	4.3	1	1.1
Five or more	10	3.1	0	0.0	1	1.1
Unspecified	2	....	1	...	1	...
Household autos						
None	5	1.5	7	15.2	9	9.9
One	84	26.0	22	47.8	41	45.1
Two	140	43.3	14	30.4	35	38.5
Three or more	94	29.1	3	6.5	6	6.6
Unspecified	5	....	1	....	1	....
Length of residence in Hicksville						
Less than 1 year	17	5.3	3	7.3	6	7.1
1 - 5 years	48	15.1	6	14.6	13	15.5
6 - 10 years	41	12.9	7	17.1	13	15.5
11 - 20 years	128	40.1	15	36.6	30	35.7
21 - 40 years	78	24.5	8	19.5	22	26.2
Over 40 years	7	2.2	2	4.9	0	0.0
Unspecified	9	....	6	....	8	....

CHAPTER 5

MACROANALYSIS OF THE DEMAND FOR SHARED-RIDE TAXI SERVICE

In this chapter the demand for the services provided by the shared-ride taxi systems of Davenport and Hicksville is examined at a macroanalytic level; that is, the emphasis is on the magnitude of the demand rather than on the characteristics of individual trips and passengers. The existence of several types of choices associated with using the taxi service formed the framework of this analysis. One set of options available to taxi users involved choosing between the standard shared-ride level of service and the more expensive exclusive cab level of service. Apart from this choice was that of either requesting immediate service or prearranging the time of boarding. Customers could request a taxi either by telephoning the cab company, appearing at the dispatching office or a cab stand, or hailing a moving taxi. Still another set of alternatives existed for taxi users in Davenport; since, for groups of passengers traveling together between the same trip origin and destination, the fare was invariant with the size of the group, customers could consider the advantages of traveling by taxi with companions as opposed to using the cab individually. Using some of the information contained in the file of Customer Data Records, this chapter considers each of these four aspects of the demand for taxi service.

Level of Service

Both taxi systems offered two levels of service, termed "shared-ride" and "exclusive cab" service in this report. Unless the exclusive use of the cab was specifically requested, the shared-ride mode was automatically in effect, meaning that the customer possibly would have to share the taxi with one or more passengers traveling in the same direction but not necessarily to the same destination. The fare charged for using the shared-ride level of service depended only on the zoned rate structure and not on the number of separate passengers ultimately sharing the cab during the course of a trip; thus, regardless of whether the customer had to ride with four other unassociated passengers or was fortunate enough to travel alone, the price of the trip was the same. For the privilege of being the sole passenger under the exclusive cab level of service, however, the user had to pay a charge in addition to that prescribed by the zoned fare schedule. In Davenport this increment in price was $1.00; in Hicksville the additional amount varied, but the total fare was generally 30 percent higher for the exclusive cab service than for the shared-ride level of service.

The rationale for ride-sharing is enhanced productivity. Since, as in car pooling, the cost of transporting two or more persons in a taxicab is not much greater than that of carrying one passenger, the higher productivity rates attending the implementation of the ride-sharing concept may result in a more lucrative operation. To the extent that an increase in profitability attracts better managers and drivers or enables a lower-priced service to be offered, ride-sharing can also be advantageous to the public.

The number of passenger trips made under each level of service on the dates covered by the Customer Data Records is shown in Table 5-1 for Davenport and Table 5-2 for Hicksville. In each study area, the demand for the shared-ride taxi company's exclusive cab service was virtually nonexistent. Apparently, taxi users were content to share a cab or did not consider the greater privacy and slight savings in time associated with the exclusive cab level of service worth its higher price. Since neither company promoted the more expensive service, many taxi patrons possibly were not aware of its availability.

In terms of magnitude, the demand for taxi service on Saturdays in Davenport was notably consistent with the mean level of ridership on weekdays. In Hicksville, however, patronage of the shared-ride taxi system on Saturdays declined by 37 percent from the average weekday demand. The magnitude of the demand declined further in Hicksville on Sundays to approximately 36 percent of the average weekday level. On Sundays in Davenport, the shared-ride taxi system transported 62 percent of the number of passengers carried on an average weekday.

As indicated in Table 5-1, more persons traveled by bus than by shared-ride cab in Davenport. Although the bus ridership totals shown cover a relatively short period, the bus system consistently accommodated approximately twice as many passengers per day as the shared-ride taxi system. Accurate estimates of the number of bus passengers from Hicksville itself were unavailable, since the bus system in that area spanned all of Nassau County.

TABLE 5-1

THE DEMAND FOR BUS, SHARED-RIDE TAXI, AND EXCLUSIVE CAB SERVICE IN DAVENPORT

Date	Passenger Trips			
	Bus	Taxi		
		Shared-Ride	Exclusive	Total
Weekdays				
04-10-73	2516	1300	3	1303
04-18-73	2622	1137	0	1137
04-26-73	2587	1103	5	1108
05-04-73	2826	1528	0	1528
06-28-73	....	1164	0	1164
08-27-73	....	1019	0	1019
09-11-73	....	887	0	887
09-19-73	....	941	0	941
09-27-73	....	755	0	755
10-23-73	....	978	1	979
10-31-73	....	841	2	843
11-08-73	....	953	0	953
11-23-73	....	859	1	860
Average	2638	1036	1	1037
Saturdays				
05-12-73	2422	1278	0	1278
10-06-73	....	1057	0	1057
11-17-73	....	980	0	980
Average	2422	1105	0	1105
Sundays				
05-20-73	a	680	0	680
10-14-73	a	587	0	587
12-16-73	a	677	0	677
Average	a	648	0	648
Special dates				
12-24-73	....	355	0	355

[a]Bus service not provided on Sundays.

TABLE 5-2

THE DEMAND FOR SHARED-RIDE AND EXCLUSIVE TAXI SERVICE IN HICKSVILLE

Date	Passenger Trips		
	Shared-Ride Service	Exclusive Service	Total
Weekdays			
04-18-73	857	1	858
05-03-73	940	3	943
05-18-73	971	0	971
06-20-73	808	0	808
07-30-73	524	8	532
08-21-73	573	0	573
09-05-73	756	0	756
09-20-73	739	0	739
10-05-73	738	0	738
11-08-73	669	0	669
12-11-73	570	0	570
01-03-74	532	0	532
01-18-74	380	0	380
Average	697	1	698
Saturdays			
06-02-73	527	1	528
10-20-73	346	0	346
Average	436	1	437
Sundays			
07-08-73	234	0	234
11-25-73	272	0	272
Average	253	0	253

Method of Requesting Taxi Service

Most customers conveyed their need for a taxi by phoning the dispatching office. This practice was more prevalent in Davenport, where between 86 and 93 percent of the requests received during the day were transmitted by phone. In Hicksville the daily proportion of phoned requests varied widely between 63 and 79 percent with the lowest percentage occurring on a Sunday.

Accounting for the smaller proportion of phoned requests in Hicksville was the larger percentage of requests occurring at the dispatching office and at cab stands. The daily percentage of persons requesting taxi service in this manner varied between 21 and 36 percent. With the dispatching office located at the local commuter railroad station, a focal point of the demand for shared-ride taxi service, many of the Hicksville cab system's users could conveniently secure a cab after leaving the train. The company also maintained stands at major shopping centers and other locations which frequently were sources of demand.

In Davenport the daily proportion of requests for taxi service made at the dispatching office and cab stands ranged between 7.5 and 14 percent. Many taxi users, after completing their work, shopping, or personal business in the downtown area, walked to the dispatching office to engage a taxi.

Hailing a cab was highly infrequent in both study areas: on each of the dates covered by the Customer Data Records, this method of requesting a taxi occurred in less than two percent of the cases. Neither shared-ride taxi system engaged in the practice of cruising. After delivering their final passengers, cabs in Davenport remained stationary

while those in Hicksville returned to the nearest cab stand until dispatched again. In each system the drivers, who leased their vehicles from the company, were further discouraged from cruising by a provision of the leasing agreement, which required them to defray their own costs for fuel.

Immediate and Time-Ordered Service

Shared-ride taxi users in Davenport and Hicksville had the option of requesting cab service either at the time at which they wished to travel or well in advance of the intended time of their trip. Cases involving the latter choice, in which customers specified their desired departure time, were known as "time orders" by taxi personnel. Requests for time-ordered or prearranged service were occasionally received a day in advance.

Time orders were more prevalent in Davenport: on weekdays an average of 16.2 percent of all taxi passenger trips in that community were prearranged, compared to 9.2 percent in Hicksville. Less variable than in Hicksville, where time orders constituted between 2.9 and 17.5 percent of all passenger trips on weekdays, the daily proportion of prearranged trips in Davenport ranged from 13.0 percent to 21.9 percent. The relative frequency of time orders in Davenport decreased to an average of 11.3 percent on Saturdays and 9.7 percent on Sundays. The proportion of prearranged trips also declined in Hicksville on Saturdays to an average of 3.9 percent but rose to 11.9 percent on Sundays.

Group Riding

Group riding and ride-sharing are two distinct events. The latter occurs whenever two or more passengers traveling individually occupy the same cab; each passenger is associated with a specific request for service, and each is considered a separate fare. If two or more passengers travel together as a group between the same trip origin and destination, group riding is indicated; in this case, a single request for service, associated with the entire group, is involved. Examples of instances of group riding include the following: a mother and her daughter making a shopping trip, two or more business associates traveling to an appointment, and two or more neighboring housewives shopping together for groceries.

In both study areas, although to a lesser extent in Hicksville, using the taxi service as a member of a group held an advantage in terms of the fare per individual. In Davenport the fare applied to a group of customers traveling collectively between the same trip origin and destination was invariant with the size of the group; that is, a group of five passengers could use the taxi service for the same total price as a single passenger making an identical trip. Since the zone fare was apportioned among the members of the group, in some cases it was possible for an individual member to travel by shared-ride taxi at a lower cost than by bus. In Hicksville the fare charged a group of customers was that computed from the zonal rate schedule plus 50 cents per group member; thus, individuals were able to travel by shared-ride taxi more inexpensively with a group of companions than as single passengers.

Table 5-3 shows that, of all the requests for taxi service included

TABLE 5-3

EXTENT OF GROUP RIDING

Size of Group	Percent of All Sampled Requests for Service	
	Davenport	Hicksville
1	85.9	90.3
2	9.8	7.4
3	2.5	1.3
4	1.3	0.7
5	0.3	0.3
6	0.2	0.0

in the file of Customer Data Records, 14.1 percent in Davenport and 9.7 percent in Hicksville involved more than one passenger. On most of the sampled weekdays in Davenport, group riding occurred in 9.0 to 16.3 percent of the cases, averaging 12.5 percent; the highest weekday percentage was 23.7 percent. In Hicksville the daily proportion of requests for group service on weekdays varied between 5.3 and 12.4 percent with an average of 9.3 percent. The incidence of group riding was higher on weekends than on weekdays in both study areas, averaging 19.4 percent on Saturdays and 17.2 percent on Sundays in Davenport and 11.7 percent on Saturdays and 11.1 percent on Sundays in Hicksville.

The extent to which the lower rate per individual associated with group riding induced some shared-ride taxi users to form groups cannot be

deducted from the above findings. In Davenport, however, it was not uncommon at the beginning of each month for two or three neighborhood housewives from low-income families, upon receiving their welfare checks, to travel together by shared-ride taxi to a grocery store, often returning with more than fifteen sacks of groceries between them. To each housewife in such cases, a round trip would often cost only 50 cents, compared to 60 cents by bus. Hence, the advantage of collectively using the shared-ride taxi service appeared to be well-recognized by at least one class of users.

Summary

The discussion in this chapter illustrates an important difference between the fixed-route, fixed-schedule bus and shared-ride taxi systems. By imposing fewer conditions upon its use and presenting customers with a series of choices, each shared-ride taxi system afforded its users greater flexibility for traveling by public transportation. In prearranging transportation for a future trip, shared-ride taxi users specified their travel requirements to the carrier instead of modifying their needs to conform with the carrier's schedule. Many taxi users exploited the advantages connected with time-ordering and group-riding.

The most visible condition placed upon the use of the taxi service, that of sharing a cab with unaffiliated passengers, did not appear to be disagreeable to users, based on the extremely small number of customers demanding exclusive use of a taxi. According to the owner of the Davenport taxi system, the firm has not encountered customer dissatisfaction with ride-sharing (Cherry, 1973, p. 94). Of course, passengers using the shared-ride level of service frequently completed a trip without

having to share the cab with other riders. The project report, Economic Characteristics of Privately Owned Shared-Ride Taxi Systems, describes in detail the actual incidence of ride-sharing in both study areas.

CHAPTER 6

EVALUATION OF THE OPERATINC PERFORMANCE OF THE SHARED-RIDE TAXI SYSTEMS

Logically, the ability to serve the transportation needs of the market dependably and expeditiously would seem to be especially critical to a relatively high-priced carrier in order to be successful. For the case of the shared-ride taxi, two prime indicators of the caliber of the service are the degree of responsiveness to requests for passenger carriage and the celerity with which trips are completed. Measures of these factors were obtained from the Customer Data Records in the form of wait times, the lapsed times between the placement of an order for taxi service and the arrival of a cab at the trip origin, and ride or travel times, the intervals of time expended during the actual journey from origin to destination. One of the objectives of this chapter is to discuss the results of analyses of wait times and ride times on the shared-ride taxi systems. Discussed in a later chapter are the users' perceptions of the speed and degree of responsiveness of the taxi systems and the importance of these factors in the modal choice decision process. The following analyses will provide a useful frame of reference for the later discussion.

Another objective of this chapter is to compare, where possible, the levels of performance of corresponding bus and shared-ride taxi systems. To make such a comparison is difficult, since the notion of responsiveness to the demand is an attribute of the shared-ride taxi but not of the bus. Although wait times can also be defined for bus trips,

either as the interval between the scheduled and the actual arrival of the bus at a bus stop or as the period between the arrival of the passenger and that of the bus at a bus stop, accurate methods of measuring them were not available. Ride time was the only comparable measure of the performance of the bus systems. In the second section of this chapter, the ride times for bus trips are compared with those for shared-ride taxi trips.

Degree of Responsiveness

To properly evaluate the responsiveness of the shared-ride taxi systems to the demand required the separation of taxi trips into those which entailed immediate service and those which involved a prearranged pick-up time. For the first type of trip, the wait time was the interval between the time at which the service was requested and the cab's time of arrival at the trip origin. The wait time associated with time-ordered service was defined as the difference between the requested and the actual time of boarding.

Immediate Service

Table 6-1 compares the distribution of wait times for immediate taxi service in Davenport with that in Hicksville. For each study area, the percentages shown were based on all trips made on the dates covered by the Customer Data Records, excluding trips which involved time orders or street hailing. The Kolmogorov-Smirnov test summarized at the bottom of the table was performed to determine whether or not statistically significant differences existed in the amount of waiting required by each of the systems.

TABLE 6-1

DISTRIBUTION OF WAIT TIMES FOR IMMEDIATE SHARED-RIDE TAXI SERVICE IN DAVENPORT AND HICKSVILLE

Length of Waiting Period (Minutes)	Percent of Trips	
	Davenport	Hicksville
5 or less	13.3	43.8
6 - 10	19.7	30.0
11 - 15	18.0	13.3
16 - 20	14.0	5.9
21 - 25	10.1	3.1
26 - 30	8.1	1.5
31 - 45	12.1	2.0
46 - 60	4.8	0.4
Median	14.7 min.	6.0 min.

Kolmogorov - Smirnov Test:
Test statistic, D = 0.409
Critical D (0.05 level) = 0.022

The shared-ride taxi service in Hicksville was considerably more prompt in responding to requests for immediate transportation than the system in Davenport. In addition to being shorter, wait times in Hicksville were also less variable or widely dispersed. For specific days the median length of waiting ranged between 4.4 and 8.2 minutes in Hicksville, compared to a range of 10.5 to 26.0 minutes in Davenport. A possible explanation for the larger and more variable wait times in Davenport

is the fact that the shared-ride taxi system in that community covered a more extensive service area and transported more passengers with fewer cabs than its counterpart in Hicksville. According to an analysis of fleet utilization contained in the project report Economic Characteristics of Privately Owned Shared-Ride Taxi Systems, on individual weekdays the Davenport system operated between 12 and 19 of its cabs, averaging 16 cabs per day, while the system in Hicksville used 15 to 27 cabs on weekdays, averaging 20 vehicles per day in operation.

In both study areas, the amount of time spent waiting for a taxi on weekends differed slightly from that on weekdays. The overall median wait times in Davenport were 14.0 minutes on weekdays, 17.5 minutes on Saturdays, and 14.0 minutes on Sundays. Possibly accounting for the longer periods of waiting on Saturdays is the fact that the cab company utilized fewer vehicles on those days, whereas the level of ridership was virtually the same on Saturdays as on the average weekday. Perhaps because the demand was considerably less intense on Sundays, the wait times on those days were more consistent with the wait times on weekdays. In Hicksville the overall median wait times were 6.0 minutes on weekdays, 5.5 minutes on Saturdays, and 7.8 minutes on Sundays. As in Davenport, the larger periods of waiting occurring on Sundays may have been due to the smaller number of vehicles in operation on those days. In any case the observed differences are not exceptionally large.

Time-Ordered Service

Table 6-2 compares the two shared-ride taxi systems in terms of the deviations between actual and requested times of boarding for prearranged trips or time orders. Once again, the Hicksville system was more

TABLE 6-2

DISTRIBUTION OF DEVIATIONS BETWEEN ACTUAL AND REQUESTED BOARDING TIMES FOR TIME-ORDERED TAXI SERVICE

Time of Boarding	Percent of Time Orders	
	Davenport	Hicksville
16 - 30 minutes early	1.0	1.2
11 - 15 minutes early	1.9	1.6
6 - 10 minutes early	5.5	9.4
0 - 5 minutes early	32.4	48.4
1 - 5 minutes late	22.4	21.5
6 - 10 minutes late	15.7	9.4
11 - 15 minutes late	8.7	4.4
16 - 30 minutes late	9.4	3.4
31 - 45 minutes late	2.1	0.5
46 - 60 minutes late	0.9	0.3
Median	2.0 min.	- 1.3 min.

Kolmogorov - Smirnov Test:
Test statistic, D = 0.196
Critical D (0.05 level) = 0.059

punctual, reaching the customer's trip origin within five minutes before or after the requested pick-up time in 69.9 percent of the cases, compared to 54.8 percent in Davenport. The negative median deviation shown for Hicksville indicates that the cabs arrived early in at least one-half of the instances involving a time order.

Wait time for time-ordered shared-ride taxi service in Davenport exhibited less of the day-to-day variability displayed for immediate service: on specific days, median deviations between actual and prearranged pick-up times varied from -0.5 to 6.0 minutes. Neither was there considerable variation in the overall median deviation times corresponding to weekdays, Saturdays, and Sundays. Similar conclusions were drawn from the Hicksville data. Apparently, regardless of the magnitude of the demand or the number of cabs in operation on a given day, both companies exerted the same amount of effort in endeavoring to serve prearranged trips on time.

Comparison of the Bus and Taxi Systems

Although wait times connected with the bus systems were not measured, in one respect the ease of acquiring bus service could be compared with that for the taxi. This was accomplished by comparing bus headways with wait times for immediate shared-ride taxi service. In Davenport the buses operated on 30-minute headways; thus, if a person decided offhand to make a trip, the chances were 50-50 that he or she would have had to delay the trip for at least 15 minutes in order to catch the next bus. Referring back to Table 6-1, it is seen that 51.0 percent of the requests for immediate taxi service were accommodated within 15 minutes after the requests were made. In terms of the expected time of waiting, then, the

shared-ride taxi service in Davenport did not appear to offer any significant advantage over the bus service. In Hicksville, however, the headways on bus routes serving the study area varied from 15 to 70 minutes during rush hours and 20 minutes to two hours during off-peak periods. Table 6-1 shows that the local shared-ride taxi service responded to 73.8 percent of the requests within ten minutes and 87.1 percent within 15 minutes. Wait time is, of course, only one factor possibly involved in the modal choice decision process; this and other determinants of modal choice will be analyzed from the viewpoint of the passenger in a later chapter.

Duration of Trips

Comparison of Shared-Ride Taxi Systems

The distributions of travel times for trips made on each of the shared-ride taxi systems are compared in Table 6-3. In both communities taxi trips tended to be short in duration, often less than ten minutes in length. The slightly larger ride times on the Davenport system may be attributable to the system's more extensive service area, resulting in larger numbers of trips covering distances longer than those of trips in Hicksville.

Unlike wait times, the amount of time spent traveling in a taxi was fairly stable from day-to-day. Median ride times for specific days varied from 7.7 to 9.5 minutes in Davenport and 5.5 to 8.8 minutes in Hicksville. On weekends in Davenport, the overall median travel times of 8.9 minutes on Saturdays and 8.2 minutes on Sundays were consistent with the median travel time of 8.6 minutes for all sampled weekdays combined. For Sunday trips in Hicksville, the median duration was 8.3 minutes,

TABLE 6-3

DISTRIBUTION OF RIDE TIMES ON THE SHARED-RIDE TAXI SYSTEMS

Duration of Trip (Minutes)	Percent of Trips	
	Davenport	Hicksville
5 or less	24.6	39.0
6 - 10	34.8	39.3
11 - 15	21.8	12.7
16 - 20	10.2	4.4
21 - 25	5.0	1.2
26 - 30	2.0	0.8
31 - 45	1.3	1.6
46 - 60	0.2	1.0
Median	8.6 min.	6.4 min.

Kolmogorov - Smirnov Test:
Test statistic, D = 0.187
Critical D (0.05 level) = 0.019

slightly larger than the median ride times of 6.3 and 6.5 minutes for weekday and Saturday trips, respectively, suggesting that the Hicksville system tended to make more medium and long-distance trips on Sundays than on other days.

Comparison of Bus and Taxi Systems

Table 6-4 displays the relative frequencies of bus trips according to trip duration. These distributions were developed from the samples of

TABLE 6-4

COMPARISON OF RIDE TIMES ON THE BUS AND SHARED-RIDE TAXI SYSTEMS

Duration of Trip (Minutes)	Percent of Trips			
	Davenport		Hicksville	
	Bus	Taxi	Bus	Taxi
5 or less	3.9	24.6	2.9	39.0
6 - 10	16.4	34.8	15.9	39.3
11 - 15	29.1	21.8	20.7	12.7
16 - 20	15.1	10.2	16.2	4.4
21 - 25	8.0	5.0	13.3	1.2
26 - 30	12.7	2.0	14.0	0.8
31 - 45	9.9	1.3	10.8	1.6
46 - 60	4.9	0.2	6.2	1.0
Median	15.2 min.	8.6 min.	18.2 min.	6.4 min.

Kolmogorov - Smirnov Test:
  Davenport
    Test statistic, D = 0.392
    Critical D (0.05 level) = 0.044
  Hicksville
    Test statistic, D = 0.595
    Critical D (0.05 level) = 0.046

bus trips made on the days of the on-board surveys. For ease of comparison, the overall distributions of shared-ride taxi travel times are reproduced in this table.

As is clearly shown, in both study areas bus trips tended to be longer in duration than taxi trips. The larger travel times associated with the Davenport bus service were very likely a consequence of the greater number of intermediate stops made by the transit vehicles during the course of a trip. In many cases, transferring to another bus also consumed additional time not entailed by the use of the shared-ride taxi system. In the Hicksville area, the disparity between bus and taxi ride times was even more pronounced, but this greater discrepancy was partially due to the much more extensive service area of the bus system; since that system was county-wide, many of the sampled bus trips had trip ends outside the shared-ride taxi system's normal area of coverage and, therefore, involved greater distances.

One additional observation can be made in comparing the swiftness of the two modes of public transportation. It is worth noting that, in Davenport, the sum of the median wait time and median travel time, 23.3 minutes, was less than the headways on the local bus system. Likewise, in Hicksville the combination of the median times for waiting and traveling on the shared-ride taxi system, equal to 12.4 minutes, was significantly less than the smallest off-peak headway on the bus routes serving the area. In terms of overall trip time, therefore, both shared-ride taxi systems appeared to hold an advantage over the fixed-route, fixed-schedule bus systems.

Summary

While in the process of delivering passengers to their destinations, the two shared-ride taxi systems performed with expedition. The most sensitive aspect of these operations was the degree of responsiveness to requests for immediate transportation, particularly in Davenport, where the period of waiting, subject to a considerable amount of variability, was often more than one-and-a-half times as long as the time spent riding in a cab. The Hicksville system was much more prompt in responding to requests for both immediate and time-ordered service, possibly because it normally operated a larger number of cabs to transport fewer passengers per day within a service area of lesser extent. In both study areas, notably Hicksville, the bus systems were slower than the shared-ride taxi systems; in this respect, the latter appeared to have an advantage over the fixed-route, fixed-schedule mode.

CHAPTER 7

CHARACTERISTICS OF BUS AND SHARED-RIDE TAXI TRIPS

Highly indicative of the nature of the demand for bus and shared-ride taxi service in Hicksville and Davenport were the characteristics of the trips made via each of these modes. An insight into the roles performed by the buses and taxis and the markets served by them was gained from an analysis of several aspects of bus and taxi trips, including their distribution over time, their spatial orientation, and the purposes for which they were taken. The on-board surveys and, in the case of the taxi systems, the Customer Data Records supplied the information needed for this investigation.

Temporal Patterns

A salient characteristic of bus trips in a large number of urban areas is their high concentration within the relatively short morning and afternoon peak periods. Thus, while having lost a large percentage of their ridership, bus systems have remained an important mode of transportation during rush hours in many cities, indicating that much of the decline in bus patronage has occurred during the off-peak hours. Relatively brief periods of intense demand constitute a major problem, since they necessitate investing in a level of service which is required by the heavy demand during peak hours but which is uneconomical during the longer off-peak periods (Owen, 1966, pp. 79-86). Conversely, in some major metropolitan areas, taxi trips have not been known to exhibit the high degree of concentration in time common to other urban transport modes

(Kirby et al., 1974, p. 169). One reason for the more uniform temporal pattern of demand for taxi service is the fact that the number of taxis is limited by regulation in many urban areas; therefore, when the supply of cabs is fully utilized during the peak hours, there are no more vehicles available to serve any latent or unsatisfied demand (Kirby et al., 1974, p. 170). In general the temporal patterns of bus and taxi trips noted above were observed in Davenport and Hicksville.

The hourly distribution of the demand for shared-ride taxi service on weekdays is depicted in Figure 7-1 for Davenport and Figure 7-2 for Hicksville. Each of these graphs is a composite of the distributions for individual weekdays included in the file of Customer Data Records, which, one may recall, stored information furnished by the cab companies' dispatching records and the drivers' logs. Since actual times of boarding were missing for a large percentage of trips, particularly in Davenport, the figures were based on the time at which a taxi was requested for cases involving immediate service and on the requested pick-up time for cases involving a time order.

In Davenport two-thirds of the weekday demand for shared-ride taxi service was rather uniformly spread over the twelve-hour period between 7:00 a.m. and 7:00 p.m. During the intervals of 7:00 a.m. - 9:00 a.m. and 4:00 p.m. - 6:00 p.m. encompassing the morning and afternoon rush hours, no significant concentrations of taxi trips were apparent; in fact, during the afternoon peak period, a slight but noticeable decline in taxicab usage was detected. The shared-ride taxi system was normally most intensively utilized between the hours of 1:00 p.m. and 4:00 p.m. Patronage of the system was also quite strong in the evening after the local bus system had ceased its day's operations; on many weekdays the

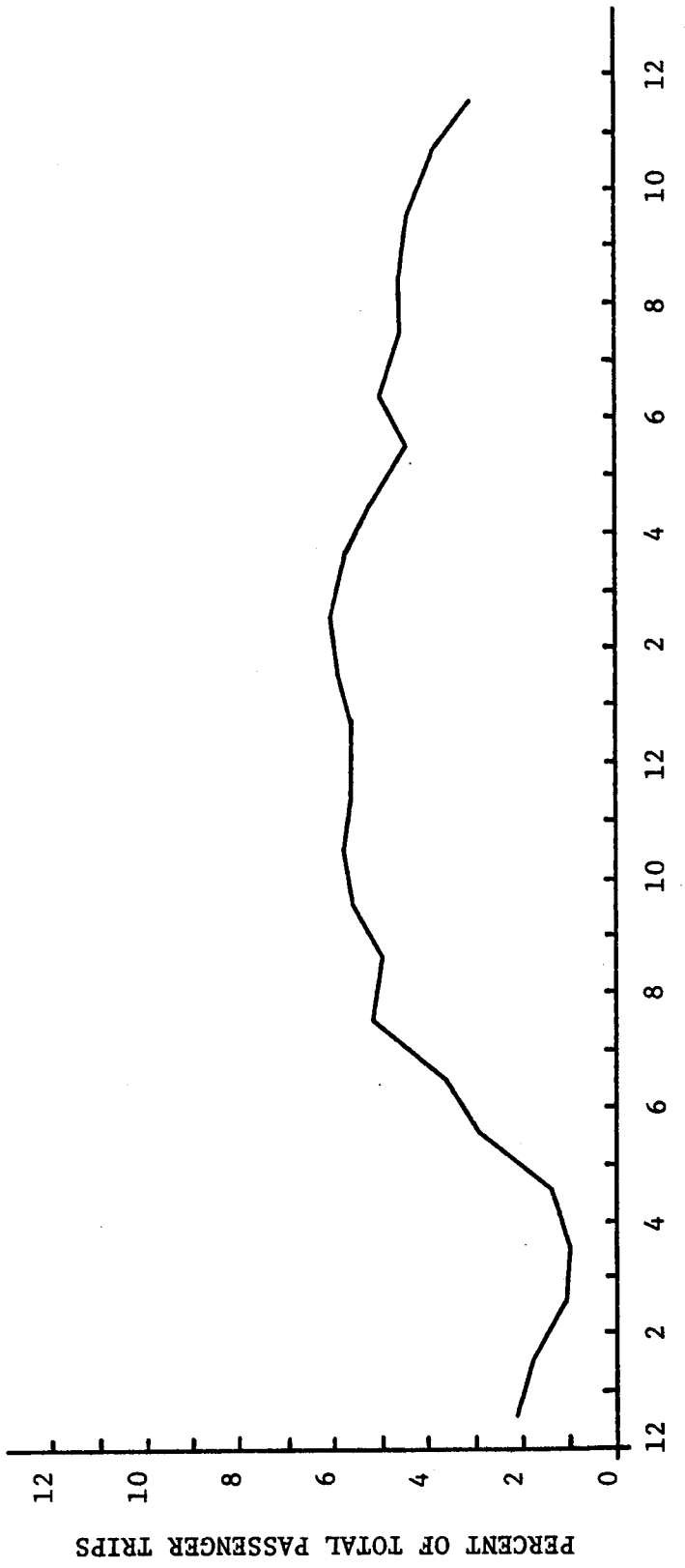


FIGURE 7-1

HOURLY DISTRIBUTION OF THE DEMAND FOR SHARED-RIDE TAXI SERVICE
IN DAVENPORT ON AN AVERAGE WEEKDAY

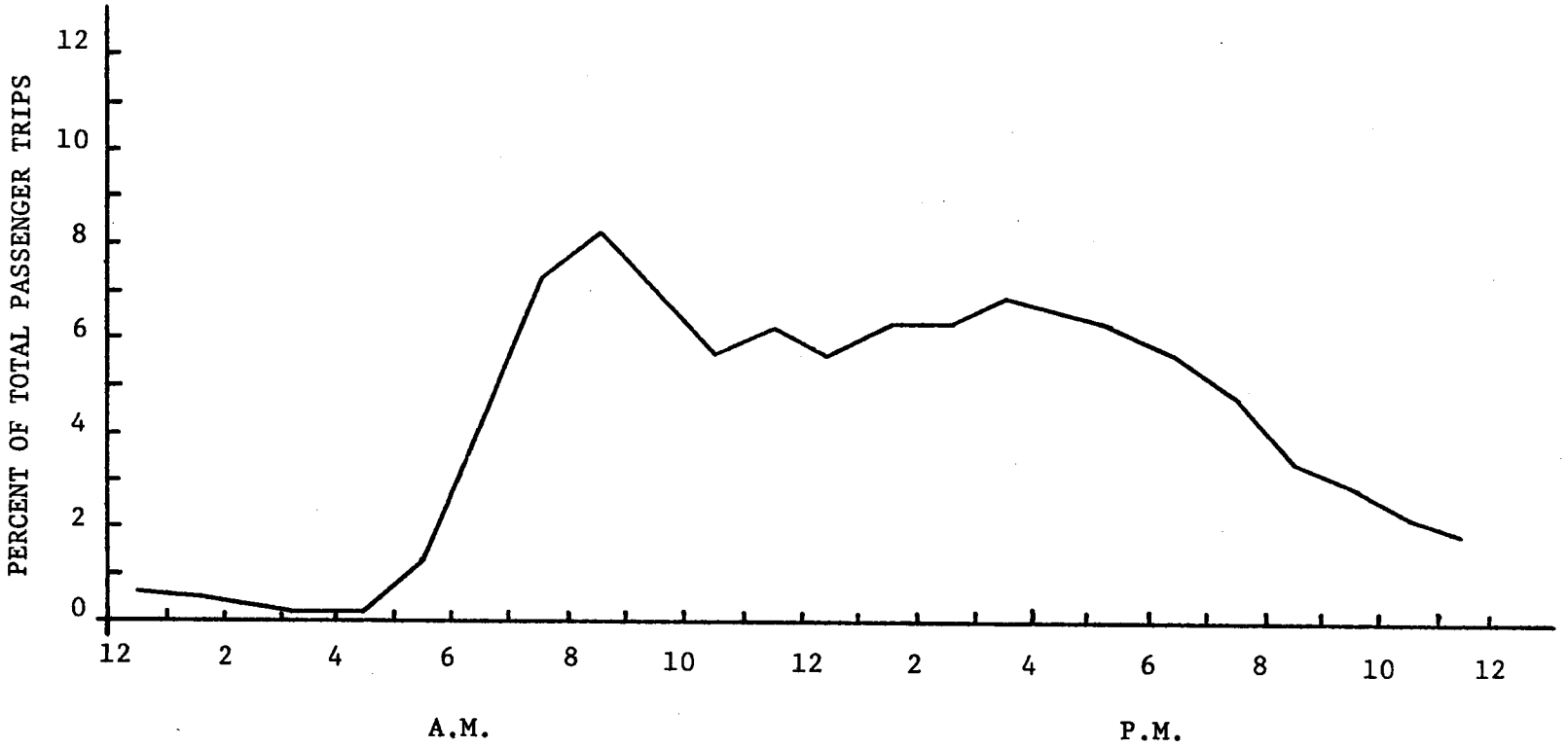


FIGURE 7-2

HOURLY DISTRIBUTION OF THE DEMAND FOR SHARED-RIDE TAXI SERVICE
IN HICKSVILLE ON AN AVERAGE WEEKDAY

demand for the taxi service did not begin to attenuate until after 10:00 p.m.

Figure 7-2 shows that the heaviest concentration of shared-ride taxi trips in Hicksville occurred in the three-hour interval of 7:00 a.m. - 10:00 a.m. during which approximately 23 percent of the day's requests for service were received. Interestingly, no correspondingly sharp peak period of demand was evident in the late afternoon. Following the morning rush period, the level of shared-ride taxi usage was fairly constant until around 6:00 p.m. with a secondary, obtuse peak generally occurring between 3:00 p.m. and 5:00 p.m. On the average weekday, the Hicksville system transported 78 percent of its customers between 7:00 a.m. and 7:00 p.m., compared to 65.4 percent during the same period in Davenport.

According to cab company dispatching records, on the average weekday the Hicksville shared-ride taxi system made a higher percentage of trips during the rush hours than the Davenport system. In Hicksville 28.4 percent of weekday taxi trips were taken during the 7:00 a.m. - 9:00 a.m. and 4:00 p.m. - 6:00 p.m. peak periods, compared to 19.9 percent in Davenport. Based on these percentages, the on-board survey samples appeared to include a disproportionately high percentage of peak-hour trips. In Davenport 32.3 percent and 24.5 percent of the taxi trips sampled in the first and second on-board surveys, respectively, were made during the rush hours; likewise, in Hicksville 37.5 percent of the trips included in the first and larger on-board survey sample were made during the peak periods. This apparent bias toward peak-hour trips may have been partly attributable to the under-representation of evening trips in the samples, thereby inflating the peak period percentages.

Hourly distributions of shared-ride taxi trips on Saturdays and Sundays were also analyzed. These are shown in Figures 7-3 and 7-4 for Davenport and Figures 7-5 and 7-6 for Hicksville. In the former community, the temporal pattern of Saturday trips was similar to that on weekdays, although the level of patronage was not as strong on Saturday mornings. On Sundays approximately one-fourth of the trips were taken in a three-hour period in the early afternoon. The most noticeable characteristic of the demand for shared-ride taxi service on weekends in Hicksville was its highly erratic nature. On Saturdays the system was most intensively utilized during the midday hours, while on Sundays the heaviest concentrations of demand occurred during the midafternoon and early evening hours.

The on-board surveys of bus passengers did not provide a true representation of the dispersion of bus trips throughout the day for comparison with the distributions of shared-ride taxi trips. As explained in Chapter 4, the imbalanced number of morning trips in the samples implied that most bus passengers completed a questionnaire for only one segment of a round trip. Nevertheless, the results supported the expected finding that the heaviest loadings on the bus systems occur during the peak periods. Peak-hour trips comprised 36.7 percent and 41.6 percent of the trips sampled in the first and second surveys, respectively, in Davenport and 37.9 percent and 42.3 percent of the sampled trips in respective surveys in Hicksville. In each study area these percentages were considerably higher than those, derived from cab company dispatching records, corresponding to the shared-ride taxi systems. Although the results of the bus on-board surveys may not have reflected the actual proportion of peak-hour bus trips, they were fairly consistent between surveys in each

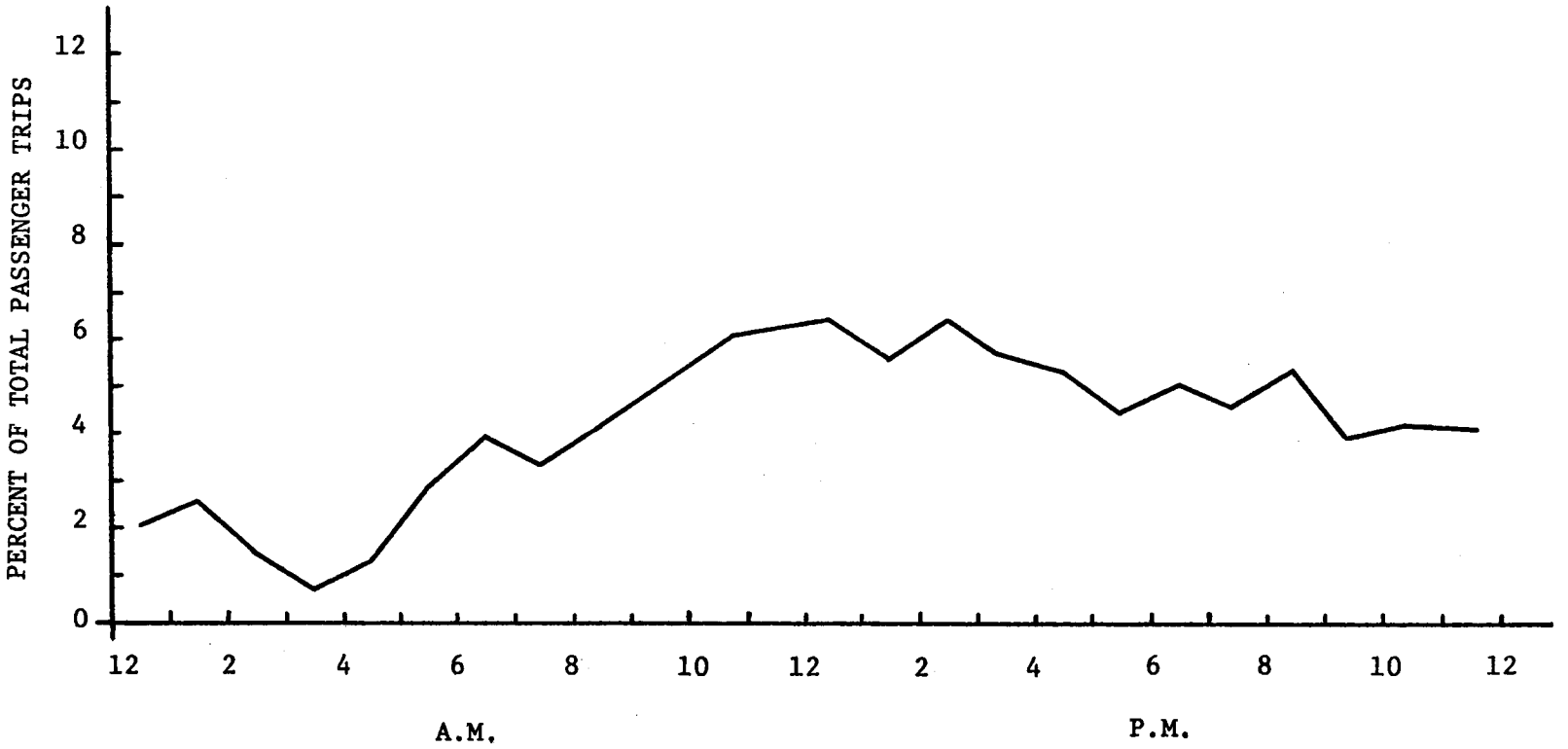


FIGURE 7-3

HOURLY DISTRIBUTION OF THE DEMAND FOR SHARED-RIDE TAXI SERVICE IN DAVENPORT ON AN AVERAGE SATURDAY

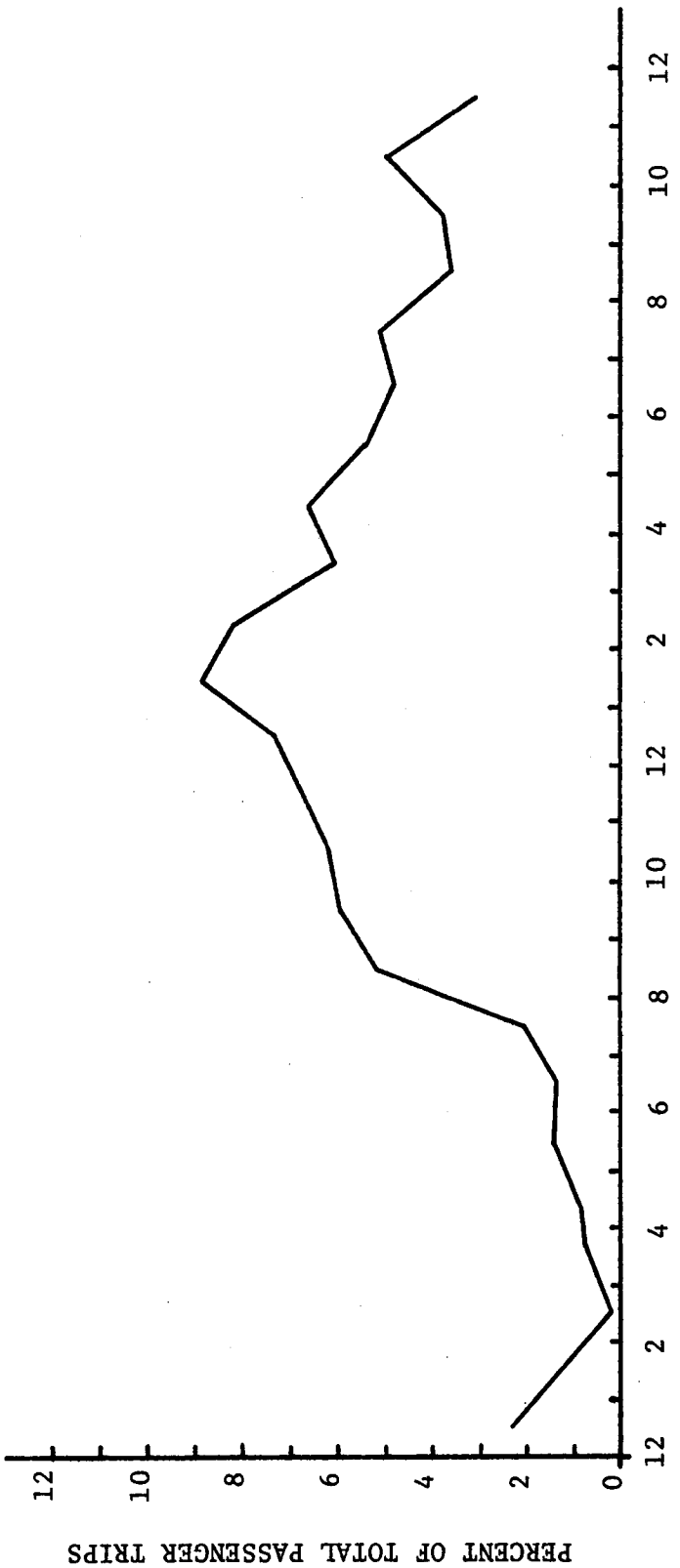


FIGURE 7-4

HOURLY DISTRIBUTION OF THE DEMAND FOR SHARED-RIDE TAXI SERVICE IN DAVENPORT ON AN AVERAGE SUNDAY

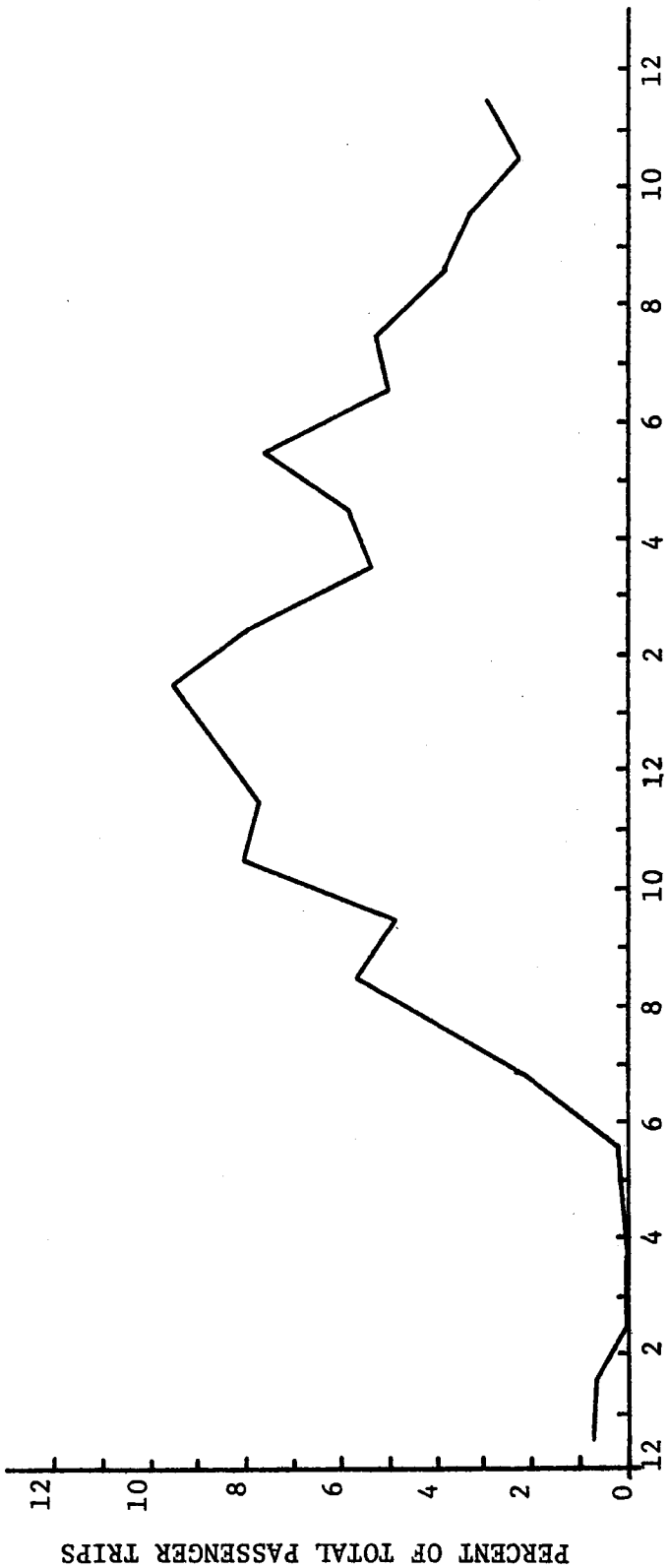


FIGURE 7-5

HOURLY DISTRIBUTION OF THE DEMAND FOR SHARED-RIDE TAXI SERVICE
IN HICKSVILLE ON AN AVERAGE SATURDAY

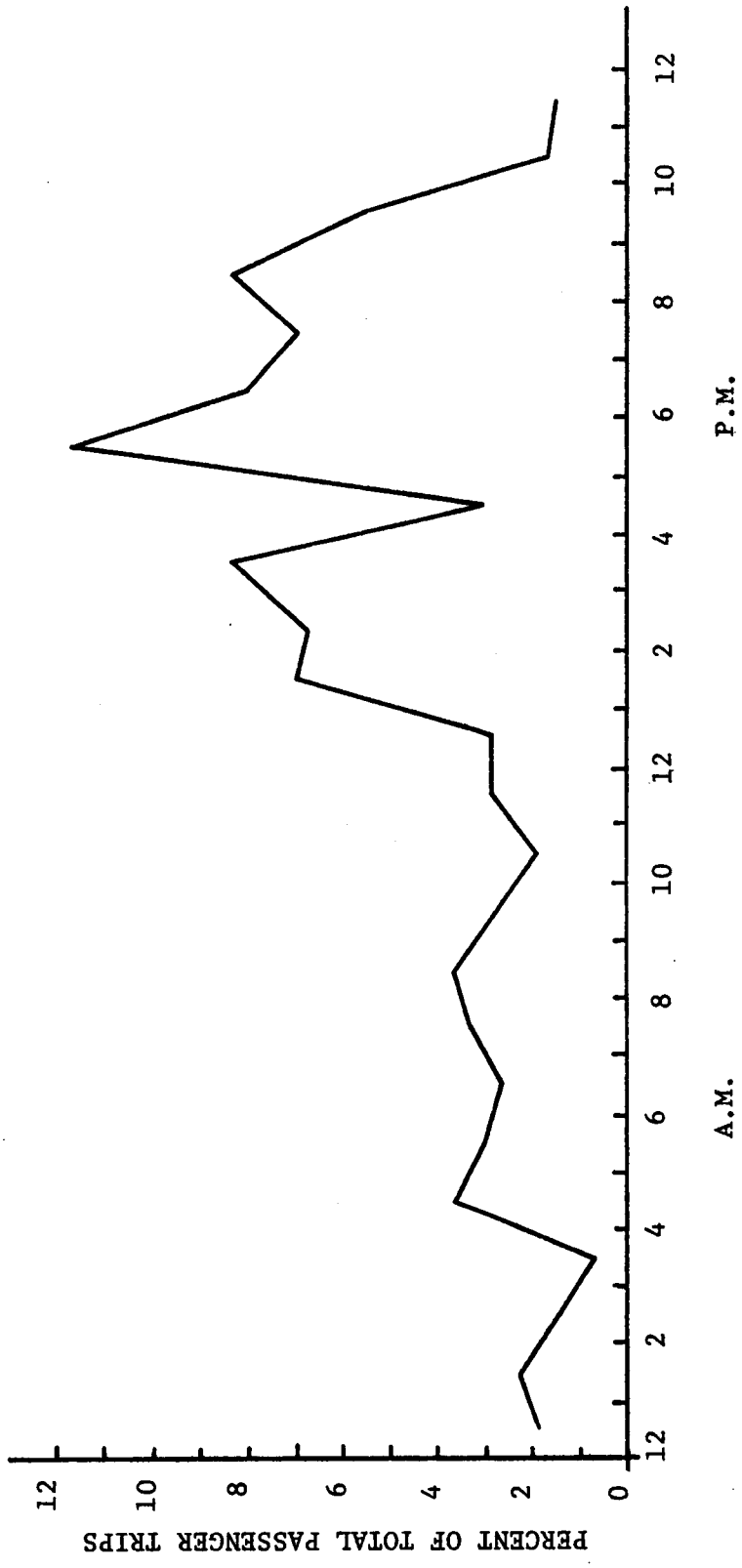


FIGURE 7-6

HOURLY DISTRIBUTION OF THE DEMAND FOR SHARED-RIDE TAXI SERVICE
IN HICKSVILLE ON AN AVERAGE SUNDAY

study area, unlike the results of the taxi passenger surveys, and were also consistent between study areas as well. In conclusion the bus systems appeared to be more important than the shared-ride taxi systems during rush hours in terms of the proportion of each mode's total weekday demand occurring in the peak periods.

Spatial Patterns

According to dispatching records kept by the shared-ride taxi fleets, the origins and destinations of cab trips were widely dispersed over developed sections lying outside the Central Business District (CBD) with the highest concentration of trip ends occurring in the CBD. Of the 110 traffic zones in Davenport, only one, located in the CBD, consistently produced and attracted over 100 taxi trips per day. One other zone, adjacent to the CBD, was habitually the origin and destination of at least 50 taxi trips per day. Conversely, on the average weekday, over 70 percent of the zones produced and attracted ten or fewer trips, accounting for 24 percent of the trip origins and 26 percent of the trip destinations. In Hicksville an average of 297 shared-ride taxi trips per day originated in the zone (census tract) encompassing the CBD, while an average of 210 trips per day terminated there. No other zone consistently produced or attracted over 50 cab trips per day. In general, the density of taxi trip ends was highest in the CBD and rapidly attentuated as the radial distance from the community's business center increased.

Table 7-1, derived from dispatching information gathered by the Customer Data Records, compares the distribution of trips between central and noncentral origins and destinations for each shared-ride taxi system. The results show that taxi trips in the Hicksville area were

TABLE 7-1

DISTRIBUTION OF SHARED-RIDE TAXI TRIPS BETWEEN CBD AND NON-CBD ORIGINS AND DESTINATIONS

	Origin	Destination	Percent of Trips	
			Davenport	Hicksville
Weekdays	CBD	CBD	1.7	7.3
	CBD	Non-CBD	21.6	35.3
	Non-CBD	CBD	15.0	22.8
	Non-CBD	Non-CBD	61.7	34.7
Saturdays	CBD	CBD	1.4	6.4
	CBD	Non-CBD	23.1	45.2
	Non-CBD	CBD	13.1	19.3
	Non-CBD	Non-CBD	62.3	29.1
Sundays	CBD	CBD	1.5	3.2
	CBD	Non-CBD	22.5	34.6
	Non-CBD	CBD	13.5	18.8
	Non-CBD	Non-CBD	62.5	43.5

much more highly centralized than in Davenport. The greater dominance of Hicksville's core area can be explained by the presence there of two major activity centers, a Long Island Railroad Station and the Mid Island Plaza regional shopping center. As will become more clearly evident in a subsequent section, these two places were important generators of shared-ride taxi trips.

The spatial patterns of shared-ride taxi trips as revealed by the first on-board survey in Davenport were in close agreement with findings from dispatching records. In the first survey sample, 44.7 percent of the trips were oriented toward the CBD, compared to the actual proportion of 46.3 percent. Taxi trips with origins or destinations in the core area were slightly under-represented in the second survey sample in which the proportion of CBD-oriented trips was 27.3 percent, somewhat below the percentage of 35.8 disclosed by dispatching records for the date of the survey. In Hicksville both on-board surveys grossly undersampled CBD-oriented trips, which comprised only 21.3 percent of the trips in the first sample and 22.0 percent of the trips in the second. The actual percentages as revealed by the Customer Data Records were 67.5 and 70.4, respectively.

Bus trips in Davenport were much more highly centralized than shared-ride taxi trips, as shown by the results of the two on-board surveys summarized in Table 7-2. Based on the findings of another study of public transportation in the Davenport (Quad Cities) area, however, the centralization of bus trips appeared to be slightly exaggerated by the on-board survey samples (Quad Cities Public Transportation Study, 1972, pp. C.1-C.7). Nevertheless, the general conclusion that bus trips were more heavily oriented toward the CBD than taxi trips still held. In addition, a comparison of the spatial distributions of bus and taxi trips in Davenport revealed an interesting inversion; whereas a higher percentage of taxi trips originated in the CBD than were destined there, the opposite was true for the bus system. This observation was supported by the results of the earlier public transportation study.

TABLE 7-2

DISTRIBUTION OF BUS TRIPS BETWEEN CBD AND NON-CBD ORIGINS AND DESTINATIONS

Origin: Destination	Davenport		Hicksville	
	Number	Percent	Number	Percent
First survey				
CBD: CBD	0	0.0	0	0.0
CBD: Non-CBD	98	19.8	28	6.7
Non-CBD: CBD	259	52.3	18	4.3
Non-CBD: Non-CBD	138	27.9	369	88.9
Unspecified	188	....	116	....
Second survey				
CBD: CBD	3	0.5	3	0.5
CBD: Non-CBD	66	12.0	90	15.5
Non-CBD: CBD	276	50.4	153	26.3
Non-CBD: Non-CBD	203	37.0	336	57.7
Unspecified	7	....	166	....

The results of the bus on-board surveys in Hicksville, also included in Table 7-2, were highly inconsistent. Accounting for this inconsistency to some extent was the fact that the community of Hicksville was only one node in the county-wide bus network. The bus routes serving the study area converged at its core near the commuter rail station and the regional shopping center. As explained in Chapter 4, a cordon line was

established around the study area, and only passengers boarding the buses within the bounded area received a questionnaire. Nevertheless, the two survey samples contained differing percentages of trips with origins and destinations outside the Hicksville shared-ride taxi system's service area. The first survey sample, which contained the smaller percentage of CBD-oriented trips, included a higher percentage of external trips, 56.1 percent compared to 26.5 percent in the second sample. Of the bus trips made wholly within the study area, 9.9 percent in the first survey and 51.6 percent in the second were directed to or from the CBD.

Trip Purpose

The on-board surveys revealed that buses and shared-ride taxis in Davenport were most frequently used for traveling to and from work. As shown by Table 7-3, however, work trips constituted a larger fraction of the bus system's operations than the taxi system's. To determine the significance of this observed discrepancy, trip purpose was dichotomized into work and nonwork trips, and a two by two contingency table analysis was performed on the samples of bus and taxi trips for each survey. The tests yielded values for chi-square of 5.27 and 13.80, respectively, both significant at the 0.05 level.

Of the nonwork categories of trip purpose, the most frequent uses of the Davenport bus service were for shopping and personal business trips. In the second survey, conducted while school was in session, the bus system was used to a much greater extent than the shared-ride taxi system for school trips. Interestingly, the taxi service accommodated less shopping trips than trips in each of the social-recreation, medical, and personal business categories.

TABLE 7-3

DISTRIBUTION OF BUS AND SHARED-RIDE TAXI TRIPS IN DAVENPORT BY TRIP PURPOSE

Trip Purpose	Bus		Shared-Ride Taxi	
	Number	Percent	Number	Percent
First survey				
Work	339	58.4	104	49.3
School	9	1.6	6	2.8
Shopping	145	25.0	19	9.0
Social-recreation	33	5.7	28	13.3
Medical	21	3.6	33	15.6
Personal business	33	5.7	21	10.0
Unspecified	103	....	57	....
Second survey				
Work	330	60.0	79	44.1
School	46	8.4	6	3.4
Shopping	56	10.2	16	8.9
Social-recreation	27	4.9	16	8.9
Medical	22	4.0	36	20.1
Personal business	69	12.5	26	14.5
Unspecified	5	....	1	....

The results of the surveys of bus and taxi users in the Hicksville area, presented in Table 7-4, were less consistent and, therefore, less conclusive. The Nassau County bus system was used primarily for traveling to and from work and shopping facilities, but the percentage of work and shopping trips varied considerably between the two samples. The shared-ride taxi system was also used extensively for purposes related to work and shopping. As in Davenport, this mode also carried a higher percentage of social-recreation, personal business, and medical trips than the buses.

Origin-Destination Patterns of Taxi Trips

In comparing the purposes for which the shared-ride taxi systems were used, it appeared that the Hicksville system was more widely utilized for work and shopping trips. Although not directly related to trip purpose, one item of information recorded on the Customer Data Records was also valuable for characterizing trips taken by taxi. Applying their knowledge of the study area, cab company personnel who completed the forms were able to note the type of facility or land use at the origin and destination of each cab trip. The resulting distributions of shared-ride taxi trips by type of origin and destination are displayed in Table 7-5 for the average weekday, while in Tables 7-6 and 7-7, the most common unidirectional taxicab movements are ranked in order of their frequency of occurrence.

One noteworthy similarity between the two shared-ride taxi systems was the strong orientation toward residences. In each study area, most taxi trips were home-based. Trips directed to or from dwelling units accounted for 83 percent of the total on the average weekday in Davenport

TABLE 7-4

DISTRIBUTION OF BUS AND SHARED-RIDE TAXI TRIPS IN HICKSVILLE BY TRIP PURPOSE

Trip Purpose	Bus		Shared-Ride Taxi	
	Number	Percent	Number	Percent
First survey				
Work	251	51.6	86	56.2
School	24	4.9	4	2.6
Shopping	174	35.8	29	19.0
Social-recreation	11	2.3	11	7.2
Medical	10	2.1	9	5.9
Personal business	16	3.3	14	9.2
Unspecified	45	....	27	....
Second survey				
Work	505	69.5	23	48.9
School	57	7.8	2	4.3
Shopping	105	14.4	8	17.0
Social-recreation	15	2.1	2	4.3
Medical	10	1.4	4	8.5
Personal business	35	4.8	8	17.0
Unspecified	21	....	3	....

TABLE 7-5

AVERAGE WEEKDAY DISTRIBUTION OF SHARED-RIDE TAXI TRIPS BY TYPE OF ORIGIN AND DESTINATION

Facility or Land Use	Davenport		Hicksville	
	Percent of Origins	Percent of Destinations	Percent of Origins	Percent of Destinations
Residences	49.7	53.2	42.2	48.7
Major industries	0.1	0.2	0.3	0.5
Shopping centers	1.9	1.7	11.2	9.2
Taverns	7.1	3.6	1.7	1.2
Hotels-motels	4.5	2.7	1.2	0.9
Other businesses	18.5	27.5	7.9	10.8
Cab terminal	9.4	0.3	....	....
Rail stations	....	....	26.3	16.3
Other transportation facilities	1.4	1.6	1.0	2.0
Medical facilities	5.2	6.5	2.3	3.1
Schools	1.1	1.4	1.8	1.7
Other public facilities	0.9	1.3	4.2	5.7

TABLE 7-6

PRINCIPAL SHARED-RIDE TAXI MOVEMENTS ON WEEKDAYS
IN DAVENPORT

Origin	Destination	Average Trips Per Day	Percent of Trips
Residence	Residence	203	19.7
Residence	Misc. business	189	18.3
Misc. business	Residence	125	12.1
Cab terminal	Residence	78	7.6
Residence	Medical facility	50	4.9
Tavern	Residence	45	4.4
Medical facility	Residence	39	3.8
Misc. business	Misc. business	35	3.4
Hotel-motel	Misc. business	21	2.0

TABLE 7-7

PRINCIPAL SHARED-RIDE TAXI MOVEMENTS ON WEEKDAYS
IN HICKSVILLE

Origin	Destination	Average Trips Per Day	Percent of Trips
Rail station	Residence	135	19.4
Residence	Rail station	88	12.7
Shopping center	Residence	69	9.9
Residence	Shopping center	50	7.2
Residence	Residence	49	7.0
Residence	Misc. business	41	5.9
Misc. business	Residence	31	4.5
Residence	Misc. public facility	26	3.7
Rail station	Misc. business	21	3.0
Misc. public facility	Residence	19	2.7
Residence	Medical facility	14	2.0

and 84 percent in Hicksville. These findings, along with the relatively few trips originating or terminating at hotels and motels, suggest that local residents rather than tourists, visiting businessmen, and other transients comprised the major share of the market for shared-ride taxi service in both study areas.

Other areas in which the two systems exhibited a high degree of correspondence were characterized by a scarcity of demand. For example, industrial workers appeared to be a weak market to both shared-ride taxi systems as indicated by the inappreciable percentage of trips to and from industrial plants. Likewise, neither fleet was used to any considerable extent for connecting with other transportation facilities such as airports and intercity bus depots. The same was true with respect to educational facilities.

Other findings demonstrated substantial differences in the roles played by each shared-ride taxi system. The most frequent cab trips in Davenport were those between two residences and between residences and a myriad of relatively small retail, wholesale, financial, and service establishments. In Hicksville, however, a primary function of the shared-ride taxi system was that of a feeder service to the Long Island Railroad network, involving the collection of persons destined to one of the rail terminals and the distribution of rail passengers from a train station to dispersed destinations in the Hicksville area. On the average weekday, approximately 42 percent of the taxi trips were linked to the commuter rail system. The shared-ride taxi service in Hicksville was also engaged in a higher percentage of trips to and from major shopping centers.

Summary

Except for the movement of masses of commuters during the peak hours, the shared-ride taxi systems performed many of the functions of the bus systems, although not to the same degree. Whereas the demand for bus service was highly concentrated in the peak periods and showed considerable slack in the off-peak intervals, the demand for shared-ride taxi service was fairly uniformly distributed throughout the daylight hours. In Davenport the origins and destinations of taxi trips were more widely scattered and less oriented toward the CBD than those of bus trips. In both study areas, the relative frequency of trips for social-recreation, medical, and personal business purposes was greater for the shared-ride taxi service than for the bus service. Since off-peak and certain non-work trips tend to be less frequent and repetitive than peak-hour and work trips, the above findings suggest that the shared-ride taxis were used particularly for inhabitual or infrequent journeys. In Davenport, where cab trips were more highly dispersed spatially, the shared-ride taxi service appeared to have been useful for trips to locations relatively inaccessible or less easily accessible by bus.

The versatility of privately owned demand-responsive transportation was demonstrated by the discovery that the two shared-ride taxi fleets performed several dissimilar roles, reflecting differences in the characteristics of the two study areas. The Hicksville service, for example, was much more heavily oriented toward major activity centers such as the CBD and large shopping centers. The most distinctive function of this system was that of transporting individuals to and from the commuter railroad stations.

CHAPTER 8

ANALYSIS OF BUS AND SHARED-RIDE TAXI USERS

In comparing the characteristics of bus and shared-ride taxi trips, several dissimilarities were detected. Because of the disparity in the fare charged by each mode, further differences in the patterns of bus and shared-ride taxi usage might be expected to appear in the personal characteristics of bus and shared-ride taxi users. One common notion is the preconception that taxicabs attract a major portion of their patronage from the higher income segments of the population. However, other studies of taxicab usage, summarized in Chapter 2, have indicated that cab users come from a broad spectrum of social, demographic, and economic groups. A central task of this research, therefore, was to determine how the total market for public transportation has been segmented into the component markets for bus and shared-ride taxi service in each of the study areas.

The analysis of bus and shared-ride taxi users took two forms. The first was a univariate approach in which simple contingency table analyses were performed, involving the application of the chi-square test for each of several socioeconomic variables. The results of this analysis are presented in the first major subsection of this chapter. In the second approach, described in the second major subsection, a discriminant model of bus and shared-ride taxi usage was developed to determine the interrelationships of a variety of user and trip characteristics in distinguishing the markets for the two modes of public transportation. Both statistical techniques utilized the data collected

during the on-board surveys.

Market Composition

Comparison of Bus and Shared-Ride Taxi Users

Davenport. Table 8-1 summarizes the results of the two on-board surveys conducted in Davenport, comparing several characteristics of bus and shared-ride taxi passengers. For each categorical variable tabulated, the results of the chi-square tests are displayed in Table 8-2 along with the values of Goodman and Kruskal's tau, a measure of the strength of the observed relationships. The latter index, whose value varies between zero and one, is in some respects analogous to the product-moment correlation coefficient computed for data measured on an interval scale. If two categorical variables, such as household income and mode of public transportation used, are statistically independent, the value of tau will be zero; conversely, if a perfect relationship exists, tau will reach unity. Unlike measures of degree of association based on the chi-square statistic, Goodman and Kruskal's tau has a practical interpretation for intermediate values, since it denotes the proportional reduction in errors made in assigning individuals to various classes of the dependent variable when the category of the independent variable to which the individual belongs is known.

Sex, age, and distance from home to bus stop were the only areas in which significant differences between bus and shared-ride taxi users were consistently found. Women were the predominant users of both modes, but the shared-ride taxi system carried a significantly higher percentage of male passengers. Bus patrons tended to be older than taxi users; in

TABLE 8-1

SOCIOECONOMIC CHARACTERISTICS OF BUS AND SHARED-RIDE TAXI USERS IN DAVENPORT

	First Survey				Second Survey			
	Bus Users		Taxi Users		Bus Users		Taxi Users	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Sex								
Male	141	22.9	85	32.3	104	18.8	48	27.9
Female	476	77.1	178	67.7	449	81.2	124	72.1
Unspecified	66	....	5	....	2	....	8	....
Age								
Under 16	23	3.8	15	5.7	18	3.3	0	0.0
16 - 21	80	13.3	28	10.6	66	12.1	26	15.2
22 - 44	140	23.2	113	43.0	125	22.9	65	38.0
45 - 64	223	37.0	69	26.2	208	38.1	56	32.7
Over 64	137	22.7	38	14.4	129	23.6	24	14.0
Unspecified	80	....	5	....	9	....	9	....
Household income								
Under $5000	144	32.0	57	30.2	142	32.9	37	31.9
$5000 - $9999	151	33.6	59	31.2	144	33.3	42	36.2
$10,000 - $14,999	89	19.8	40	21.2	72	16.7	19	16.4
$15,000 - $19,999	50	11.1	22	11.6	50	11.6	11	9.5
$20,000 and over	16	3.6	11	5.8	24	5.6	7	6.0
Unspecified	233	....	79	....	123	....	64	....
Employed	401	65.6	160	61.3	375	68.8	110	65.9

TABLE 8-1 (Continued)

	First Survey				Second Survey			
	Bus Users		Taxi Users		Bus Users		Taxi Users	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Retired	81	13.4	26	10.1	87	16.2	19	11.4
Housewives	77	12.7	62	24.1	55	13.1	27	19.7
Students	64	10.6	22	8.6	73	14.2	8	5.4
Handicapped	...	....	...	....	27	5.0	15	8.8
Nondrivers	369	60.7	163	61.5	348	64.0	102	59.6
Household autos								
None	209	37.1	86	35.4	217	39.2	83	48.0
One	236	41.9	100	41.2	213	38.4	55	31.8
Two	90	16.0	44	18.1	93	16.8	29	16.8
Three or more	28	5.0	13	5.3	31	5.6	6	3.5
Unspecified	120	....	25	....	1	....	7	....
Distance from home to bus stop								
0 - 1 block	322	59.4	117	50.0	327	60.9	61	38.9
1 - 2 blocks	109	20.1	45	19.2	106	19.7	27	17.2
2 - 4 blocks	86	15.9	42	17.9	74	13.8	30	19.1
Over 4 blocks	25	4.6	30	12.8	30	5.6	39	24.8
Unspecified	141	....	34	....	18	....	23	....

TABLE 8-2

RESULTS OF TESTS FOR DIFFERENCES IN THE CHARACTERISTICS OF BUS AND SHARED-RIDE TAXI USERS IN DAVENPORT

	First Survey		Second Survey	
	Chi-Square Test Statistic	Goodman-Kruskal's Tau	Chi-Square Test Statistic	Goodman-Kruskal's Tau
Sex	8.66	0.010	6.56	0.009
Age	39.42	0.046	24.48	0.034
Household income	2.14	a	0.65	a
Employed	1.49	a	0.51	a
Retired	1.80	a	2.18	a
Housewives	17.24	0.020	3.56	a
Students	0.83	a	8.40	0.013
Handicapped	....	....	3.28	a
Nondrivers	0.05	a	1.04	a
Household autos	0.67	a	5.23	a
Distance from home to bus stop	18.59	0.024	58.56	0.084

[a]Chi-square test statistic not significant at 0.05 level.

particular, senior citizens comprised a much larger fraction of the bus system's ridership, possibly because of the reduced bus fare in effect for such persons. During the school year, the buses also transported a higher percentage of students. Bus users were more likely to reside within a block of a bus stop, whereas taxi users were more likely to live more than four blocks away; however, a majority of the passengers in both groups lived within reasonable walking distance from a bus route. Although statistically significant, all of the above relationships were relatively weak, as indicated by the extremely small values of Goodman and Kruskal's tau.

With the exception of the differences noted above, the composition of the markets for bus and shared-ride taxi service was remarkably similar. No statistically significant differences were detected relative to ability to drive, household income, employment status, number of autos available to the household, and physical handicap. Nondrivers constituted a major portion of each system's market. Though less than a majority, at least one-third of each mode's customers were unemployed; however, on the date of the first survey, the shared-ride taxi system transported a significantly higher percentage of housewives. Most bus and shared-ride taxi users belonged to households whose total annual income was less than $10,000; moreover, few came from multi-car families. Finally, whereas the bus system carried a larger number of passengers with physical handicaps, the taxis carried a higher, though not significantly different, percentage of such individuals.

Hicksville. Presented in Table 8-3 is a breakdown of the characteristics of bus and shared-ride taxi users in Hicksville. The outcomes of the univariate statistical tests for significant differences

TABLE 8-3

SOCIOECONOMIC CHARACTERISTICS OF BUS AND SHARED-RIDE TAXI USERS IN HICKSVILLE

	First Survey				Second Survey			
	Bus Users		Taxi Users		Bus Users		Taxi Users	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Sex								
Male	111	22.0	52	31.5	233	31.4	14	28.0
Female	394	78.0	113	68.5	509	68.6	36	72.0
Unspecified	26	....	15	....	6	....	0	....
Age								
Under 16	64	12.8	1	0.6	21	2.9	1	2.0
16 - 21	113	22.6	20	12.3	115	15.8	6	12.0
22 - 44	117	23.4	64	39.5	240	32.9	25	50.0
45 - 64	179	35.8	70	43.2	300	41.2	17	34.0
Over 64	27	5.4	7	4.3	53	7.3	1	2.0
Unspecified	31	....	18	....	19	....	0	....
Household income								
Under $5000	56	15.3	8	6.2	126	22.5	1	2.9
$5000 - $9999	88	24.0	27	20.9	129	23.0	6	17.1
$10,000 - $14,999	95	25.9	40	31.0	142	25.3	14	40.0
$15,000 - $19,999	78	21.3	29	22.5	110	19.6	9	25.7
$20,000 and over	50	13.6	25	19.4	54	9.6	5	14.3
Unspecified	164	....	51	....	187	....	15	....
Employed	292	58.1	121	72.0	544	78.8	30	63.8

TABLE 8-3 (Continued)

	First Survey				Second Survey			
	Bus Users		Taxi Users		Bus Users		Taxi Users	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Retired	31	6.3	5	3.0	26	3.8	1	2.1
Housewives	54	10.9	39	23.4	53	10.8	9	28.1
Students	134	27.1	5	3.0	90	14.6	5	10.6
Handicapped	...	....	...	....	23	3.1	2	4.1
Nondrivers	344	69.5	95	56.2	473	64.0	33	66.0
Household autos								
None	55	12.2	12	8.8	188	25.2	6	12.0
One	197	43.6	63	46.3	305	40.8	25	50.0
Two	142	31.4	47	34.6	193	25.8	14	28.0
Three or more	58	12.8	14	10.3	61	8.2	5	10.0
Unspecified	79	....	44	....	1	....	0	....
Distance from home to bus stop								
0 - 1 block	116	31.0	19	15.4	221	31.3	5	12.8
1 - 2 blocks	77	20.6	28	22.8	150	21.3	6	15.4
2 - 4 blocks	97	25.9	25	20.3	178	25.2	8	20.5
Over 4 blocks	84	22.5	51	41.5	156	22.1	20	51.3
Unspecified	157	....	57	....	43	....	11	....

between the two groups are displayed in Table 8-4.

The results for Hicksville were less consistent and less conclusive than those for Davenport because of discrepancies between samples for each mode and because of the smallness of the second sample of taxi users. Although both surveys revealed significant differences in the percentage of unemployed persons carried by each mode, the direction of these differences was reversed between the two sets of data; that is, in the first set of surveys, the buses carried the higher percentage of unemployed persons, whereas, in the second set, the taxis carried the higher percentage. The shared-ride taxi system, however, consistently transported a larger proportion of housewives. Taxi users also tended to have higher household incomes; in particular, they were more likely to come from households whose annual earnings exceeded $20,000, whereas bus users were more likely to belong to households with incomes under $5000. Despite these dissimilarities in household income, no significant differences were detected in a related area--the number of automobiles available to the household. Finally, as in Davenport, bus users tended to live closer to the bus routes than shared-ride taxi users; in particular, the former were more likely to reside within a block of a bus stop, whereas the latter were more likely to live more than four blocks away.

The data from the first set of on-board surveys distinguished bus users from shared-ride taxi users to a greater extent than the data from the second set. Although most of the passengers in each group were female, males were more likely to use the taxi. The bus system attracted a higher percentage of students and persons under 21 years of age in addition to a higher percentage of nondrivers. As indicated by

TABLE 8-4

RESULTS OF TESTS FOR DIFFERENCES IN THE CHARACTERISTICS OF BUS AND SHARED-RIDE TAXI USERS IN HICKSVILLE

	First Survey		Second Survey	
	Chi-Square Test Statistic	Goodman-Kruskal's Tau	Chi-Square Test Statistic	Goodman-Kruskal's Tau
Sex	6.14	0.009	0.25	a
Age	38.57	0.058	7.03	a
Household income	9.83	0.020	10.49	0.018
Employed	10.39	0.015	5.76	0.008
Retired	2.61	a	0.36	a
Housewives	15.93	0.024	8.64	0.017
Students	43.77	0.066	0.57	a
Handicapped	.....	.....	0.13	a
Nondrivers	9.92	0.015	0.08	a
Household autos	2.07	a	4.56	a
Distance from home to bus stop	21.96	0.044	18.40	0.025

[a]Chi-square test statistic not significant at 0.05 level.

the low values of Goodman and Kruskal's tau, however, these differences were not meaningfully large in terms of being useful for predicting modal choice.

Comparison of Shared-Ride Taxi Markets

As shown by the results of chi-square tests summarized in Table 8-5, the composition of each shared-ride taxi system's ridership differed in several respects, due to some extent to differences in the characteristics of each study area's population. The Davenport system, for example, carried a higher percentage of elderly persons; senior citizens, however, also represented a larger proportion of the population in Davenport than in Hicksville. Residents of the Hicksville area tended to have higher household incomes and to belong to multi-car families; congruently, the relative frequency of shared-ride taxi users from households in the upper income brackets and from multi-car families was greater in Hicksville. Because of the more limited coverage of the bus system in the Hicksville area, taxi users in that community tended to reside farther away from a bus stop. A comparison of the first taxi on-board surveys in each community also disclosed significant differences in the area of employment; specifically, Davenport's shared-ride taxi system transported a larger percentage of unemployed persons and retirees. The implication of these findings is that the market for shared-ride taxi service can be expected to vary among differing urban areas.

Discriminant Analysis of Bus and Shared-Ride Taxi Usage

The contingency table analyses whose results were discussed in the preceding section revealed only a few consistent, statistically significant relationships between the socioeconomic characteristics of the passenger

TABLE 8-5

RESULTS OF TESTS FOR DIFFERENCES IN THE CHARACTERISTICS OF SHARED-RIDE TAXI USERS IN DAVENPORT AND HICKSVILLE

	First Survey		Second Survey	
	Chi-Square Test Statistic	Goodman-Kruskal's Tau	Chi-Square Test Statistic	Goodman-Kruskal's Tau
Sex	0.03	a	0.00	a
Age	25.98	0.061	10.03	0.045
Household income	45.55	0.143	26.60	0.176
Employed	5.20	0.012	0.07	a
Retired	7.58	0.018	3.74	a
Housewives	0.03	a	1.05	a
Students	5.26	0.012	1.60	a
Handicapped	....	.....	1.18	a
Nondrivers	1.20	a	0.66	a
Household autos	37.17	0.098	22.06	0.099
Distance from home to bus stop	55.15	0.154	13.64	0.070

[a]Chi-square test statistic not significant at the 0.05 level.

and the mode of public transportation used. Moreover, most of these relationships were found to be relatively weak in terms of enabling one to accurately predict an individual's choice of mode on the basis of knowledge of any one of these characteristics. A linear combination of two or more of the above variables, however, may differentiate the two groups of public transportation users more effectively than any single variable. In order to discover the existence of such a multivariate relationship and to assess its predictive capabilities, the technique of discriminant analysis was performed on the samples of bus and shared-ride taxi trips obtained from the on-board surveys.

Review of Discriminant Analysis

Discriminant analysis is a sophisticated technique for classifying individuals into two or more distinct groups, using an optimally derived linear combination of the independent variables. The model resulting from a discriminant analysis might be applied to future cases or subjects as a method for predicting the group with which each is affiliated. In the context of this study, such a model would be used to predict an individual's choice of mode of public transportation. More fundamentally, a discriminant analysis discloses which variables or characteristics are effective in distinguishing between groups. Thus, a firm engaged in developing a market strategy for a new public transportation service might, on the basis of the results of a discriminant analysis, direct its advertising toward persons who exhibit the characteristics of those likely to use the service.

Subjects are classified into groups on the basis of a linear classification function involving the independent variables. In a

one-dimensional discriminant analysis for two groups, this function is developed through a least-squares procedure and takes the following form:

$$Y_i = k_1 X_{1i} + k_2 X_{2i} + \ldots + k_m X_{mi}.$$

In this formulation the X's correspond to the independent variables and the subscript "i" denotes the ith individual. Interpreted geometrically, the coefficients "k" are the direction cosines of the line which optimally discriminates the two groups, and the values of Y are the projections on this line of the vectors of independent variables, (X_{1i}, X_{2i}, . . . , X_{mi}). The parameters "k" are derived in such a manner that the probability of misclassifying an individual is minimized. Mathematically, this is accomplished by maximizing the ratio of the difference between the mean values of Y for each group and the pooled estimate of the variance of Y. An individual is classified into group 1 or group 2 depending on whether the value of the discriminant function, Y_i, for that individual lies closer to the mean value of Y for the first group or to the mean value of Y for the second.

A second approach, applicable to problems involving more than two groups, is more complicated and is based on the concept of Mahalanobis distance, a generalization of classical Pythagorean distance. Basically, the Mahalanobis D^2-statistic can be regarded as the square of the distance between two vectors or points in standardized space. Assuming that the variances of the independent variables and the covariances between independent variables are the same for each group, by manipulating the mathematical definition of Mahalanobis distance, a linear discriminant function of the following form can be derived for each group "g":

$$f(D_g^2) = b_0 + b_1X_1 + b_2X_2 + \ldots + b_mX_m.$$

To classify an individual, each function is first evaluated by substituting the observed values of the independent variables. The individual is then assigned to the group which corresponds to the function giving the highest value of $f(D_g^2)$. This method of classification is equivalent to that of assigning an individual to the nearest group in terms of Mahalanobis distance.

The approach described above can also be interpreted in terms of Bayes' Theorem. Given a vector $\underline{X}$ of observed values of the independent variables for some individual and P_1 and P_2, the prior or unconditional probabilities that the individual belongs to group 1 (G_1) and group 2 (G_2), respectively, Bayes' Theorem can be stated as follows:

$$\frac{P(G_1 \mid \underline{X})}{P(G_2 \mid \underline{X})} = \frac{P_1}{P_2} \cdot \frac{P(\underline{X} \mid G_1)}{P(\underline{X} \mid G_2)}.$$

The second factor on the right side of the equal sign is known as the likelihood ratio. Under the assumption that $\underline{X}$ was drawn from a multivariate normal distribution, it can be shown that the ratio

$$e^{f(D_1^2)} \Big/ e^{f(D_2^2)}$$

is the likelihood ratio in Bayes' Theorem. Hence, by adjusting for "a priori" probabilities, the set of discriminant functions of the above form can be used to determine the probability that a given individual belongs to a certain group.

The effectiveness of the discriminant model can be evaluated by means of both statistical criteria and predictive criteria. One of the

more common statistical indices, used to test the equality of the group means, is Wilks' Lambda or the U-statistic, which is normally converted into an approximate F-statistic. To determine the significance of differences between means for each pair of groups, an F-statistic directly proportional to the square of the Mahalanobis distance between the group means is calculated. To correctly apply these tests requires the assumption that observations were independently drawn from a multivariate normal distribution.

Perhaps the simplest measure of the model's performance is the percentage of individuals correctly classified. This criterion can be misleading, however, particularly in situations where the sample size of one group is exceedingly larger than that of the other group, since the model will tend to classify subjects into the larger group. Furthermore, when the same individuals used to derive the model's parameters are then classified, an upward bias results; that is, the model may appear to discriminate better than is actually the case. For this reason, the recommended procedure is to "split" the sample, using one set of observations to develop the discriminant functions and the second set to validate the model.

A discriminant analysis can be performed in a stepwise manner similar to that of a stepwise regression analysis. At each step, a variable is entered into or deleted from the model on the basis of its partial F-statistic. Using a stepwise procedure, one can determine the importance of each independent variable by itself, the relative importance of an independent variable as it is added to the model, and the overall importance of a subset of variables.

Procedure

The intent of this application of the discriminant analysis technique was to determine which subset of variables best differentiated bus users from shared-ride taxi users rather than to develop a traditional modal split model. Stated in another way, the primary objective was to determine the extent to which the two groups could be distinguished from each other.

Ten categorical variables, defined in Table 8-6, were chosen as the independent variables in the analysis. These were then transformed into twenty dichotomous or dummy variables. As indicated in the table, two groupings of variables were examined, one set involving characteristics of the passenger and the other involving characteristics of the trip. In one application of the technique, both sets of variables were used in order to ascertain the relative importance of trip and passenger characteristics in discriminating between bus and shared-ride taxi users. In a second application, only passenger-related variables were introduced into the model. Because categorical variables were involved, the results of tests of each model's statistical significance could be questioned, since the use of such variables automatically violates the assumption of multivariate normality. Hence, in evaluating the results of the discriminant analyses, greater emphasis was placed on the model's ability to classify bus and shared-ride taxi users correctly.

By means of the BMD07M stepwise discriminant analysis computer program, the models for Davenport were calibrated using the first on-board survey samples. The models were then validated by using the resultant sets of discriminant functions to classify the respondents in the second on-board surveys. In deriving the discriminant functions

TABLE 8-6

VARIABLES USED IN THE DISCRIMINANT ANALYSIS

Categorical Variable	Dummy Variable	Definition
Passenger-related		
Sex	1	0 - Male 1 - Female
Age	2	1 - Under 16 0 - Otherwise
	3	1 - 16-21 0 - Otherwise
	4	1 - 22-44 0 - Otherwise
	5	1 - 45-64 0 - Otherwise
Employment status	6	0 - Unemployed 1 - Employed
Household income	7	1 - Under $5000 0 - Otherwise
	8	1 - $5000-$9999 0 - Otherwise
	9	1 - $10,000-$14,999 0 - Otherwise
	10	1 - $15,000-$19,999 0 - Otherwise
Driver's license	11	0 - No 1 - Yes
Household autos	12	1 - None 0 - Otherwise
	13	1 - One 0 - Otherwise
	14	1 - Two 0 - Otherwise

TABLE 8-6 (Continued)

Categorical Variable	Dummy Variable	Definition
Distance between home and nearest bus stop	15	1 - One block or less 0 - Otherwise
	16	1 - Two blocks 0 - Otherwise
	17	1 - Three or four blocks 0 - Otherwise
Trip-related		
Trip purpose	18	0 - Nonwork 1 - Work
Period of day	19	0 - Offpeak period 1 - Peak period
Spatial orientation	20	0 - Between noncentral locations 1 - To or from CBD

from data collected in Hicksville, only bus and shared-ride taxi trips with both origin and destination in the study area were considered. Since the second on-board survey sample of bus passengers contained the larger number of internal trips, this sample was utilized in the calibration of the models. Likewise, because of its larger size, the first survey sample of shared-ride taxi users was chosen for the purpose of calibrating the discriminant functions. Both of these data sets were also used to evaluate the performance of the resulting models.

Results of Discriminant Analyses: Davenport

Model 1: Passenger and trip characteristics. Presented in Table 8-7 are the results of the discriminant analysis performed using both passenger-related and trip-related variables. Only the five dichotomous variables shown in the table contributed significantly toward differentiating between bus and shared-ride taxi users, based on the partial F-statistic, an indicator of the importance of a variable after the effects of previously entered variables have been controlled. The resultant model clearly indicated that bus and shared-ride taxi users were more distinguishable by the characteristics of their trips than by their personal characteristics.

The results of the discriminant analysis can be interpreted by comparing the magnitude of the two coefficients for each variable. Thus, with all other factors held constant, a trip origin and destination in the CBD enhanced the likelihood of the bus service being used because of the larger magnitude of the coefficient corresponding to the group of bus users. Similarly, the model indicated that individuals making a work trip or residing within one or two blocks of a bus stop were also more likely to use a bus, while persons between the ages of 22 and 44 were more likely to be cab users. Therefore, from the standpoint of being in agreement with both theoretical expectations and previous findings, the results of the first discriminant analysis were realistic. However, one noteworthy discrepancy between the model and previous analyses was the model's failure to incorporate into its structure the period of the day during which a trip was taken. One may recall that, in Davenport, taxi trips were rather uniformly distributed over time, whereas bus trips

TABLE 8-7

RESULTS OF DISCRIMINANT ANALYSIS FOR DAVENPORT BASED ON BOTH PASSENGER AND TRIP CHARACTERISTICS

Step Entered	Variable	Coefficients		Partial F
		Bus	Taxi	
1	20--Spatial orientation	3.90097	2.25867	44.12
2	4--22-44 age group	0.81356	2.21785	28.82
3	18--Trip purpose	3.24021	2.19492	17.63
4	15--One-block distance from bus stop	5.10984	4.03211	9.34
5	16--Two-block distance from bus stop	5.23672	4.40893	5.56

were more highly concentrated in the peak periods. Accounting for this time factor to some extent was the purpose of the trip, since work trips are commonly made during the peak periods. However, the absence from the model of the variable denoting the period of day was also very likely a consequence of the bias in the first sample of shared-ride taxi users. As noted in the discussion in Chapter 7 of the temporal patterns of bus and taxi usage, peak-hour cab trips were over-represented in each of the on-board survey samples.

The model's performance was evaluated by means of the classification matrix, which summarizes the number of correct and incorrect classifications for each group. Classification matrices for the two

on-board surveys are shown in Table 8-8. Although the model, which was calibrated using the data from the first bus and taxi surveys, correctly identified 76.1 percent of the respondents in those surveys, only 37.6 percent of the shared-ride taxi users were correctly classified. Prior odds, however, strongly favored the group of bus users, as indicated by the large disparity in the sample size of each group. In fact, if one were to randomly assign the respondents on the basis of "a priori" probabilities, one would expect to correctly classify 59.7 percent of them and only 7.8 percent of the shared-ride taxi users. Evaluated in this context, the model performed reasonably well. A more definitive measure of the model's predictive capability, however, would be its degree of accuracy in classifying new individuals. Table 8-8 shows that 77.1 percent of all respondents and 36.0 percent of the cab users in the second data set were correctly identified, virtually the same results as those obtained for the data set used to calibrate the model.

Model 2: Passenger characteristics only. In the second application of the stepwise discriminant analysis technique, only passenger-related variables were allowed to enter the model. As indicated in Table 8-9, only four variables exhibited a significant relationship with modal choice. An examination of the model's coefficients revealed that an individual's likelihood of being a bus user was enhanced if he or she resided within one or two blocks of a bus stop or was employed. Conversely, the probability of being a patron of the shared-ride taxi service was increased if the person was between 22 and 44 years of age.

TABLE 8-8

CLASSIFICATION MATRICES FOR DAVENPORT MODEL DERIVED FROM BOTH PASSENGER AND TRIP CHARACTERISTICS

Actual Group	Predicted Group		Total
	Bus	Taxi	
First survey			
Bus	312	31	343
Taxi	83	50	133
Total	395	81	476
Second survey			
Bus	345	55	400
Taxi	57	32	89
Total	402	87	489

Three of the four variables in the second model had also appeared in the first. Interestingly, the chi-square tests described earlier in the chapter had not detected a significant relationship between the "extra" variable, employment status, and mode of public transportation used. This was also the case in the stepwise discriminant analysis which showed that employment status by itself was a poor discriminator, having a partial F-statistic of 1.53 (insignificant at the 0.05 level). Only after the effects of age had been controlled did employment status become important, its partial F-statistic

TABLE 8-9

RESULTS OF DISCRIMINANT ANALYSIS FOR DAVENPORT BASED ON PASSENGER CHARACTERISTICS ONLY

Step Entered	Variable	Coefficients		Partial F
		Bus	Taxi	
1	4--22-44 age group	0.67441	2.01675	29.99
2	15--One-block distance from bus stop	4.74000	3.84056	7.30
3	6--Employment status	3.29832	2.70528	5.40
4	16--Two-block distance from bus stop	5.15171	4.43794	4.63

increasing to 5.58. Similarly, the fourth variable to enter the model, two-block distance from a bus stop, did not attain significance until the effects of the first three variables had been taken into account.

The classification matrices are shown in Table 8-10. In terms of classifying shared-ride taxi users, the second model was less accurate than the first. Although correctly identifying 74.6 percent of the respondents in the first data set, upon which it was calibrated, and 80.4 percent of the respondents in the second data set, the second model accurately placed only 24.1 percent and 19.1 percent, respectively, of the cab passengers. These observations further supported the conclusion that, in Davenport, the mode of public transportation chosen was less a function of the characteristics of the individual than a

TABLE 8-10

CLASSIFICATION MATRICES FOR DAVENPORT MODEL DERIVED FROM PASSENGER CHARACTERISTICS ONLY

Actual Group	Predicted Group		Total
	Bus	Taxi	
First survey			
Bus	323	20	343
Taxi	101	32	133
Total	424	52	476
Second survey			
Bus	376	24	400
Taxi	72	17	89
Total	448	41	489

function of the characteristics of the trip.

Results of Discriminant Analyses: Hicksville

Model 1: Passenger and trip characteristics. The results of the first discriminant analysis of the Hicksville data are presented in Table 8-11. The Hicksville model developed from the full set of variables differed from the corresponding model for Davenport in the types of personal characteristics which best differentiated bus users from shared-ride taxi users. According to the discriminant coefficients, persons from households with an aggregate income under $5000 were more

TABLE 8-11

RESULTS OF DISCRIMINANT ANALYSIS FOR HICKSVILLE BASED ON BOTH PASSENGER AND TRIP CHARACTERISTICS

Step Entered	Variable	Coefficients		Partial F
		Bus	Taxi	
1	20--Spatial orientation	2.40589	0.75649	49.64
2	7--Household income under $5000	1.89752	1.05454	8.61
3	11--Possession of driver's license	1.49935	2.19860	6.23
4	18--Trip purpose	3.10068	2.44725	5.85

likely to use the bus service, while persons possessing a driver's license were more likely to engage a cab. Each of these two variables was significant by itself and with the effects of the other three variables included.

The model reflected a serious flaw in the sample of shared-ride taxi passengers. As was reported in Chapter 7, taxi trips to or from the Hicksville CBD were grossly undersampled for unknown reasons in each of the on-board surveys. Whereas the cab company's dispatching records for the date of the first survey indicated that 67.5 percent of the system's trips were oriented toward the community's center, only 18.8 percent of the trips in the survey sample, used to calibrate the model, originated or terminated there. Since 57.0 percent of the sampled

bus trips were CBD-oriented, spatial orientation naturally became a highly significant discriminator. The effect of removing this variable from the analysis will be seen in the model derived from passenger characteristics only, to be discussed subsequently.

The first Hicksville model did not perform as well as the corresponding model for Davenport. As evidenced by the classification matrix in Table 8-12, the model was extremely accurate with respect to bus users but highly inaccurate with respect to cab users, correctly identifying only 16.8 percent of the latter. By comparison, 6.1 percent was the proportion of shared-ride taxi patrons who could be expected to be correctly classified if all the respondents in the data set were randomly assigned on the basis of "a priori" probabilities. The results of the classification procedure demonstrated not only the disparity in the size of each sample but the similarity of the two groups as well.

Model 2: Passenger characteristics only. Of the passenger-related variables, the most consequential discriminators were those shown in Table 8-13. Only variables 11 and 7 were important by themselves. Employment status became significant only after the effect of possession or non-possession of a driver's license was taken into account, and the "distance" variable became significant only after the first two variables were included. According to the model's coefficients, the probability of being classified as a bus user was increased by belonging to a household whose annual earnings totaled less than $5000, by being employed, and by residing three or four blocks from a bus stop; conversely, possessing a driver's license enhanced the likelihood of being classified as a cab user.

TABLE 8-12

CLASSIFICATION MATRIX FOR HICKSVILLE MODEL DERIVED FROM BOTH PASSENGER AND TRIP CHARACTERISTICS

Actual Group	Predicted Group		Total
	Bus	Taxi	
Bus	297	10	307
Taxi	84	17	101
Total	381	27	408

TABLE 8-13

RESULTS OF DISCRIMINANT ANALYSIS FOR HICKSVILLE BASED ON PASSENGER CHARACTERISTICS ONLY

Step Entered	Variable	Coefficients		Partial F
		Bus	Taxi	
1	11--Possession of driver's license	0.94735	1.72411	10.85
2	7--Household income under $5000	2.13531	1.24051	6.91
3	6--Employment status	4.97096	4.34966	4.29
4	17--Three or four blocks from bus stop	1.62945	1.06017	3.96

As Table 8-14 clearly indicates, the second model placed nearly all of the respondents in the data set into the group of bus users. More notably, the model correctly identified only 5.9 percent of the taxi users, compared to the 6.1 percent which could be expected if all respondents were randomly assigned on the basis of prior odds. In comparing the performance of this model with that of the first, it is apparent that the socioeconomic, demographic, and other personal variables used, as operationally defined for this analysis, were poor indicators of modal choice in Hicksville.

Summary

The shared-ride taxi systems attracted a wide variety of customers and nearly the same types of people as the bus systems. In Davenport more than two-thirds of both the bus and taxi users were women, although the taxi system carried a significantly higher percentage of male passengers. Bus patrons in Davenport tended to be older than their taxi counterparts, and during the school year the bus system carried a significantly greater percentage of students. On the other hand, the Davenport taxi system's ridership included a higher proportion of housewives. In terms of ability to drive, household income, employment status, household auto ownership, and physical handicap, however, no statistically significant differences were detected in the market composition of each mode. In Hicksville the bus system attracted a slightly higher percentage of nondrivers and persons under 21 years of age, while the shared-ride taxi system carried a higher proportion of male passengers, housewives, and persons from households with aggregate annual incomes exceeding $10,000. Although statistically significant,

TABLE 8-14

CLASSIFICATION MATRIX FOR HICKSVILLE MODEL DERIVED FROM PASSENGER CHARACTERISTICS ONLY

Actual Group	Predicted Group		Total
	Bus	Taxi	
Bus	302	5	307
Taxi	95	6	101
Total	397	11	408

the above variations were not large enough to be especially useful for predicting modal choice. In fact, one major result of the discriminant analyses of bus and shared-ride taxi usage performed for each study area was the finding that trip characteristics differentiated bus users from cab users more successfully than the socioeconomic, demographic, and other characteristics of the passengers.

CHAPTER 9

EXTENT OF INDIVIDUAL USAGE OF THE BUS AND SHARED-RIDE TAXI SYSTEMS

Thus far, the demand for bus and shared-ride taxi service has been analyzed in terms of travel patterns and market composition. Another important aspect is the frequency, both relative and absolute, with which each form of public carriage is utilized. In the mail surveys and home interviews, the question of degree of utilization was specifically addressed by having the respondents tabulate the number of trips taken during the previous week by mode and by trip purpose. From this enumeration of trips, it was possible to compare bus users with shared-ride taxi users in terms of the frequency with which they used a bus or a cab, their dependence upon public transportation, and their overall mobility.

Frequency of Utilization

Tables 9-1 and 9-2 reveal how often bus users and shared-ride taxi users in Davenport and Hicksville, respectively, traveled via their respective modes of public transportation over the period of a week. In both study areas, bus users tended to utilize the bus service more frequently than shared-ride taxi users utilized a cab. In Davenport the median number of bus trips per week was 5.8, compared to only 1.75 taxi trips. Similarly, in Hicksville the median number of trips per week made by individual users was 8.9 via the bus and 1.5 via the taxi.

TABLE 9-1

FREQUENCY OF UTILIZATION OF THE BUS AND SHARED-RIDE TAXI SYSTEMS IN DAVENPORT

Total Trips per Week by Bus or Taxi	Bus Users		Taxi Users	
	Number	Percent	Number	Percent
0	23	6.1	45	30.8
1 - 2	40	10.6	32	21.9
3 - 4	56	14.8	15	10.3
5 - 6	80	21.1	22	15.1
7 - 8	32	8.4	9	6.2
9 - 10	61	16.1	14	9.6
11 - 12	35	9.2	3	2.1
13 - 14	20	5.3	1	0.7
15 - 16	15	4.0	2	1.4
17 - 18	5	1.3	2	1.4
19 - 20	3	0.8	0	0.0
Over 20	9	2.4	1	0.7
Total	379	100.0	146	100.0

Kolmogorov - Smirnov Test:
Test statistic, D = 0.361
Critical D (0.05 level) = 0.132

TABLE 9-2

FREQUENCY OF UTILIZATION OF THE BUS AND SHARED-RIDE TAXI SYSTEMS IN HICKSVILLE

Total Trips per Week by Bus or Taxi	Bus Users		Taxi Users	
	Number	Percent	Number	Percent
0	12	3.8	28	31.5
1 - 2	28	8.8	22	24.7
3 - 4	21	6.6	13	14.6
5 - 6	53	16.7	8	9.0
7 - 8	29	9.1	2	2.2
9 - 10	81	25.5	12	13.5
11 - 12	28	8.8	0	0.0
13 - 14	11	3.5	1	1.1
15 - 16	14	4.4	0	0.0
17 - 18	4	1.3	0	0.0
19 - 20	15	4.7	1	1.1
Over 20	22	6.9	2	2.2
Total	318	100.0	89	100.0

Kolmogorov - Smirnov Test:
Test statistic, D = 0.516
Critical D (0.05 level) = 0.163

Relative Usage

As a result of their more frequent utilization of their selected mode of public transportation, bus users tended to make a higher percentage of trips by bus than shared-ride taxi users relative to the cab service. Table 9-3 shows that 58.8 percent of the bus riders but only 31.6 percent of the taxi riders in Davenport traveled via their respective modes for more than half of their trips. Whereas more than 50 percent of the taxi users made less than 30 percent of their trips by cab, a majority of the bus riders utilized the bus system for over 60 percent of their trips. Furthermore, a larger percentage of the bus users were totally reliant upon their chosen mode, although a substantial percentage of the taxi users were also completely reliant upon the shared-ride taxi system. Similar observations were made from Table 9-4 for Hicksville, where 59.1 percent of the bus users and 22.4 percent of the taxi users made a majority of their trips by means of their respective modes of public transportation.

The above findings imply that bus users were generally more dependent upon public transportation. In particular, the buses appeared to transport a higher proportion of so-called captive riders, persons who have no alternative means for traveling other than some form of public conveyance. In general, to most users the local bus system functioned as their primary mode of transportation, whereas to most taxi users the shared-ride taxi system performed as a secondary or auxiliary means of travel, although for particular trips the taxi may have been used as the primary mode.

TABLE 9-3

RELATIVE USAGE OF THE BUS AND SHARED-RIDE TAXI SYSTEMS IN DAVENPORT

Percent of All Trips by Bus or Taxi	Bus Users		Taxi Users	
	Number	Percent	Number	Percent
0 - 10	30	7.7	55	37.7
11 - 20	27	6.9	15	10.3
21 - 30	32	8.2	11	7.5
31 - 40	34	8.7	6	4.1
41 - 50	38	9.7	13	8.9
51 - 60	21	5.4	3	2.1
61 - 70	25	6.4	8	5.5
71 - 80	29	7.4	1	0.7
81 - 90	22	5.6	3	2.1
91 - 99	5	1.3	0	0.0
100	128	32.7	31	21.2
Total	391	100.0	146	100.0

Kolmogorov - Smirnov Test:
Test statistic, D = 0.333
Critical D (0.05 level) = 0.132

TABLE 9-4

RELATIVE USAGE OF THE BUS AND SHARED-RIDE TAXI SYSTEMS IN HICKSVILLE

Percent of All Trips by Bus or Taxi	Bus Users		Taxi Users	
	Number	Percent	Number	Percent
0 - 10	23	7.2	44	49.4
11 - 20	26	8.1	7	7.9
21 - 30	27	8.4	8	9.0
31 - 40	27	8.4	4	4.5
41 - 50	28	8.8	6	6.7
51 - 60	24	7.5	0	0.0
61 - 70	15	4.7	5	5.6
71 - 80	20	6.3	0	0.0
81 - 90	17	5.3	1	1.1
91 - 99	10	3.1	0	0.0
100	103	32.2	14	15.7
Total	320	100.0	89	100.0

Kolmogorov - Smirnov Test:
Test statistic, D = 0.425
Critical D (0.05 level) = 0.163

Overall Mobility

Tables 9-5 and 9-6 contain frequency distributions of total trips per week made by bus and shared-ride taxi users on all modes combined. Despite differences in the relative usage of each mode of public transportation, the propensity of bus and shared-ride taxi users to travel within the study area was virtually the same for both groups. In Davenport the median number of total trips per week was 11.8 for bus users and 10.1 for shared-ride taxi users, while in the Hicksville area, the median number of total trips per week was 14.3 for bus patrons and 15.3 for taxi users.

Within both groups, overall mobility was related to the degree of dependence on the selected mode of public transportation. Table 9-7 shows that, as the level of utilization of either the bus or the taxi rose, the propensity to travel fell. Thus, persons who were highly reliant upon public transportation, regardless of its form, exhibited a marked tendency to travel less often than persons who utilized the bus and shared-ride taxi systems less intensively.

Summary

The preceding analyses provided further insight into the nature of the markets for each of the two types of public carriage. The shared-ride taxi systems, for example, were especially useful to residents who only occasionally either needed or preferred to use public transportation, although a substantial percentage of each cab system's customers depended on the taxi for a major portion of their transportation needs. To the bus patrons, however, who tended to make a higher percentage of their

TABLE 9-5

PROPENSITY OF BUS AND SHARED-RIDE TAXI USERS
IN DAVENPORT TO TRAVEL

Total Trips per Week	Bus Users		Taxi Users	
	Number	Percent	Number	Percent
1 - 2	12	3.1	7	4.8
3 - 4	29	7.4	13	8.9
5 - 6	41	10.5	20	13.7
7 - 8	23	5.9	10	6.8
9 - 10	46	11.8	22	15.1
11 - 12	49	12.5	17	11.6
13 - 14	44	11.3	8	5.5
15 - 16	23	5.9	4	2.7
17 - 18	28	7.2	11	7.5
19 - 20	22	5.6	5	3.4
21 - 22	15	3.8	5	3.4
23 - 24	15	3.8	3	2.1
25 - 26	8	2.0	2	1.4
27 - 28	9	2.3	3	2.1
29 - 30	7	1.8	2	1.4
31 - 32	6	1.5	3	2.1
33 - 36	7	1.8	3	2.1
37 - 40	0	0.0	3	2.1
41 - 50	4	1.0	5	3.4
Over 50	3	0.8	0	0.0
Total	391	100.0	146	100.0

Kolmogorov - Smirnov Test:
Test statistic, D = 0.107
Critical D (0.05 level) = 0.132

TABLE 9-6

PROPENSITY OF BUS AND SHARED-RIDE TAXI USERS
IN HICKSVILLE TO TRAVEL

Total Trips per Week	Bus Users		Taxi Users	
	Number	Percent	Number	Percent
1 - 2	8	2.5	4	4.5
3 - 4	8	2.5	11	12.4
5 - 6	21	6.6	5	5.6
7 - 8	9	2.8	2	2.2
9 - 10	48	15.0	7	7.9
11 - 12	35	10.9	7	7.9
13 - 14	28	8.8	6	6.7
15 - 16	18	5.6	4	4.5
17 - 18	13	4.1	4	4.5
19 - 20	20	6.3	1	1.1
21 - 22	20	6.3	6	6.7
23 - 24	15	4.7	1	1.1
25 - 26	12	3.8	4	4.5
27 - 28	8	2.5	4	4.5
29 - 30	11	3.4	3	3.4
31 - 32	8	2.5	5	5.6
33 - 36	12	3.8	3	3.4
37 - 40	3	0.9	2	2.2
41 - 50	14	4.4	4	4.5
Over 50	9	2.8	6	6.7
Total	320	100.0	89	100.0

Kolmogorov - Smirnov Test:
Test statistic, D = 0.119
Critical D (0.05 level) = 0.163

TABLE 9-7

RELATIONSHIP BETWEEN RELATIVE USAGE OF THE BUS OR THE SHARED-RIDE TAXI AND THE PROPENSITY TO TRAVEL

Percent of All Trips by Bus or Taxi	Median Total Trips Per Week			
	Davenport		Hicksville	
	Bus Users	Taxi Users	Bus Users	Taxi Users
0 - 25	17.5	12.6	21.5	19.5
26 - 50	15.1	11.0	21.6	14.0
51 - 75	12.6	8.0	16.5	15.0
76 - 100	8.9	8.0	10.2	4.5

trips by public transportation, the bus service was more often the principal mode of travel; consequently, this system was generally used more frequently by individual riders than the shared-ride taxi. Nevertheless, in terms of total trips irrespective of mode, both groups exhibited virtually the same propensity to travel, with those persons most reliant upon either the bus or the taxi making the fewest trips altogether.

CHAPTER 10

ANALYSIS OF THE CHOICE OF MODE OF PUBLIC TRANSPORTATION

The third major objective of this research was to explore the factors and circumstances which influence public transportation users in choosing between the bus and the shared-ride taxi. In previous analyses several possible factors, including level of service, price, trip purpose, location of origin and destination, time of day, and household income, were examined in another context. It was discovered, for example, that among the apparent effects of the disparity in the fare charged by each mode were the heavier demand for and more frequent utiliziation of the bus service. Nevertheless, considerable overlap was found in the markets for each type of public transportation; moreover, many of the trips which were taken by taxi could conceivably have been made by bus.

The choice of mode of public transportation was studied from the standpoints of the initial use of the mode and the basis for the persistent use of the selected mode. In the latter approach, a descriptive model of the modal choice decision process as formulated by Lovelock (Lovelock, 1972, pp. 48-60) proved to be useful. According to this model, the consumer in deciding to make a trip first specifies the characteristics of the trip and the modal attributes required for the trip. The consumer then selects for evaluation one or more modes of transportation from a mental "modal pool" with the number and types of modes selected contingent upon the personal characteristics of the consumer, his or her past experience with and knowledge of available

modes, and his or her values and attitudes. In the evaluation stage, the perceived characteristics of each selected alternative are compared with the ideal modal attributes, and the most suitable means of travel is chosen. In the event that no mode is suitable, the consumer may either revise the perceived modal requirements of the trip and repeat the process or decide to forego the trip. The process as it is represented by the model may seem cumbersome. However, Lovelock notes that the consumer "may not actually be aware of each stage in this process, particularly for trips of a repetitive nature where he may be content to maintain an habitual behavioral pattern based upon an earlier decision" (Lovelock, 1972, p. 50). Although the premises of the above model were not tested in this research, the conceptual basis of the model was used as a framework for studying the decision to use either the bus or the shared-ride taxi. In the analysis of the basis for an individual's modal preference, the fundamental purpose was to determine the relative importance of various modal attributes in the evaluation stage of the modal choice decision process.

Initial Use of the Bus and Shared-Ride Taxi

Extent of User Experience

In the second mail surveys and the home interviews, respondents were asked to indicate how long they had been using either the bus or the shared-ride taxi service. The resulting distributions of their responses are displayed in Table 10-1. Because of the exceedingly small number of replies, the second mail survey of taxi users in Hicksville was excluded from the analysis.

TABLE 10-1

EXTENT OF USER EXPERIENCE WITH THE BUS AND SHARED-RIDE TAXI SYSTEMS

Years of Regular Use	Davenport				Hicksville			
	Bus System		Taxi System		Bus System		Taxi System	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Mail survey								
0 - 2	63	21.6	10	29.4	97	31.9	....	....
3 - 6	45	15.5	10	29.4	77	25.3	....	....
7 - 10	28	9.6	6	17.6	38	12.5	....	....
11 - 20	44	15.1	2	5.9	65	21.4	....	....
Over 20	111	38.1	6	17.6	27	8.9	....	....
Household survey								
0 - 2	27	20.3	23	22.1	12	30.8	23	31.9
3 - 6	20	15.0	32	30.8	13	33.3	23	31.9
7 - 10	23	17.3	15	14.4	5	12.8	10	13.9
11 - 20	15	11.3	15	14.4	7	17.9	13	18.1
Over 20	48	36.1	19	18.3	2	5.1	3	4.2

Cab users in Davenport tended to be relative newcomers to the shared-ride taxi system. More notably, a majority of them had begun to use the service in the six years between the acquisition of the fleet by the present owner and the conduct of this study. In that period, during which annual taxi ridership increased nearly 180 percent, the cab company under its new management apparently had attracted a sizeable number of new customers in addition to possibly recapturing many former users. By contrast, bus users were more likely to have been steady customers of the bus service for longer periods of time. Over one-third of the transit riders had established their practice of using the bus well in the past.

In Hicksville no statistically significant differences were detected between bus and taxi users relative to the extent of their experience with their respective modes. A large percentage in each group consisted of recent customers, persons who had begun patronizing either the bus or the taxi service within the last six years. Compared to Davenport, relatively few were long-term users of either form of public carriage.

Age at the Time of Initial Use

Table 10-2 indicates that most individuals started traveling by bus or by taxi prior to reaching middle age. In Davenport bus riders were much more likely to have begun using public transportation during childhood and adolescence. Since they also tended to be older than shared-ride taxi users, use of the Davenport bus service was a particularly well-established practice of many of the bus riders. From the standpoint of statistical significance, however, the results were less

TABLE 10-2

AGE AT THE TIME THE BUS OR SHARED-RIDE TAXI WAS INITIALLY USED

Age When First Used	Davenport				Hicksville			
	Bus System		Taxi System		Bus System		Taxi System	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Mail survey								
Under 22	99	34.0	6	17.6	61	19.9	....	....
22 - 44	107	36.8	17	50.0	156	50.8	....	....
45 - 64	66	22.7	10	29.4	83	27.0	....	....
Over 64	19	6.5	1	2.9	7	2.3	....	....
Household survey								
Under 22	59	44.4	22	21.2	14	35.9	11	15.1
22 - 44	43	32.3	51	49.0	16	41.0	37	50.7
45 - 64	24	18.0	22	21.2	6	15.4	24	32.9
Over 64	7	5.3	9	8.7	3	7.7	1	1.4

definitive than the tabulated percentages may seem to indicate. In comparing the mail survey samples of bus and taxi users in Davenport, no significant differences were detected by the chi-square test; conversely, when applied to the household survey data, the test yielded a significant value for the chi-square statistic. Inconsistent results were also obtained from the Hicksville data in that the two surveys of bus riders gave somewhat different distributions of responses. Nevertheless, all the samples indicated that the initial decision to use either the bus or the taxi was usually made at a fairly early age.

Ability to Drive

As Table 10-3 indicates, most respondents did not possess a driver's license at the time they began using either the bus or the taxi. With the exception of the household survey samples from Hicksville, the chi-square tests performed on the various samples of bus and taxi users did not detect any significant differences between the two groups in terms of ability to drive at the time of initial use. For the most part, the percentages of originally unlicensed bus and taxi users shown in the table were either virtually the same as or slightly above the percentages of nondrivers found in the on-board survey samples, implying that most bus and taxi users who were nondrivers originally tended to remain as such.

Other Factors Involved in the Initial Modal Choice Decision

Based on extemporaneous interviews with bus and taxi riders and a review of the literature on modal choice behavior, a series of statements was developed, embracing a variety of possible reasons for starting to use either the bus or the shared-ride taxi. A separate set

TABLE 10-3

ABILITY TO DRIVE AT THE TIME OF INITIAL USE

Possession of Driver's License	Davenport				Hicksville			
	Bus System		Taxi System		Bus System		Taxi System	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Mail survey								
Licensed	98	33.2	10	28.6	94	31.0	....	....
Unlicensed	197	66.8	25	71.4	209	69.0	....	....
Household survey								
Licensed	43	32.1	36	34.6	9	23.1	25	33.8
Unlicensed	91	67.9	68	65.4	30	76.9	49	66.2

of responses was prepared for each mode. Basically, these statements collectively embodied a number of general factors which potentially could have induced an individual to begin using either the bus or the shared-ride taxi service. The affordability and availability of alternative modes were two such factors. Changes in an individual's environment or customary pattern of activities such as those resulting from a new place of residence or a new job may also have necessitated a change in travel behavior. Still another inducement to begin using either the bus or the taxi might have been dissatisfaction or disenchantment with another mode of transportation caused by traffic conditions, increased cost of utilization, or general deterioration in the quality of the service. In the mail surveys and home interviews, respondents were presented with the appropriate set of possible responses and were requested to check all that applied in their case. The results are displayed in Table 10-4 for the bus systems and Table 10-5 for the shared-ride taxi systems.

In Davenport the most common reason underlying the initial use of the bus service -- the only reason cited by a majority of the respondents in both surveys -- was the relatively easy access to the system from the user's home. A related item, the proximity of the service to the user's place of employment, was second in importance and was specified by a slight majority of the respondents in the mail survey. Also frequently mentioned was the inability to operate an automobile, although the number of bus users responding to this item was less than had been expected, since two-thirds of the respondents did not possess a driver's license at the time they began utilizing the transit system. Likewise, the affordability of the bus, although ranking fourth in importance, received less emphasis than had been predicted beforehand. Of the remaining items, all of

TABLE 10-4

REASONS FOR STARTING TO USE THE BUS SERVICE

Response	Davenport				Hicksville			
	Mail Survey		Household Survey		Mail Survey		Household Survey	
	Rank	Percent of Respondents	Rank	Percent of Respondents	Rank	Percent of Respondents	Rank	Percent of Respondents
Only affordable mode	4	39.9	4	34.3	3	43.1	3	36.8
Unable to drive	3	45.6	3	45.5	2	49.3	1	60.5
Family car unavailable	6	21.6	5	20.9	5	27.1	6	18.4
Residence near bus stop	1	68.9	1	69.4	1	52.9	2	50.0
Place of work near bus stop	2	56.4	2	47.0	4	38.9	4	31.6
Unable to car pool	7	19.6	6	20.1	6	20.3	5	28.9
Change of job	11	9.8	10	8.2	10	9.5	11	7.9
Change of residence	8	17.9	8	14.2	8	16.0	7T	13.2
No longer able to drive	13	3.0	13	6.0	13	1.6	12	5.3
No longer preferred to drive in heavy traffic	10	10.5	11T	7.5	11T	6.2	13	2.6
Dislike of taxi service	9	16.9	9	10.4	9	11.4	7T	13.2
No longer preferred to use taxi	12	6.4	11T	7.5	11T	6.2	10	10.5
Other	5	22.3	7	16.4	7	19.6	7T	13.2

T denotes a tie.

TABLE 10-5

REASONS FOR STARTING TO USE THE SHARED-RIDE TAXI SERVICE

Response	Davenport				Hicksville Household Survey	
	Mail Survey		Household Survey			
	Rank	Percent of Respondents	Rank	Percent of Respondents	Rank	Percent of Respondents
Car unaffordable	3T	25.7	5	17.9	10T	4.1
Unable to drive	2	40.0	1	35.8	1	54.8
Family car unavailable	7T	11.4	6	16.0	2	28.8
Worked at night when buses were not operating	5	20.0	3	21.7	8T	5.5
Change of job; bus no longer convenient	9T	8.6	12	5.7	13T	1.4
Change of residence; bus no longer convenient	6	17.1	10T	6.6	6	13.7
Previously used bus route discontinued	9T	8.6	13T	4.7	7	6.8
Dislike of bus service	9T	8.6	7	14.2	5	15.1
Increase in bus fare	15	0.0	15	3.8	13T	1.4
No longer preferred the bus	13T	2.9	10T	6.6	13T	1.4
Concern over personal safety while waiting for a bus	7T	11.4	9	7.5	8T	5.5
No longer preferred to drive in heavy traffic	12	5.7	13T	4.7	10T	4.1
No longer able to drive	13T	2.9	8	10.4	10T	4.1
Unable to car pool	3T	25.7	4	18.9	4	26.0
Other	1	42.9	2	34.9	3	27.4

T denotes a tie.

which were noted by fewer than one-fourth of the bus users, the most frequently cited were the unavailability of the family car and the inability to car pool. However, a large number of bus users signified that reasons different from those presented to them were involved in their original decision to use the bus. These reasons, where specified, were highly individualized and, hence, difficult to categorize.

There were no outstanding reasons for starting to utilize the shared-ride taxi service in Davenport. In fact, many of the taxi users provided their own special reasons, often expressions of a preference for the taxi over the bus. Of the structured responses, inability to drive was most frequently specified. Factors related to the bus service were only occasionally mentioned. A few respondents began taking a taxi because the bus system was not as easily accessible from their new home or from their new place of employment. Many more, however, had worked in the evening when the bus system was not operating and, lacking other alternatives, had engaged a taxi for their trip to work.

In Hicksville the reasons for starting to travel by bus were ranked in nearly the same order as in Davenport. Perhaps because of the more limited areal coverage of the bus system in the Hicksville area, accessibility to the service, both from the home and from the place of work, was not as highly influential. In regards to the shared-ride taxi systems, however, there was considerable disagreement between the two study areas. Most notably, a considerably higher percentage of the taxi users in Hicksville cited their inability to drive and the unavailability of an automobile at the time when the system was first used; conversely, a much smaller percentage had been unable to afford an automobile or had been forced to use the taxi for the trip to work because the bus

system was not in operation. As in Davenport, however, factors related to the bus system were, for the most part, inconsequential.

Mode Switching

Of special concern to this study was the degree to which the improved taxi service in Davenport had induced bus patrons to switch from the bus to the taxi. Fostering this interest in the incidence of mode switching were the recent trends in the annual ridership on the bus and shared-ride taxi systems. Specifically, between 1967, when the taxi fleet was acquired by the present owner, and 1972 annual ridership on the shared-ride taxi system had increased approximately 179 percent. During this same period, annual ridership on the Davenport bus system had declined nearly 50 percent. Although by no means conclusive, these trends strongly suggested that the phenomenon of mode switching may have occurred to a considerable extent. From the examination of the reasons for starting to utilize the cab service, it was apparent that changes in the bus service or in the attitudes toward it seldom were factors. However, other information gathered in the mail surveys and home interviews did indicate some degree of mode switching having occurred.

Under the presumption that the bus and the taxi were initially used as a replacement for some other mode, bus and taxi users in both study areas were asked to specify the mode involved. A summary of their responses is presented in Table 10-6. In many instances, neither the bus nor the taxi were initially chosen to supplant any other single mode. It is likely that, in most of these cases, the bus or the taxi was first engaged for an original purpose such as traveling to or from a new job. However, the results also show that a significant percentage of the taxi

TABLE 10-6

MODE OF TRANSPORTATION REPLACED BY EITHER THE BUS OR THE SHARED-RIDE TAXI

Mode Replaced	Davenport				Hicksville			
	Bus Users		Taxi Users		Bus Users		Taxi Users	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Mail survey								
Bus	....	....	8	24.2	....	....	....	....
Taxi	8	2.9	....	....	20	6.8	....	....
Auto -- driver	43	15.7	4	12.1	47	16.0	....	....
Auto -- passenger	66	24.1	4	12.1	76	25.9	....	....
Walk	50	18.2	3	9.1	33	11.3	....	....
No single mode	107	39.1	14	42.4	117	39.9	....	....
Household survey								
Bus	....	....	22	20.8	....	....	8	11.3
Taxi	4	3.1	....	....	3	8.1	....	....
Auto -- driver	29	22.3	15	14.2	3	8.1	10	14.1
Auto -- passenger	26	20.0	21	19.8	9	24.3	17	23.9
Walk	33	25.4	10	9.4	6	16.2	14	19.7
No single mode	38	29.2	38	35.8	16	43.2	22	31.0

users in Davenport had been diverted from the bus. This percentage becomes more significant when compared with the corresponding figure for Hicksville.

Other evidence of the occurrence of mode switching in Davenport was provided by the various surveys. Of the 94 taxi users responding to the relevant item on the first mail survey questionnaire, 74 (78.7 percent) were once regular customers of the bus service. In the second mail survey, 17 (48.6 percent) of the 35 respondents reported having used the bus prior to their initial use of the taxi; however, six of these individuals also indicated that they still habitually traveled by bus. Finally, of the 104 taxi users interviewed in the household survey, 54 (51.9 percent) had often used the bus service before patronizing the taxi service for the first time; 41 of these individuals, however, had likewise continued to use the bus. Thus, although the taxi system appeared to have attracted a sizeable number of bus riders, in many cases mode switching in the strictest sense had not occurred, since the new taxi riders had not completely abandoned the bus system.

The extent of mode switching in Hicksville was more difficult to ascertain due to the low rates of response of the taxi users to the mail surveys. In the first such survey, 16 (47.1 percent) of 35 respondents had been regular users of the bus service, but in the household survey, only 16 of 68 taxi users, or 23.5 percent, had previously used the bus; moreover, 13 of these individuals had continued to travel on the transit system. Thus, as in Davenport, while the shared-ride taxi system had attracted a moderate number of bus passengers, very few of these new customers had switched modes completely.

Influence of Service Attributes on Mode Selection

In the modal choice decision process as modeled by Lovelock, one of the initial steps is the specification of the attributes of the ideal mode for a given trip. These qualities constitute the criteria by which alternative modes are evaluated. To assess the relative importance of various characteristics of the bus and shared-ride taxi systems, two approaches were taken. The first of these, incorporated into the first mail survey questionnaire, used the technique of Likert scales to measure bus and taxi users' attitudes toward a variety of features of each mode. In the second mail survey, respondents were asked to select from a list of possible responses their reasons for using either the bus or the taxi.

User Evaluation of the Bus and Taxi Systems

Eleven statements covering various aspects of the bus and shared-ride taxi systems were presented to bus and taxi users in the first mail survey. These statements were the following:

1. The bus (taxi) fare is reasonable.
2. The bus (taxi) rides well.
3. The bus (taxi) gets me to my destination when I want it to.
4. The time spent waiting for the bus (taxi) is not very long.
5. The time spent riding in a bus (taxi) is not very long.
6. Bus (taxi) drivers are safe drivers.
7. Bus (taxi) drivers are often helpful and courteous.
8. Buses (taxis) are usually clean and in good repair.
9. There is not much chance of getting robbed in a bus (taxi).

10. It is easy to get anywhere I want to go in a bus (taxi).
11. It is easy to carry groceries or other packages in a bus (taxi).

The respondents indicated their degree of agreement or disagreement with each of these statements on the following scale:

1. Strongly agree
2. Agree
3. Neither agree nor disagree
4. Disagree
5. Strongly disagree

In calculating the median response for each attribute, the above scale was assumed to be continuous with the scale values representing the midpoints of unit intervals. Thus, a median scale value less than or equal to 1.5 indicated that a majority strongly agreed with the statement in question. Likewise, a median scale value less than or equal to 2.5 was an indication that at least half of the respondents were either strongly or moderately in agreement. Conversely, a median score greater than 3.5 signified disagreement on the part of a majority of the respondents. Since each statement was worded positively, the smaller the magnitude of the median response, the more favorable was the overall attitude toward the attribute in question.

Table 10-7 summarizes the bus users' impressions of the bus and shared-ride taxi systems in Davenport. The table clearly shows that, while being highly complimentary toward their own mode, the bus users were more critical of the taxi. Often, however, the bus users had no definite opinion on a certain attribute of the shared-ride taxi service. Although the Wilcoxon matched-pairs signed-ranks test was employed to

TABLE 10-7

BUS USERS' EVALUATION OF THE BUS AND SHARED-RIDE TAXI SYSTEMS IN DAVENPORT

Attribute	Bus System			Shared-Ride Taxi System		
	Percent Agreeing	Percent Disagreeing	Median Scale Value	Percent Agreeing	Percent Disagreeing	Median Scale Value
Reasonable fare	89.2	7.1	1.90	39.1	39.6	3.01
Comfortable ride	63.4	19.9	2.25	30.6	41.4	3.19
Arrives at destination at the proper time	84.1	5.8	1.97	41.9	36.2	2.87
Waiting period brief	78.3	13.0	2.04	20.1	57.9	3.69
Travel period brief	88.1	5.8	1.97	45.8	28.0	2.66
Drivers safe	87.3	1.0	1.93	35.7	26.9	2.88
Drivers helpful and courteous	88.5	2.7	1.89	45.5	20.4	2.63
Vehicles clean and in good repair	61.7	12.5	2.27	19.5	54.9	3.61
Chances of being robbed minimal	71.0	6.6	2.13	15.0	52.0	3.55
Accessible to any destination	49.0	34.7	2.56	50.8	21.3	2.48
Easy to carry belongings	50.8	28.6	2.48	48.7	20.7	2.54

determine the statistical significance of differences between the ratings of the two modes for each attribute, in most cases the disparity was so large as to render the test superfluous.

Several of the details in Table 10-7 warrant mentioning. First, whereas few of the bus riders were dissatisfied with the bus fare, they were considerably more discontented with the taxi fare; however, the respondents were almost evenly divided in their opinions of the cab fare, and nearly one-fifth of them had no definite opinion in either direction. The bus users were unexpectedly critical of the taxi's ability to deliver them to their destinations at the proper time and generally considered the time spent waiting for a cab to be excessively long. At the same time, they rated the bus service very favorably in each of these two areas. These attitudes were very likely the result of the bus users' being highly acclimated to the bus schedule; thus, they arrived at their destination at the proper time by bus because they had adjusted their travel requirements to conform with those of the bus schedule. Very probably, too, there was less uncertainty attached to the arrival time of a bus at a bus stop than to the arrival time of a cab at the trip origin. In a related area, the bus users also tended to regard ride times on the bus system much more favorably, despite the fact that previous analyses had shown taxi trips generally to be shorter in duration. Finally, in only one respect, accessibility to any destination, was the taxi accorded a more satisfactory rating than the bus. The Wilcoxon test was unable to detect any significant difference between the ratings for this attribute nor for the one concerning the ease with which personal effects could be accommodated.

A summary of the taxi users' evaluation of the bus and shared-ride taxi systems in Davenport is presented in Table 10-8. Contrary to the bus users, patrons of the taxi service had favorable impressions not only of their own mode but also of the bus. The only areas in which the buses were considered to have a distinct advantage over the taxis were in the amount of waiting time required and the condition of the vehicles. Conversely, the taxis were much more highly regarded in terms of their ability to reach any destination in the community and to accommodate large numbers of personal items such as groceries, shopping bags, packages, etc. Interestingly, the taxi users did not perceive any significant differences in the ride times on each mode, even though such differences were found by previous analyses.

In comparing the bus and taxi users' attitudes toward the attributes of the bus service, very little meaningful disagreement was found between the two groups. In fact, the chi-square test revealed no significant differences in the manner in which each group viewed the bus system in the areas of fare, comfort, and vehicle appearance and condition. Taxi users, however, appeared to be more highly cognizant of the difficulty of reaching some points in the community by bus. Likewise, they also seemed to be more aware of the problems of coping with large numbers of personal belongings in a bus.

In all respects, the bus and taxi users in Davenport held differing and often conflicting views of the shared-ride taxi system. The widest difference of opinion, as reflected by the disparity in the median scale values, occurred in regard to the likelihood of being robbed while traveling in a cab. There was also considerable disagreement between the two groups over the reasonableness of the cab fare, indicating that

TABLE 10-8

TAXI USERS' EVALUATION OF THE BUS AND SHARED-RIDE TAXI SYSTEMS IN DAVENPORT

Attribute	Bus System			Shared-Ride Taxi System		
	Percent Agreeing	Percent Disagreeing	Median Scale Value	Percent Agreeing	Percent Disagreeing	Median Scale Value
Reasonable fare	87.8	6.7	1.89	72.5	18.7	2.07
Comfortable ride	68.1	16.0	2.21	51.1	29.3	2.47
Arrives at destination at the proper time	58.9	31.1	2.33	63.0	19.6	2.24
Waiting period brief	62.6	26.4	2.28	36.6	39.8	3.07
Travel period brief	75.6	12.2	2.13	72.2	15.6	2.14
Drivers safe	79.1	7.7	2.04	66.3	9.8	2.21
Drivers helpful and courteous	71.1	11.1	2.17	73.6	16.5	2.07
Vehicles clean and in good repair	63.0	18.5	2.26	41.5	37.2	2.90
Chances of being robbed minimal	59.6	12.4	2.33	50.5	20.4	2.49
Accessible to any destination	22.5	53.9	3.60	86.5	5.2	1.96
Easy to carry belongings	35.6	52.9	3.57	76.6	8.5	2.08

bus users were more sensitive to this aspect of public transportation. This would seem to be quite natural, since persons who utilized the bus generally depended more heavily on public transportation.

In general, Hicksville's bus users were also more complimentary toward the buses than toward the taxis. However, as Table 10-9 reveals, there were several notable deviations from the pattern found in Davenport. Although patrons of the bus service regarded it approvingly in most respects, many were less inclined to agree that the amount of time expended in waiting for a bus was nominal. Moreover, contrary to the bus users in Davenport, a slight majority also recognized the bus system's inability to reach all desired local destinations. These impressions reflected the relatively long headways and limited areal coverage of the bus system in the Hicksville area. With regard to the shared-ride taxi system, Hicksville's bus users were even more critical of the cab fare than were their counterparts in Davenport. The buses were also considered to be superior to the taxis in most other respects. However, in two areas--accessibility and ease of accommodating personal effects--the bus users regarded the taxis as being more advantageous.

Table 10-10 shows that persons who utilized the shared-ride taxi system in Hicksville appeared to be highly satisfied with the service they received from this mode. Many, however, did not hold a favorable opinion of the cab fare, which was considerably higher in Hicksville than in Davenport. Likewise, there was a disinclination on the part of many taxi users to agree with the statement concerning the condition of the vehicles. In all respects except the fare, the quality of the taxi service was considered to be on a level with or above that of the

TABLE 10-9

BUS USERS' EVALUATION OF THE BUS AND SHARED-RIDE TAXI SYSTEMS IN HICKSVILLE

Attribute	Bus System			Shared-Ride Taxi System		
	Percent Agreeing	Percent Disagreeing	Median Scale Value	Percent Agreeing	Percent Disagreeing	Median Scale Value
Reasonable fare	52.6	35.2	2.44	12.6	72.4	4.05
Comfortable ride	66.9	13.2	2.20	34.2	35.9	3.03
Arrives at destination at the proper time	59.8	25.8	2.31	52.8	26.2	2.44
Waiting period brief	41.7	46.9	3.22	34.0	42.3	3.18
Travel period brief	71.6	13.6	2.16	55.5	25.4	2.39
Drivers safe	74.3	5.4	2.11	31.1	30.2	2.99
Drivers helpful and courteous	64.1	17.4	2.23	48.1	20.1	2.56
Vehicles clean and in good repair	55.7	27.8	2.38	24.9	45.6	3.35
Chances of being robbed minimal	60.8	11.8	2.31	32.2	30.1	2.97
Accessible to any destination	34.3	50.8	3.52	48.1	27.9	2.58
Easy to carry belongings	41.5	35.5	2.87	58.8	15.9	2.34

TABLE 10-10

TAXI USERS' EVALUATION OF THE BUS AND SHARED-RIDE TAXI SYSTEMS IN HICKSVILLE

Attribute	Bus System			Shared-Ride Taxi System		
	Percent Agreeing	Percent Disagreeing	Median Scale Value	Percent Agreeing	Percent Disagreeing	Median Scale Value
Reasonable fare	65.6	12.5	2.25	33.3	41.7	3.17
Comfortable ride	59.4	12.5	2.33	62.9	20.0	2.28
Arrives at destination at the proper time	26.7	36.7	3.14	72.2	16.7	2.17
Waiting period brief	12.9	54.8	3.63	62.2	24.3	2.28
Travel period brief	32.3	25.8	2.92	73.0	16.2	2.16
Drivers safe	62.5	9.4	2.28	64.9	8.1	2.23
Drivers helpful and courteous	50.0	18.7	2.50	75.7	5.4	2.07
Vehicles clean and in good repair	45.2	22.6	2.65	38.9	36.1	2.94
Chances of being robbed minimal	35.5	16.1	2.80	58.3	8.3	2.33
Accessible to any destination	15.6	53.1	3.60	82.9	8.6	2.06
Easy to carry belongings	21.2	57.6	3.73	74.3	0.0	2.13

bus service. In particular, the time spent waiting for a bus was considered to be excessively long, the accessibility of the bus system was thought to be highly restricted, and the problems of coping with personal belongings while traveling in a bus were felt to be intolerable by a majority of the taxi users. The Wilcoxon test indicated that in three areas--comfort, driver safety, and condition of the vehicles--taxi users gave both modes virtually the same rating.

The results of chi-square tests revealed that both groups had similar impressions of many of the attributes of the bus system. Strangely, the taxi users were more inclined to view the bus fare as being reasonable than were the bus users themselves. However, in the other areas in which significant disagreement was found, including arrival time at the destination, wait time, ride time, and ease of carrying personal belongings, the taxi users held the less favorable opinion of the bus.

Bus and taxi users in Hicksville differed considerably in their opinions of the shared-ride taxi service. Where significant differences of opinion existed, without exception the bus users were more critical in their evaluation. According to the results of chi-square tests, both groups held virtually the same opinions of the ride times on the system, the taxis' ability to deliver passengers to their destinations at the desired time, the appearance and condition of the cabs, and the facility with which personal belongings can be accommodated in a cab.

Basis for Modal Preference

Although the psychological scaling technique provided an insight into the modal choice decision process, in the second mail survey and

the home interviews, a second, more direct approach was taken. From extemporaneous interviews with bus and taxi passengers and from a review of previous research on travel behavior, separate lists of potential reasons for preferring either the bus or the taxi were compiled. Respondents were requested to note all that applied.

As indicated in Table 10-11, to the bus users in Davenport, the most compelling reasons for using the bus centered around its lower cost and its accessibility to the home and to habitual destinations. There were two aspects to the factor of cost, the first implying inability to afford the more expensive taxi service and the second simply reflecting the lower fare for the bus. The results showed that, although a slight majority indicated an inability to bear the expense of using the taxi to the same extent as the bus, the low fare itself was a much more powerful inducement. Only one other factor--a perceived shorter wait time--was cited by a majority of the respondents in each survey. In the mail survey, however, more than half of the respondents felt that they could save time by using the bus. Among the items least mentioned in both surveys were the ease of ingress and egress, the ease of carrying personal belongings, and the ease of managing children on the bus.

In Hicksville cost and accessibility were also the principal reasons underlying the preference for the bus service, although the latter factor was not as highly stressed as in Davenport. More bus users were influenced by the low fare itself than by a sense of being unable to afford the taxi service. The lower cost and the convenient proximity of the bus system were by far the most important inducements in Hicksville. None of the remaining factors was mentioned by more

TABLE 10-11

REASONS FOR PREFERRING THE BUS

Response	Davenport				Hicksville			
	Mail Survey		Household Survey		Mail Survey		Household Survey	
	Rank	Percent of Respondents	Rank	Percent of Respondents	Rank	Percent of Respondents	Rank	Percent of Respondents
Residence near bus stop	1	88.2	2	78.8	2	67.9	2	60.5
Many habitual destinations accessible by bus	4	54.8	3	57.6	3	44.5	3	51.2
Familiar with other bus riders	8T	23.3	9T	14.4	9	14.3	8T	14.0
Taxi unaffordable	3	56.4	...	....	1	69.5	...	....
Less costly than the taxi	...	....	1	92.4	...	....	1	95.3
Friendlier drivers	7	42.3	8	16.7	5	22.4	8T	14.0
Shorter wait time	2	58.7	4	54.5	8	14.6	13	7.0
Less time required to complete a trip	5	51.5	5	35.6	11	13.0	5T	16.3
Easier to enter and leave a bus	13	17.7	12	10.6	13	8.4	5T	16.3
More comfortable	8T	23.3	9T	14.4	7	16.2	4	18.6
Buses in better condition	10	21.6	7	22.7	10	13.3	10	11.6
Safer drivers	6	44.6	6	26.5	4	23.4	5T	16.3
Easier to carry belongings	12	20.3	13	6.8	12	9.4	11T	9.3
Easier to handle children on the bus	14	5.6	14	3.8	14	4.2	11T	9.3
Other	11	20.7	11	11.4	6	20.1	14	4.7

T denotes a tie.

than one-fourth of the respondents in either survey.

The responses of the taxi users in Davenport, summarized in Table 10-12, were less definitive and consistent. Unlike the situation for the bus, there were no prevailing reasons for choosing the taxi. Several of the most frequently cited reasons intimated a desire for the door-to-door service provided by the taxi. For example, in the home interviews a slight majority of the taxi users identified the ability to travel at any time to any destination as a major consideration. Likewise, in both surveys a relatively large percentage of the respondents indicated that many of their destinations were inaccessible by bus. Yet another attribute related to the taxi's door-to-door service and often mentioned in both surveys was the better protection from the weather afforded by the use of a taxi. Some emphasis was also placed on the ease of handling personal belongings in a cab, and in the household survey a relatively large percentage of the taxi users traveled by cab instead of by bus in order to save time. In general, however, there were no overriding reasons for selecting the shared-ride taxi instead of the bus in Davenport; rather, the basis for choosing the taxi was highly individualized.

In Hicksville several reasons for using the shared-ride taxi system were rather prominent. As in Davenport, many of these reflected a desire for door-to-door service; however, the limited areal coverage of the bus system as well as its long headways may also have had a strong influence. Thus, the three most important reasons for choosing the taxi over the bus were the shorter wait time, the smaller amount of time required to complete a trip, and the greater accessibility connected with the cab system. In addition, more than half of the respondents

TABLE 10-12

REASONS FOR PREFERRING THE SHARED-RIDE TAXI

Response	Davenport				Hicksville Household Survey	
	Mail Survey		Household Survey			
	Rank	Percent of Respondents	Rank	Percent of Respondents	Rank	Percent of Respondents
Bus inaccessible from the home	3T	33.3	11T	18.9	5	48.6
Many habitual destinations inaccessible by bus	1	42.9	3T	43.4	2T	62.2
Bus system not in operation	6T	31.0	...	....	...	....
More privacy	19T	0.0	...	....	...	....
Missed the bus	19T	0.0	...	....	...	....
Friendlier drivers	9T	23.8	14T	11.3	13T	10.8
Shorter wait time	9T	23.8	9T	26.4	1	73.0
Less time required to complete a trip	6T	31.0	2	45.3	2T	62.2
More protection from the weather	3T	33.3	3T	43.4	7	43.2
Unfamiliar with the bus service	14	11.9	7T	28.3	6	45.9
Transfer not required	15T	9.5	7T	28.3	12	13.5
Easier to enter and leave a cab	12T	16.7	13	17.0	13T	10.8
Unsafe to wait on street corner for a bus	12T	16.7	9T	26.4	10T	16.2
More comfortable	11	19.0	6	30.2	8	29.7
Taxicabs in better condition	18	2.4	14T	11.3	16	2.7
More flexibility and freedom to travel	8	28.6	1	56.6	4	54.1
Safer drivers	17	7.1	17	5.7	17	0.0

TABLE 10-12 (Continued)

Response	Davenport				Hicksville Household Survey	
	Mail Survey		Household Survey			
	Rank	Percent of Respondents	Rank	Percent of Respondents	Rank	Percent of Respondents
Easier to carry belongings	3T	33.3	5	34.0	9	18.9
Easier to handle children in a taxi	15T	9.5	11T	18.9	13T	10.8
Other	2	38.1	14T	11.3	10T	16.2

T denotes a tie.

used the taxi because it enabled them to travel at any time to any destination. In Hicksville unfamiliarity with the routes and schedule of the bus system was also a consideration in many instances.

To summarize, cost and accessibility appeared to be the most important criteria in the modal choice decision process. Bus users, who tended to be more heavily dependent upon public transportation, were particularly sensitive to the aspect of cost. In addition to the relatively low fare, however, the fact that the bus system was readily accessible from the home and from many of the user's habitual destinations provided another incentive to use the bus. Taxi users seemed to prefer the cab for reasons related to its greater flexibility of movement and, hence, its accessibility to all areas of the community. Both groups tended to view other aspects of their selected modes favorably, yet except in Hicksville where wait time and overall travel time were of importance to taxi users, few persons in either group indicated that perceived advantages in comfort, safety, vehicle condition, or other qualities were the basis for their choice of mode.

Dual Patronage

In the investigation into the occurrence of mode switching, it was discovered that both shared-ride taxi systems had attracted a substantial number of bus users, although most of these individuals continued to use the bus. In an extension of this analysis in the second mail survey, bus users were queried about the extent of their usage of the shared-ride taxi system. Table 10-13 shows that, in both study areas, nearly half of the respondents also traveled by taxi although usually not to the same extent as the bus.

TABLE 10-13

EXTENT OF TAXICAB USAGE BY PATRONS OF THE BUS SYSTEM

Degree of Taxicab Usage	Davenport		Hicksville	
	Number	Percent	Number	Percent
Not used	142	49.1	143	47.4
Less frequently than the bus	141	48.8	143	47.4
As frequently as the bus	3	1.0	14	4.6
More frequently than the bus	3	1.0	2	0.7

The instances in which the taxi was chosen instead of the bus are analyzed in Table 10-14. In Davenport most of the bus riders who also patronized the shared-ride taxi service engaged a cab at night or on Sundays when the buses were not operating. A slight majority also traveled by taxi to reach destinations not accessible by bus. In Hicksville, in addition to these instances, failing to catch the bus was a particularly motivating reason for using the taxi service because of the long headways on the bus system. Conversely, transfers, uncertainty about which bus to take, and children rarely were considerations in either study area.

The rather extensive incidence of dual patronage may partially explain why the discriminant models were not overly successful in differentiating between bus and taxi riders on the basis of user characteristics alone. In both study areas, there was considerable

TABLE 10-14

CIRCUMSTANCES UNDER WHICH THE SHARED-RIDE TAXI SYSTEM IS UTILIZED BY PATRONS OF THE BUS SYSTEM

Response	Davenport		Hicksville	
	Rank	Percent of Respondents	Rank	Percent of Respondents
Buses not in operation	1	70.3	1	57.8
Rigid time schedule	6	12.9	4	25.1
Destination far from a bus stop	2	52.5	3	39.0
Unpleasant weather	3	23.8	5	23.8
Trips which would require changing buses	8T	4.0	9	3.6
Uncertain about which bus to take	8T	4.0	8	7.6
Failure to catch the bus	5	15.3	2	39.5
Large number of goods items to be carried	7	11.4	7	14.8
Children accompanying	10	3.0	10	1.8
Other	4	18.8	6	18.8

intermingling of the two markets.

Summary

Most individuals had their first experience with the bus or the taxi service before they had reached middle age. This was particularly true for the bus users, who were more likely to have begun using the bus

service during childhood and adolescence. In Davenport patrons of the bus service also tended to be long-term users of the system, whereas the taxi riders, most of whom began to patronize the cab service after it had been acquired by its present owner in 1967, were relative newcomers to the shared-ride taxi system.

The decision to begin using either the bus or the taxi was primarily the result of the unavailability of a private means of transportation. A large majority of both bus users and taxi users had been without a driver's license at the time the bus or taxi was initially used. Although specific reasons for starting to use either mode varied widely, the more common ones were inability to drive, unavailability of the family car, and inability to car pool. The bus users were also highly influenced by the convenient proximity of the bus system to their homes and to many of their habitual destinations.

Because of the large rise in taxi ridership and the simultaneous decline in bus ridership in Davenport, special consideration was given to the occurrence of mode switching in that community. The newly purchased shared-ride taxi system had indeed attracted a substantial number of bus riders, but most of these people had continued to use the buses. In a few instances, an individual had begun to utilize the taxi service because the bus system was not accessible from his or her new home or new place of work. Rarely, however, had individuals switched to the taxi because of dissatisfaction with the bus service.

The question of whether to use the bus or the shared-ride taxi was decided primarily on the basis of cost and accessibility rather than on the basis of the quality of the service. To the bus users, who tended to be more heavily dependent on public transportation, cost was

the most critical factor. However, in addition to the low fare, most bus users were also influenced by the fact that the system was readily accessible from their homes and from many of their habitual destinations. Shared-ride taxi users preferred the cab for reasons related to its flexibility of movement and door-to-door service, in spite of the fact that many users were critical of the long, uncertain wait times and the condition of the vehicles.

One of the most significant findings was the discovery that a significant number of taxi users were also habitual bus users. The two modes, however, were not interchangeable. Few individuals made a complete conversion from the bus to the taxi, and the latter mode was generally used only when the bus system was inaccessible. Nevertheless, the fact that many individuals utilized both modes was significant since it indicated that the two markets were intermingled and not separate.

CHAPTER 11

MODAL PREFERENCES OF THE NONUSERS OF PUBLIC TRANSPORTATION

The final major objective addressed by this research concerned the public sentiment toward the bus and shared-ride taxi systems. This inquiry into the attitudes of both users and nonusers of public transportation toward each of these modes was directed into several areas. The first of these, discussed in this chapter, involved the nonusers of public transportation and their preferences for either the bus or the shared-ride taxi. Three objectives of the household survey, therefore, were to ascertain (1) the modal preferences of this subgroup, (2) the predictability of these preferences, and (3) the basis for them.

Modal Preferences and Their Predictability

In the home interviews, persons who used neither the bus nor the taxi were asked to specify which of these modes they would select if an automobile was unavailable. The bus was the predominant choice of these people. This mode was selected by 76.7 percent of the respondents in Davenport and 67.6 percent in Hicksville.

The choice of mode was cross-tabulated with each of several social, economic, and demographic characteristics of the respondents. The results of chi-square tests, displayed in Table 11-1, revealed no significant relationships between sex, age, employment status, etc. and modal preference. By themselves, these variables were poor predictors of modal choice. Of course, there may exist a discriminant function of two or more of these variables which more accurately differentiates

TABLE 11-1

RELATIONSHIP BETWEEN CHOICE OF MODE AND SEVERAL CHARACTERISTICS OF THE NONUSERS OF PUBLIC TRANSPORTATION

	Davenport		Hicksville	
	Chi-Square	Significance Level	Chi-Square	Significance Level
Sex	0.00	0.99	1.07	0.30
Age	0.56	0.91	2.38	0.50
Employment status	2.06	0.15	0.08	0.78
Marital status	3.92	0.14	1.39	0.50
Possession of driver's license	0.40	0.53	0.00	0.98
Household size	5.74	0.45	5.23	0.52
Household auto ownership	3.34	0.34	4.67	0.20
Length of residence in study area	4.62	0.47	3.70	0.59

nonusers who prefer the bus from those who prefer the taxi. A discriminant analysis was not attempted in this case, however, and based on the results of the previous applications of the technique, it was doubtful that an effective model would have been produced.

Basis for Modal Preference

The nonusers of public transportation also noted their reasons for choosing either the bus or the taxi, using the same lists of possible

responses presented to bus riders and taxi riders. The results are summarized in Table 11-2 for those who preferred the bus and in Table 11-3 for those who preferred the taxi.

As was true for patrons of the bus service, the low fare was the nonusers' overriding reason for preferring the bus. The system's proximity to the respondent's home or to many of his or her habitual destinations was also a relatively important factor, more so in Davenport than in Hicksville. All of the remaining reasons were relatively minor considerations, although a significant percentage of the nonusers in Davenport claimed that wait times were shorter for the bus than for the taxi.

There were no overly predominant reasons for choosing the shared-ride taxi, and residents of Davenport emphasized factors different from those stressed by residents of Hicksville. In the former community, the principal consideration was the inaccessibility of the bus service either from the home or from frequent destinations. In Hicksville considerably more emphasis was placed on the shorter wait time and the overall savings of time attending the use of a cab. A majority of the respondents in Hicksville also based their preference for the taxi on their unfamiliarity with the bus service. In both study areas, many nonusers of public transportation chose the taxi service because it afforded greater mobility and more protection from the weather, factors related to the taxi's door-to-door service. Except for the fact that trips by taxi do not require an intramodal transfer, the remaining considerations were relatively minor.

TABLE 11-2

NONUSERS' REASONS FOR PREFERRING THE BUS

Response	Davenport		Hicksville	
	Rank	Percent of Respondents	Rank	Percent of Respondents
Residence near bus stop	2	68.2	2	49.3
Many habitual destinations accessible by bus	3	37.1	3	38.0
Less costly than the taxi	1	93.9	1	98.6
Friendlier drivers	9	8.6	13T	2.8
Shorter wait time	4	26.1	7	8.9
Less time required to complete a trip	6	17.1	12	3.8
Easier to enter and leave a bus	13	4.6	10T	5.6
More comfortable	10	6.8	6	9.9
Buses in better condition	7	15.0	5	10.8
Safer drivers	5	22.9	4	16.4
Familiar with other bus riders	8	8.9	13T	2.8
Easier to carry belongings	11	5.7	9	7.5
Easier to handle children on the bus	12	5.0	8	8.5
Other	14	3.6	10T	5.6

T denotes a tie.

TABLE 11-3

NONUSERS' REASONS FOR PREFERRING THE TAXI

Response	Davenport		Hicksville	
	Rank	Percent of Respondents	Rank	Percent of Respondents
Bus inaccessible from the home	1T	52.4	7	39.6
Many destinations inaccessible by bus	1T	52.4	6	42.6
Unfamiliar with bus service	9	19.0	4	53.5
Friendlier drivers	15	4.8	16T	1.0
Shorter wait time	6T	32.1	2	59.4
Less time required to complete a trip	5	45.2	1	60.4
More protection from the weather	3T	48.8	5	51.5
Transfer not required	6T	32.1	8	33.7
Easier to enter and leave a cab	12	11.9	11	11.9
More comfortable	8	22.6	10	15.8
Taxis in better condition	16T	1.2	15	4.0
Safer drivers	16T	1.2	16T	1.0
More flexibility and freedom to travel	3T	48.8	3	55.4
Unsafe to wait on street corner for a bus	13	9.5	14	6.9
Easier to carry belongings	10T	13.1	9	22.8
Easier to handle children in a taxi	10T	13.1	12T	10.9
Other	14	7.1	12T	10.9

T denotes a tie.

Summary

The analysis of the modal preferences of those who use neither the bus nor the taxi yielded results which were highly similar to those found in the surveys of actual users. Various demographic and socio-economic variables were observed to have no statistically significant relationship with modal choice. Moreover, the basis for the nonusers' modal preferences was much the same as that for the bus and taxi riders.

CHAPTER 12

USERS' AND NONUSERS' PERCEPTIONS OF THE QUALITY OF THE BUS AND SHARED-RIDE TAXI SERVICE

The second area in which attitudes toward the bus and shared-ride taxi systems were measured involved the quality of each type of service. The perceptions of not only the existing state of each system but also the direction of changes in the quality of each mode's service were studied. Moreover, in these analyses, performed on a subset of the household survey data, the views of bus users, taxi users, and nonusers of public transportation were examined separately.

Changes in the Quality of the Service

In the years immediately preceding this study, both bus systems and the shared-ride taxi system in Davenport experienced conditions and underwent alterations which may have either directly or indirectly affected their levels of performance. The dual problem of declining ridership and rising costs which beset each bus system has already been detailed along with management's reaction to the problem. At the commencement of this study, both bus systems were in the process of making the transition from private to public ownership, and the transit authority in each study area was either developing or implementing capital improvement plans. The shared-ride taxi system in Davenport also underwent a change of ownership which ultimately resulted in an increase in the number of cabs in operation and the institution of a service-oriented market strategy and business philosophy (Cherry, 1973, p. 94).

The apparent effect of these changes in the taxi service was a sustained yearly increase in ridership. In view of these developments, an important objective of the household survey was to determine the sensitivity of users and nonusers to variations in the quality of the service resulting from the aforementioned changes in the bus and shared-ride taxi systems.

The analysis pursuant to this objective was general in nature. To quantify the users' and nonusers' impressions of the direction of changes in the states of the bus and shared-ride taxi systems, the psychological scaling technique of semantic differentials was employed. For each mode, the respondents were asked to compare the existing service with that of five years ago and to grade the present service as:

1. Very much better now.
2. Much better now.
3. Slightly better now.
4. About the same.
5. Slightly worse now.
6. Much worse now.
7. Very much worse now.

The responses of bus users, taxi users, and nonusers of public transportation are summarized in Table 12-1. The median response of each group was determined assuming a continuous scale. Thus, median scale values less than or equal to 3.5 indicate that at least half of the respondents in the group perceived some degree of improvement in the service; conversely, median scale values greater than 4.5 signify that at least half of the respondents considered

TABLE 12-1

PERCEIVED CHANGES IN THE QUALITY OF BUS AND SHARED-RIDE TAXI SERVICE OVER FIVE-YEAR PERIOD

Study Area and Mode	Nonusers of Public Transportation			Bus Users			Taxi Users		
	Percent Claiming Service Better	Percent Claiming Service Worse	Median Scale Value	Percent Claiming Service Better	Percent Claiming Service Worse	Median Scale Value	Percent Claiming Service Better	Percent Claiming Service Worse	Median Scale Value
Davenport									
Bus	25.2	25.5	4.00	31.7	22.8	3.90	22.0	27.5	4.05
Taxi	13.3	26.7	4.11	22.5	36.3	4.17	34.7	26.3	3.39
Hicksville									
Bus	36.8	20.7	3.81	42.1	18.4	3.70	21.1	28.1	4.07
Taxi	20.9	19.9	3.99	18.5	33.3	4.15	25.0	27.8	4.03

the service to have deteriorated to some degree. In addition, median scores between 3.5 and 4.5 indicate an overall tendency to regard the quality of the service as having remained unchanged.

Table 12-1 shows that none of the groups had strong impressions of a change in the quality of Davenport's bus service notwithstanding the system's huge loss of ridership and unsound financial position. Nearly half of the respondents in each group did not perceive any noticeable change. The opinions of the nonusers of public transportation, however, were significantly different from those of the bus users and the taxi users, based on the results of chi-square tests. Members of the nonuser group were almost evenly divided on the question of the direction of the change in quality, while the bus users tended to perceive an improvement in the bus service. The taxi users, however, exhibited a slight tendency to regard the bus service as being poorer in quality. Since a moderate number of the respondents patronized both public transportation systems and, therefore, were included in both user groups, a statistical test was unavailable to determine the significance of differences in the judgments of bus users and taxi users; however, from the table it is apparent that the two groups held rather widely divergent views.

Despite the large rise in taxi ridership and the increased number of cabs, the nonusers of public transportation in Davenport were more likely to feel that the shared-ride taxi service had worsened rather than improved over the five-year period, although 60 percent did not perceive any noticeable change. As was true in the case of the bus service, members of the nonuser group had impressions which differed significantly from those of both the bus users and the taxi users. With

regard to the bus riders, the difference in viewpoints was a matter of degree. The taxi users, however, were the only individuals more inclined to feel that the cab service had been improved. It therefore appears that either the efforts of the new owner to raise the standards of the cab company's service were not visible to most nonusers or, in spite of these efforts, as far as most of these people were concerned, no improvements in the service had been effected.

Regarding the bus service in the Hicksville area, the nonusers of public transportation and the bus users held virtually the same opinions, both tending to believe that the quality of the service had risen rather than fallen. As in Davenport, the taxi users were more likely to hold the opposite view, although in this case nearly half of the cab riders did not notice any change in the quality of the bus service.

Among the nonusers of public transportation and the taxi users themselves, there was no concensus on the direction of changes in the quality of Hicksville's shared-ride taxi service. The major difference between the two groups resided in the larger percentage of nonusers perceiving no change at all. The bus users, however, in following the pattern observed in all other cases, were more inclined to express the view that the taxi service had deteriorated over the five-year span.

Quality of Existing Service

The results of a detailed evaluation of the bus and shared-ride taxi systems by those who utilize them have already been presented. In the household survey, a general evaluation was made by users as well as nonusers of public transportation. The respondents graded the present bus and shared-ride taxi service on the following scale:

1. Very good.
2. Good.
3. Adequate.
4. Poor.
5. Very poor.

Table 12-2 summarizes the responses of the three groups. Based on a continuous scale, median scores below 2.5 denote favorable overall ratings, while median responses above 3.5 indicate generally unfavorable attitudes.

In Davenport both nonusers of public transportation and taxi users considered the bus service to be slightly inadequate, whereas the bus patrons themselves regarded the existing service as being reasonably good. Those who traveled solely by private automobile were harshest in their appraisal of the bus system. According to the results of chi-square tests, their perceptions were significantly less favorable than those of either of the other two groups. The shared-ride taxi service was also rated as slightly inadequate by the nonuser group as well as by the bus users. Again, the chi-square tests showed the nonusers of public transportation to be the most critical of all in their evaluation.

According to the results of the Wilcoxon matched-pairs signed-ranks test, individuals who used neither the bus nor the taxi did not exhibit any marked tendency to consistently rate one mode more favorably than the other. Nearly half (48.7 percent) of the respondents in this group gave each system the same grade, 27.4 percent rated the bus service more favorably, and 23.9 percent evaluated the taxi service more highly. Likewise, no statistically significant differences were discerned in the taxi user's evaluation of each mode. In this group, 41.5 percent of the

TABLE 12-2

EVALUATION OF THE QUALITY OF THE PRESENT BUS AND SHARED-RIDE TAXI SERVICE

Study Area and Mode	Nonusers of Public Transportation			Bus Users			Taxi Users		
	Percent Rating More Than Adequate	Percent Rating Less Than Adequate	Median Scale Value	Percent Rating More Than Adequate	Percent Rating Less Than Adequate	Median Scale Value	Percent Rating More Than Adequate	Percent Rating Less Than Adequate	Median Scale Value
Davenport									
Bus	21.5	39.8	3.24	48.5	20.5	2.55	30.6	34.7	3.06
Taxi	12.1	36.5	3.24	23.4	37.8	3.19	37.8	26.1	2.84
Hicksville									
Bus	19.2	52.7	3.59	36.4	29.5	2.90	16.4	55.7	3.65
Taxi	28.6	20.7	2.92	23.5	35.3	3.14	34.5	21.4	2.85

respondents rated each system identically, 29.8 percent gave the taxi a better rating, and 28.7 percent regarded the bus system more favorably. Only the bus users consistently evaluated one mode--the bus--more highly than the other.

In Hicksville the nonusers of public transportation and the taxi users had much stronger opinions than their counterparts in Davenport relative to the quality of the existing bus service. Despite the similar median responses, from the standpoint of statistical significance, these two groups tended to have slightly different views, the major difference being the higher probability of individuals in the nonuser group to make an extremely unfavorable evaluation, and conversely, the higher probability of taxi users to make an extremely favorable one. In comparing the nonuser group's impressions of the existing shared-ride taxi service first with those of the bus users and secondly with those of the taxi users, no significant differences were detected. All three groups were inclined to rate the cab service as adequate, although not surprisingly taxi users were the least critical and bus users the most.

According to the Wilcoxon test, nonusers of public transportation in Hicksville tended to grade the taxi more favorably than the bus. While only 11.4 percent of these individuals felt that the buses provided the better service, 48.9 percent held the opposite view. Likewise, the taxi users, contrary to their counterparts in Davenport, consistently rated the taxi system more favorably than the bus with 54.2 percent considering the taxi as the better form of transportation. Surprisingly, the bus users, most likely as a result of the smallness of the sample, did not exhibit a statistically significant propensity to grade one mode higher than the other.

Summary

Notwithstanding the efforts of the new management to improve the taxi service in Davenport, efforts which resulted in a steady growth in ridership and an increase in the number of cabs in operation, relatively few nonusers of public transportation detected any noticeable improvements in the service. If, indeed, the efficiency, reliability, and responsiveness of the system had been enhanced, knowledge of these positive changes was not widely disseminated. Very probably, the respondents in the nonuser group formulated their opinions on the basis of outward appearances and preconceptions based on past experience or hearsay.

A comparatively larger percentage of the taxi users in Davenport did feel that the existing service was better than that which had been provided five years earlier; nevertheless, only approximately one-third of the cab patrons shared this impression. One possible explanation for the unexpectedly small percentage of users claiming better service lies in the system's responsiveness to requests for service. As a result of the rather large increase in ridership, significant reductions in the wait time may not have been effected, despite the increased number of cabs in operation. Moreover, during the period in question, the cab company experimented with computer dispatching which, because of hardware and software limitations, often generated unnatural delays, thereby alienating many riders (Cherry, 1973, p. 96). Therefore, in assessing the existing cab service in relation to the earlier service, many shared-ride taxi users very likely employed as one of their principal criteria the time spent waiting for a cab, one of the few attributes which patrons

tended to view with disfavor.

Both the bus users and the taxi users were inclined to have a higher regard for their own mode than for its alternate. This may have stemmed from a general feeling that the selected mode was more suitable to one's needs than the alternative mode. Many bus users, for example, may have adopted the attitude that any difference in the quality of each type of service was not as large as the disparity in the fares. From the taxi users' standpoint, the relative inflexibility of the bus may have biased many of these individuals in their appraisal of this mode. Since the future of the bus service in each study area may have seemed uncertain to many bus riders, there is also the real possibility that such persons adopted a defensive position in responding to the various surveys, evincing an attitude not truly indicative of their actual impressions of each system. In general, however, most users' and nonusers' perceptions of the quality of the bus and shared-ride taxi service were rather conservative.

CHAPTER 13

USERS' AND NONUSERS' PERCEPTIONS OF THE IMPORTANCE OF THE BUS AND SHARED-RIDE TAXI SERVICE

A third indicator of the public sentiment toward the bus and shared-ride taxi systems is the perceived importance of each mode to certain population groups and to the community in general. A community's support for public subsidization of mass transit operations, with or without public ownership, may stem to some extent from a general awareness of the importance of these systems to persons who do not have immediate access to an automobile. It is also highly probable that certain people in the public as well as the private sector consider public transportation to be beneficial if not essential to the community in general, particularly in maintaining the attractiveness of the Central Business District and in controlling traffic congestion and its concomitant effect, air pollution. However, because of the usually wide gap between the bus and taxi fare, one would not expect the same degree of importance to be attached to each of these modes. Thus, another objective of the household survey was to gather information which would enable a comparison to be made of users' and nonusers' notions of (1) the markets for each mode and (2) each system's impact upon the community's economic and physical environment.

Importance to Various Population Groups

In the home interviews, respondents were asked to consider the relative importance of the bus and shared-ride taxi service to each

of fifteen population groups. The following scale served to quantify each respondent's impressions:

1. Very important.
2. Fairly important.
3. Fairly unimportant.
4. Not important at all.

The above scale values were assumed to be at the midpoints of unit intervals on a continuous scale. Thus, median scores less than or equal to 2.5 indicate that at least half of the respondents considered the mode to be of some importance to the group in question, while those above 2.5 indicate that a majority regarded the service as being either moderately or extremely unimportant to the relevant population group.

The median responses of bus users, taxi users, and nonusers of public transportation in Davenport are displayed in Table 13-1. It is evident from this table that, within each group of respondents, notions of the market for the bus service were quite different from those of the market for the shared-ride taxi. In general, all three groups considered the bus to be the more important mode to a much broader base of the population. According to the results of the Wilcoxon test, exceptions to this generalization were the high-income workers, the handicapped, new residents, and nonresident businessmen. Persons with a high income were considered more likely to choose a cab than a bus, but most respondents agreed that neither mode was important to this population group. Both the nonusers of public transportation and the taxi users tended to attach a higher degree of importance to the taxi than to the bus in considering the handicapped, while the bus users generally regarded

TABLE 13-1

IMPORTANCE OF THE BUS AND SHARED-RIDE TAXI SERVICE TO VARIOUS POPULATION GROUPS IN DAVENPORT

Population Group	Median Scale Values					
	Nonusers of Public Transportation		Bus Users		Taxi Users	
	Bus	Taxi	Bus	Taxi	Bus	Taxi
Low-income workers	1.27	3.09	1.06	3.10	1.09	2.78
Middle-income workers	2.13	2.71	1.70	2.47	1.86	2.28
High-income workers	3.74	3.00	3.58	3.05	3.55	2.64
The unemployed	1.29	3.61	1.15	3.56	1.17	3.33
Persons without a car	1.08	1.81	1.03	1.79	1.06	1.56
One-car families	2.03	2.64	1.64	2.28	1.83	2.13
Large families	1.99	3.03	1.70	2.78	1.75	2.55
Small families	2.51	2.88	1.99	2.60	2.06	2.52
The elderly	1.09	1.70	1.05	1.61	1.08	1.30
Children	1.67	3.43	1.24	3.35	1.29	2.92
Housewives	2.13	2.73	1.55	2.65	1.74	2.33
The handicapped	2.03	1.53	1.43	1.52	1.36	1.24
Downtown shoppers	1.36	2.38	1.17	2.40	1.30	2.17
New residents	2.25	2.14	1.88	1.98	2.02	1.71
Nonresident businessmen	3.69	1.58	3.67	1.65	3.71	1.36

both modes as being equally important to this segment of the population. Taxi users also exhibited a significant tendency to rate the taxi as being more important than the bus to new residents; respondents in the other two groups, however, did not perceive any significant difference in the relative importance of the two modes to these people. Most respondents in each group regarded nonresident businessmen as a major market for the shared-ride taxi and a highly insignificant one for the bus. In considering each of the remaining population groups, however, the respondents in each group showed a marked inclination to view the bus as being the more important of the two modes.

There were no inordinately large differences of opinion between the three groups of respondents. Nevertheless, chi-square tests comparing the impressions of the nonusers of public transportation with those of the bus users and taxi users yielded results significant at the 0.05 level in most instances. These differences of opinion, however, were more a matter of degree than a manifestation of divergent views. Generally, those who used neither form of public transportation were inclined to be more conservative than the bus users and taxi users in their assessment of the importance of each mode to the various population groups. Although the bus users and taxi users could not be compared by means of a statistical test since the samples of each were neither independent nor completely matched, patrons of the shared-ride taxi system were usually more conservative in considering the bus and more liberal in considering their own mode.

The median responses of residents of Hicksville are shown in Table 13-2. The major difference between these findings and those for Davenport was in the slightly greater overall importance attached to the

TABLE 13-2

IMPORTANCE OF THE BUS AND SHARED-RIDE TAXI SERVICE TO VARIOUS POPULATION GROUPS IN HICKSVILLE

Population Group	Median Scale Values					
	Nonusers of Public Transportation		Bus Users		Taxi Users	
	Bus	Taxi	Bus	Taxi	Bus	Taxi
Low-income workers	1.14	3.25	1.07	3.34	1.07	3.05
Middle-income workers	1.95	2.66	1.79	2.48	1.65	2.25
High-income workers	3.61	2.24	3.57	2.32	3.27	2.10
The unemployed	1.17	3.59	1.21	3.63	1.13	3.62
Persons without a car	1.07	1.77	1.03	1.75	1.07	1.57
One-car families	2.00	2.30	1.65	2.31	1.76	2.04
Large families	1.93	2.99	1.53	2.81	1.49	2.75
Small families	2.24	2.71	2.12	2.53	1.99	2.43
The elderly	1.18	1.78	1.10	1.91	1.13	1.62
Children	1.70	3.61	1.67	3.75	1.37	3.30
Housewives	2.10	2.48	1.41	2.40	1.38	2.09
The handicapped	1.58	1.56	1.28	1.70	1.26	1.36
Downtown shoppers	1.73	2.41	1.57	2.65	1.37	2.15
New residents	2.00	2.19	1.68	2.27	1.40	1.87
Nonresident businessmen	3.47	1.39	3.35	1.40	3.00	1.48

shared-ride taxi service in Hicksville. In Davenport a majority in each category of respondents cited six population groups as being relatively significant users of the taxi system, while in Hicksville eight groups—high-income workers, persons without a car, one-car families, the elderly, the handicapped, housewives, new residents, and nonresident businessmen—were labeled as such. To this list the taxi users and the nonusers of public transportation added downtown shoppers. The actual users of the shared-ride taxi service were the most liberal in their evaluation of the importance of this mode, identifying eleven of the fifteen groups as relatively significant markets for the taxi.

In most cases the bus was more likely to be considered as the more important mode. Two notable exceptions were high-income workers and nonresident businessmen. In addition, neither the bus users nor the taxi users distinguished any difference in the importance of the two modes to the handicapped. According to the Wilcoxon test, the taxi users also showed no inclination to consistently judge one mode as being more important than the other to new residents. In general, however, the bus was perceived to be the more important mode, serving a much broader market.

As in Davenport, there were no outstanding differences of opinion between the three groups of respondents. In fact, the chi-square tests indicated that the nonusers of public transportation and the bus users were usually in close agreement with each other over the relative importance of each mode. Only in their evaluation of the utility of the bus service to one-car families and housewives did the two groups significantly disagree. On the other hand, a considerable amount of disagreement was found to exist between the taxi users and the nonusers of

public transportation in their assessment of each mode. These differences of opinion, however, primarily reflected slightly differing impressions of the degree of importance or unimportance of the mode under consideration. The taxi users were the most liberal of the three groups in their evaluation, usually attaching a higher level of importance to each mode than did the respondents in either of the other two groups.

Importance to the Community

Although it may be questionable whether public transportation has a significant impact on traffic congestion, air pollution, or downtown business in communities of the size of Davenport and Hicksville, perceptions of the respective roles of the bus and shared-ride taxi systems in each of these three problem areas were nevertheless analyzed as another gauge of the public's sentiment toward each mode. Respondents were asked to consider the effect which the discontinuation of either the bus or the shared-ride taxi service would have on downtown business, traffic congestion, and air pollution. In each case, attitudes were quantified by the technique of semantic differentials. Within each group of respondents, the Wilcoxon matched-pairs signed-ranks test was used to determine if the respondents' impressions of the bus differed from their impressions of the taxi. For each mode, the responses of the nonusers of public transportation were compared with those of the bus users and taxi users, respectively, by means of the chi-square test.

Downtown Business

Table 13-3 details the perceived impact which discontinuation of either the bus or the shared-ride taxi service would have on downtown

TABLE 13-3

PERCEIVED EFFECT OF THE DISCONTINUATION OF EITHER THE BUS OR SHARED-RIDE TAXI SERVICE ON DOWNTOWN BUSINESS

Extent of Harm on Downtown Business	Percent of Respondents					
	Nonusers of Public Transportation		Bus Users		Taxi Users	
	Bus	Taxi	Bus	Taxi	Bus	Taxi
Davenport						
Extensive	59.1	12.2	87.0	19.5	75.7	34.8
Moderate	31.2	41.6	12.3	48.9	13.5	43.5
Minor	7.5	38.6	0.7	24.8	6.3	17.4
No effect	2.2	7.6	0.0	6.8	4.5	4.3
Hicksville						
Extensive	20.4	11.8	56.5	18.2	43.6	29.9
Moderate	39.8	40.6	23.9	38.6	35.9	43.7
Minor	25.3	35.5	17.4	34.1	10.3	20.7
No effect	14.5	12.1	2.2	9.1	10.3	5.7

business. In Davenport a majority of the respondents felt that the loss of either mode would have at least a moderately harmful effect on the vitality of the Central Business District (CBD). Within each group of respondents, however, the consequences of losing the bus service were considered to be potentially more detrimental than those attending the loss of the taxi service. Although the three groups were in agreement on the relatively greater impact of the bus, significant differences of opinion were found to exist between them. The nonusers of public transportation were least likely to hold an extreme view of the importance of either mode, while the bus users and taxi users were each more likely to regard the loss of their own mode in the most serious terms.

In Hicksville a majority of the respondents in each group also felt that the loss of either mode would be at least moderately harmful to the CBD, although a comparatively smaller percentage of the respondents in each group thought that downtown business would be extensively affected by the cessation of the bus service. The bus users and the nonusers of public transportation considered the consequences resulting from the loss of the bus service to be more deleterious. According to the Wilcoxon test, the taxi users did not regard the bus as the more important mode to a significant extent. The opinions of those who used neither form of public carriage were significantly more conservative than those of either the bus users or the taxi users with respect to the bus and, in addition, were significantly more conservative than those of the taxi users with respect to the cab.

Traffic Congestion

Table 13-4 clearly shows that both the users and nonusers of public transportation in Davenport were rather inclined to believe that existing

TABLE 13-4

PERCEIVED EFFECT OF THE DISCONTINUATION OF EITHER THE BUS OR SHARED-RIDE TAXI SERVICE ON TRAFFIC CONGESTION

Effect on Traffic Congestion	Percent of Respondents					
	Nonusers of Public Transportation		Bus Users		Taxi Users	
	Bus	Taxi	Bus	Taxi	Bus	Taxi
Davenport						
Definitely an increase	27.2	6.5	56.3	10.6	45.0	15.8
Probably an increase	32.0	16.4	24.4	20.5	24.8	21.9
Uncertain	20.4	28.5	8.9	27.3	17.4	29.8
Probably no increase	13.4	38.2	5.9	32.6	7.3	24.6
Definitely no increase	7.0	10.5	4.4	9.1	5.5	7.9
Hicksville						
Definitely an increase	16.6	4.8	23.9	6.8	15.0	12.6
Probably an increase	26.0	15.0	30.4	18.2	16.3	19.5
Uncertain	22.7	31.5	23.9	40.9	28.8	27.6
Probably no increase	25.3	35.7	21.7	27.3	21.3	33.3
Definitely no increase	9.4	13.1	0.0	6.8	18.8	6.9

traffic problems would be aggravated more by the discontinuation of the bus rather than the shared-ride taxi service. For each group of respondents, the observed differences in the distribution of responses for each mode were highly significant according to the results of the Wilcoxon test. The views of the nonusers of public transportation differed significantly from those of the bus and taxi users relative to the bus service in that individuals in the two user groups, particularly the bus users, tended to be more convinced of the adverse effects which discontinuation of the bus service would have on traffic circulation. With regard to the shared-ride taxi, the nonusers of public transportation and the taxi users also disagreed to a significant degree as a result of the latter group's stronger feelings.

In Hicksville only the taxi users did not manifest a marked propensity to regard the loss of the bus service as being more detrimental to traffic flow. However, even the respondents in the other two groups were not as strongly convinced as their counterparts in Davenport that the effects of losing the bus service would be highly consequential in terms of increased traffic congestion. The three groups of respondents in Hicksville were also in much closer agreement than the groups in Davenport on the relative importance of each mode. Only the impressions of the taxi users relative to the shared-ride taxi system differed significantly from those of the nonusers of public transportation, who tended to be more conservative in their judgments.

Air Pollution

Although increased air pollution is usually associated with increased traffic congestion, the effect of a curtailment of either the bus or the

shared-ride taxi service on the level of air pollution was generally not considered to be as serious as the effect on traffic congestion. Nevertheless, as Table 13-5 shows, in both study areas, the same overall pattern of perceptions was observed; that is, the termination of the bus service was perceived to be more deleterious than the loss of the shared-ride taxi service by the respondents in each group. In Davenport, those who did not travel via public transportation were less inclined than the bus and taxi users to believe that the cessation of taxi operations would have a detrimental effect on air pollution. Likewise, in both study areas, the nonusers of public transportation were not as convinced as the bus users that an increase in air pollution was likely to ensue from a curtailment of the bus service.

Summary

In general, both the users and nonusers of public transportation tended to regard the bus as the more vital mode of public carriage. This mode was perceived to be more highly important than the taxi to a much broader base of the population. Moreover, it was felt that the community as a whole derived more benefits from the bus than the taxi. In particular, the former was considered to be more essential for maintaining the vitality of the CBD and for controlling the level of traffic congestion and air pollution.

TABLE 13-5

PERCEIVED EFFECT OF THE DISCONTINUATION OF EITHER THE BUS OR SHARED-RIDE TAXI SERVICE ON AIR POLLUTION

Effect on Air Pollution	Percent of Respondents					
	Nonusers of Public Transportation		Bus Users		Taxi Users	
	Bus	Taxi	Bus	Taxi	Bus	Taxi
Davenport						
Definitely an increase	18.3	4.8	34.8	16.0	29.7	17.7
Probably an increase	26.9	18.3	29.6	16.8	27.0	13.3
Uncertain	24.5	25.5	17.8	25.2	18.0	31.9
Probably no increase	21.2	37.9	11.1	30.5	15.3	24.8
Definitely no increase	9.1	13.4	6.7	11.5	9.9	12.4
Hicksville						
Definitely an increase	19.5	5.8	34.8	4.5	23.8	10.5
Probably an increase	25.7	13.8	34.8	27.3	27.5	23.3
Uncertain	26.1	31.5	17.4	31.8	12.5	23.3
Probably no increase	18.9	35.7	8.7	20.5	21.3	27.9
Definitely no increase	9.8	13.2	4.2	15.9	15.0	15.1

CHAPTER 14

ATTITUDES TOWARD ALTERNATIVE MEANS OF FINANCING AND OWNING THE BUS AND SHARED-RIDE TAXI SERVICE

The final dimension of the public sentiment toward the bus and shared-ride taxi systems involved the areas of financial support and ownership. The direct involvement of local government in the provision of mass transportation has become rather widespread. However, despite the prevalence of public financial support and ownership of mass transit systems, in smaller urban areas, the notion of direct governmental involvement in the provision of public transportation may not be as widely acceptable as some planners and elected officials may suppose (Greater Lafayette Area Bus Transit Study, 1971, pp. 40-41, 58-59, 62-63, 68; Heathington and Middendorf, 1972, pp. 34-35, 39-43, 55-57, 60-64). In addition, the local government which subsidizes and perhaps owns and operates the bus system also usually exercises some regulatory control over the local privately owned taxicab enterprises. An important objective of the household survey, therefore, was to determine users' and nonusers' attitudes toward various ways of financing and owning both forms of public transportation.

Two types of analysis were performed pursuant to this objective. The first employed the psychological scaling technique known as the method of pair comparisons to determine the importance of public transportation in general as a candidate for additional tax support relative to other common areas of public investment. In the second analysis, the acceptability of several alternative methods of financially supporting

and owning the bus and shared-ride taxi service was measured by a rating scale technique.

Public Investment in Public Transportation

The importance of public transportation as a service eligible for public support was determined in relation to other services or problem areas competing for available tax monies. The following eight general areas were chosen for consideration:

1. Parks and recreation areas
2. Police protection
3. Pollution control
4. Public transportation
5. Schools
6. Streets and highways
7. Water and sewage
8. Welfare.

Each item was paired once with every other item. For each pair, the respondent in the home interview was asked to select the area which he or she felt was more important for receiving additional tax monies. Through the method of pair comparisons, the above eight items were then ranked in the order of their priority for additional tax support.

The Method of Pair Comparisons

The psychological scaling technique known as the method of pair comparisons enables three or more stimuli--in this case, areas of public investment--to be ranked or scaled on a psychological continuum. According to psychophysical theory, a stimulus, when presented to an individual,

elicits a response, the result of what is termed a discriminal process. Another individual, however, will not be expected to make the same response to the same stimulus; that is, the response is a random variable to which there is associated a frequency distribution or discriminal dispersion, assumed to be a normal distribution. The objective of the pair comparisons technique is to determine the mean response or scale value for each stimulus, thereby effecting a ranking of each stimulus on the psychological continuum.

Derivation of the scale values proceeds from Thurstone's law of comparative judgment:

$$R_j - R_k = Z_{jk}\sqrt{\sigma_j^2 + \sigma_k^2 - 2r_{jk}\sigma_j\sigma_k}$$

where R_j and R_k = mean scale values for stimuli S_j and S_k, respectively;

Z_{jk} = deviate from the mean of the unit normal distribution;

σ_j and σ_k = standard deviations of the distributions of responses to stimuli S_j and S_k, respectively; and

r_{jk} = correlation between responses to stimuli S_j and S_k.

The values of the standard deviations and the correlation coefficient are usually unknown; consequently, the above equation cannot be solved directly, since there are more unknowns than equations. In order to determine R_j and R_k, some simplifying assumptions are required. Five approximations to the law of comparative judgment have been put forth of which only two were useful to this particular application of the technique. The first of these, known as Case III, makes the assumption that there is no correlation between the responses to any pair of stimuli. Thurstone's law in this case reduces to

$$R_j - R_k = Z_{jk}\sqrt{\sigma_j^2 + \sigma_k^2}\ .$$

Estimates of the standard deviations are then obtained from a formula proposed by Burros. The second approximation of interest, Case V, requires the further assumption that all the standard deviations are equal. In this case, the formulation of Thurstone's law becomes

$$R_j - R_k = cZ_{jk}$$

where c is a constant. Regardless of which approximation is used, the procedure starts with the proportion matrix, which shows the proportion of times each stimulus is judged greater than every other stimulus in some defined respect. The validity of the assumptions for each Case can be tested by reproducing the proportion matrix, using the scale values derived under the assumptions to be verified. A chi-square test exists for determining the goodness-of-fit of the two matrices.

Community Priorities

One of the columns of the proportion matrix is shown for each group of respondents in Tables 14-1 and 14-2 for Davenport and Hicksville, respectively. These tables show, for each item paired with public transportation, the percentage of respondents who chose public transportation as the area which should receive additional tax support. In Davenport most of the nonusers of public transportation felt that additional funds should be allocated to police protection, schools, or streets and highways before being allocated to public transportation. The taxi users generally considered police protection and schools as the only areas more in need of additional tax support than public transportation.

TABLE 14-1

PERCENTAGE OF RESPONDENTS CHOOSING PUBLIC TRANSPORTATION OVER EACH OF THE OTHER AREAS FOR ADDITIONAL TAX SUPPORT, DAVENPORT

Item	Nonusers of Public Transportation	Bus Users	Taxi Users
Parks and recreation areas	58.9	78.6	66.1
Police protection	31.4	49.2	44.6
Pollution control	60.5	82.4	79.5
Schools	27.8	55.7	49.1
Streets and highways	39.2	64.9	58.9
Water and sewage	53.2	85.5	73.9
Welfare	77.0	78.6	77.7

TABLE 14-2

PERCENTAGE OF RESPONDENTS CHOOSING PUBLIC TRANSPORTATION OVER EACH OF THE OTHER AREAS FOR ADDITIONAL TAX SUPPORT, HICKSVILLE

Item	Nonusers of Public Transportation	Bus Users	Taxi Users
Parks and recreation areas	63.5	78.6	75.0
Police protection	36.8	42.9	40.5
Pollution control	58.9	76.2	66.2
Schools	36.9	42.9	50.0
Streets and highways	51.1	78.6	67.5
Water and sewage	46.6	59.5	57.0
Welfare	84.2	88.1	83.7

Only police protection was regarded as a more important area by a majority of the bus users in Davenport. Somewhat similar results were obtained from the Hicksville survey. In general, the bus users attached the greatest importance to public transportation, followed closely by the taxi users, and finally by the nonusers of public transportation.

The actual ranking of the eight items is illustrated in Figures 14-1 and 14-2. The scale values shown in these figures were derived using the Case III approximation to the law of comparative judgment. In testing for internal consistency under Case V, the chi-square test statistic was significant for each group of respondents in Davenport, indicating that the standard deviations of the responses to each item may not have been equal. Although this was not the case for Hicksville, for the sake of consistency, only the results of Case III were used in each study area.

The scale positions corroborated the findings of Tables 14-1 and 14-2. The relative importance of public transportation varied between the groups of respondents. In both study areas, those who used either the bus or shared-ride taxi service considered public transportation to be second or third in importance to schools and police protection. However, as the figures plainly show, there was relatively little difference between the scale values of these three items. The nonusers of the bus and taxi service, on the other hand, were less willing to spend additional funds for public transportation. In Davenport the nonuser group also regarded further public investment in this area as being less important than additional expenditures for street and highway improvements. In Hicksville, however, all three groups attached a higher priority to public transportation than to streets and highways.

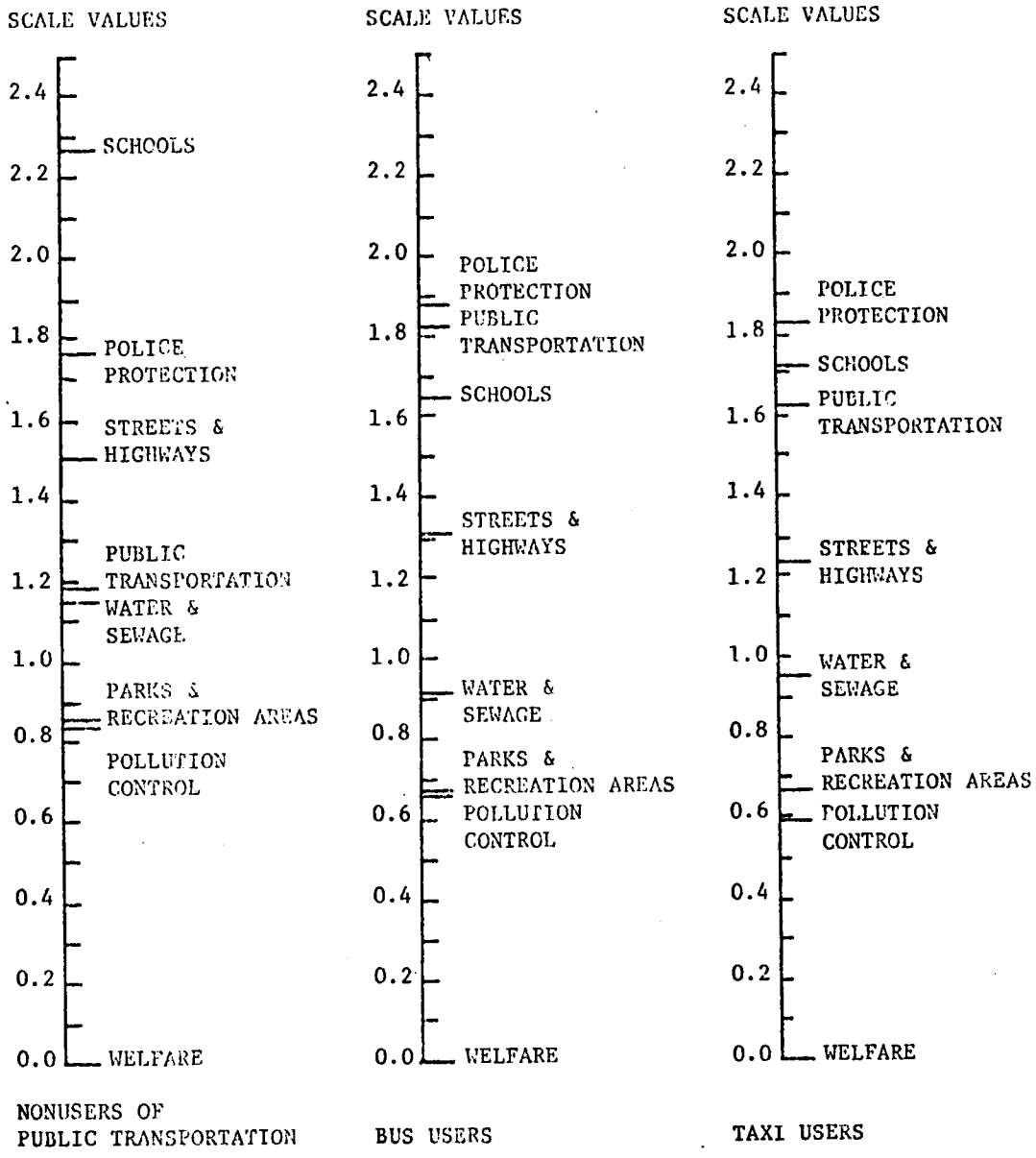


FIGURE 14-1

PRIORITIES FOR PUBLIC INVESTMENT IN DAVENPORT

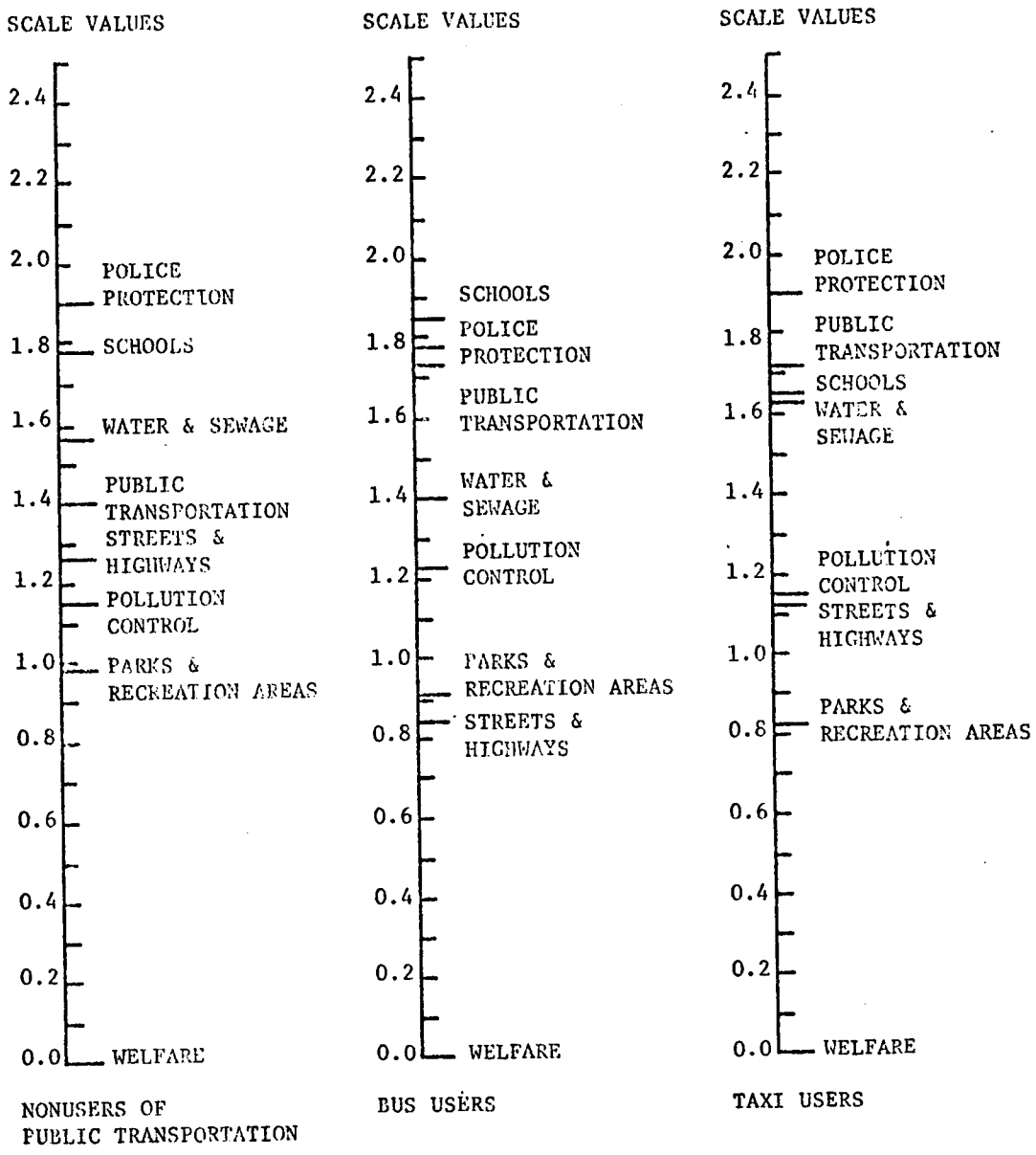


FIGURE 14-2

PRIORITIES FOR PUBLIC INVESTMENT IN HICKSVILLE

As noted previously, when applied to the Davenport data, the chi-square test of the assumptions under Case V indicated that the standard deviations for the eight items may have differed from each other. The range of the estimated standard deviations varied between groups. The widest range was associated with the taxi users, the largest standard deviation being 3.9 times the size of the smallest, while the narrowest range belonged to the nonusers of public transportation, the largest standard deviation in this case being 1.9 times the size of the smallest. For each group, however, schools and welfare, the items with the largest and smallest scale values, respectively, produced the widest dispersion of responses, indicating considerable disagreement over the scale positions of these items. Likewise, for each group, the third largest standard deviation or dispersion of responses was that corresponding to public transportation. The least variation occurred in the area of streets and highways.

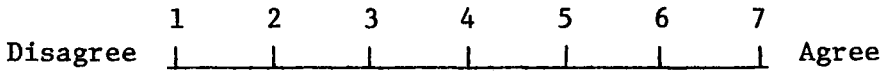
The analysis of community priorities has served to place into perspective the users' and nonusers' willingness to support further public investment in public transportation. Neglected by this analysis, however, was the possibility that, rather than additional tax support, many persons would have preferred no tax support of public transportation. Moreover, some individuals may have had different opinions regarding public support for the two types of public transportation being studied. These two aspects were examined in the following analysis for which the findings of the pair comparisons analysis provided a useful frame of reference.

Methods of Financing

Three alternative ways of defraying the costs of bus and shared-ride taxi service were examined. These alternatives were presented to the respondents in the form of the following statements:

1. Bus (taxi) service should pay for itself from fares charged users
2. Bus (taxi) service should be supported in part by fares and in part by local taxes
3. Bus (taxi) service should be free with the entire cost paid from local taxes.

The person being interviewed indicated the degree of his or her disagreement with each statement by circling a number on the following scale:



In computing the median response to each alternative, this scale was assumed to be continuous. Thus, median scale values less than 3.5 indicate some degree of disagreement, while those above 4.5 indicate agreement with the method by a majority.

It is obvious from Table 14-3 that, in Davenport, the only popular method of financing shared-ride taxi service was through user charges. From the large values of the median responses, it is also apparent that a majority of the respondents were strongly in favor of this method. Moreover, there was no significant disagreement between the three groups over the desirability of this alternative. By contrast,

TABLE 14-3

ATTITUDES TOWARD ALTERNATIVE METHODS OF FINANCING BUS AND SHARED-RIDE TAXI SERVICE IN DAVENPORT

Alternative	Nonusers of Public Transportation			Bus Users			Taxi Users		
	Percent in Favor	Percent Opposed	Median Scale Value	Percent in Favor	Percent Opposed	Median Scale Value	Percent in Favor	Percent Opposed	Median Scale Value
Fare only									
Bus	51.1	28.9	4.61	39.1	42.9	3.90	47.7	37.8	4.34
Taxi	86.3	6.5	6.82	80.9	10.7	6.84	85.1	9.6	6.81
Fare and local taxes									
Bus	42.0	41.5	4.02	66.9	22.6	6.51	55.9	33.3	5.43
Taxi	6.7	86.0	1.21	16.9	77.7	1.21	20.4	72.6	1.32
Entirely by local taxes									
Bus	5.9	89.8	1.12	7.5	84.2	1.15	10.8	82.0	1.21
Taxi	3.2	94,3	1.07	2.3	94.7	1.07	1.8	93.0	1.10

support for even partial subsidization of the shared-ride taxi service was minimal. In this case the median scores indicate that a majority opposed this approach with the strongest of feelings. There was likewise no significant disagreement between the groups over the unacceptability of a free taxi service supported solely by local taxes. However, the chi-square test did detect significant differences of opinion between the nonusers of public transportation and both the bus users and taxi users relative to partial subsidization. The table shows that each of the latter were more likely to support to some extent partial subsidization and, conversely, were less likely to oppose this alternative than were persons in the nonuser group. From a practical standpoint, however, these differences do not appear to be meaningful.

The most popular method of financing the bus service in Davenport was dependent upon the group involved. The nonusers of public transportation were moderately in favor of supporting the system solely through the farebox and preferred this method over the other two. The taxi users were also slightly inclined to approve of this alternative, while bus users were generally neutral to it. The majority of the latter were rather strongly in favor of partial subsidization. This alternative was also preferred by the taxi users, although they were less in favor of it than the bus users. Interestingly, those who use neither form of public transportation were nearly evenly divided over the issue of partially subsidizing the bus service. Thus, despite the fact that the bus system had been subsidized through local taxes for several years prior to this study, there was still no strong support of this alternative on the part of the nonusers of public transportation, who

constitute a large majority of the population. Without question, however, complete subsidization was the least popular means of discharging the costs of the bus system, being strongly opposed even by the bus users.

For the most part, the results of the Hicksville survey, summarized in Table 14-4, were similar. The concensus of each group was that the taxi service should be financed strictly by the fares charged its customers. Even partial subsidization of the taxi service was highly unacceptable to most respondents in each of the groups. Regarding the bus system, the nonusers of public transportation preferred to have the service financed strictly through the farebox, an alternative to which the bus users were generally neutral. The latter, however, were highly in favor of partial subsidization. Both of the above methods were slightly acceptable to the taxi users. In Davenport the nonusers of public transportation were divided over partial subsidization; in Hicksville, however, this group was decidedly opposed to this alternative even though partial tax support of the system, newly acquired by the public, was being considered by the local transit authority. Complete subsidization, however, as in Davenport, was highly unacceptable to all groups.

Methods of Providing the Service

The following analysis was conducted in a manner similar to that above. Three alternatives were presented to the respondents in the form of the following statements:

1. The bus (taxi) service should be privately owned

TABLE 14-4

ATTITUDES TOWARD ALTERNATIVE METHODS OF FINANCING BUS AND SHARED-RIDE TAXI SERVICE IN HICKSVILLE

Alternative	Nonusers of Public Transportation			Bus Users			Taxi Users		
	Percent in Favor	Percent Opposed	Median Scale Value	Percent in Favor	Percent Opposed	Median Scale Value	Percent in Favor	Percent Opposed	Median Scale Value
Fare only									
Bus	56.5	31.5	5.18	36.4	38.6	3.96	46.5	34.9	4.31
Taxi	86.9	8.3	6.88	79.5	13.6	6.81	85.9	11.8	6.86
Fare and local taxes									
Bus	37.3	50.8	3.39	61.4	18.2	6.00	48.2	38.8	4.36
Taxi	8.5	86.8	1.13	9.1	79.5	1.35	7.1	87.1	1.14
Entirely by local taxes									
Bus	14.1	80.3	1.19	9.1	77.3	1.35	7.1	84.7	1.19
Taxi	7.5	89.3	1.08	13.6	81.8	1.13	5.9	87.1	1.12

2. The public should buy the buses (taxis) and lease them to a private company to operate
3. The bus (taxi) service should be provided by the public and not by a private company.

The scale used in the analysis of financial alternatives was also employed in this case to quantify the respondents' opinions; hence, the same interpretation could be made of the median response to each alternative.

The results of the Davenport survey, shown in Table 14-5, paralleled to some extent those which emerged from the analysis of financial alternatives. It is clear that any form of public involvement in the actual provision of the shared-ride taxi service, including that of leasing the cabs to private operators, was highly undesirable. According to the results of the chi-square test, however, a statistically significant difference of opinion did exist between the nonusers of public transportation and the taxi users regarding the desirability of private ownership. This was due primarily to the higher percentage of taxi users who opposed this option; from a practical standpoint, however, the discrepancy was minor. For the other two alternatives, the pattern of responses was virtually the same for each group.

The users' and nonusers' of public transportation in Davenport differed in their views of how the bus service should be provided. Those who used neither the bus nor the taxi were divided over whether the system should be privately or publicly owned. The bus users, on the other hand, were strongly in favor of public ownership and, conversely, strongly opposed to private ownership of the bus system. This was also

TABLE 14-5

ATTITUDES TOWARD ALTERNATIVE METHODS OF PROVIDING BUS AND SHARED-RIDE TAXI SERVICE IN DAVENPORT

Alternative	Nonusers of Public Transportation			Bus Users			Taxi Users		
	Percent in Favor	Percent Opposed	Median Scale Value	Percent in Favor	Percent Opposed	Median Scale Value	Percent in Favor	Percent Opposed	Median Scale Value
Private Ownership									
Bus	34.8	40.2	3.89	15.8	66.9	1.44	24.3	59.5	1.95
Taxi	84.4	6.2	6.82	82.4	12.2	6.84	77.2	16.7	6.79
Public leasing of vehicles to private operators									
Bus	12.4	62.4	1.91	13.5	69.2	1.43	12.7	72.7	1.39
Taxi	5.7	82.7	1.19	8.5	83.8	1.17	8.8	85.0	1.17
Public Ownership									
Bus	39.7	40.5	3.98	62.1	24.2	6.50	56.4	31.8	6.17
Taxi	7.5	80.6	1.20	12.3	80.0	1.18	11.5	82.3	1.16

true of the taxi users, although for both alternatives the views of these individuals were often not as extreme. Interestingly, all three groups were highly opposed to the public's leasing the buses to a private firm although, as confirmed by the Wilcoxon test, not quite to the same degree as in the case of the taxi. This opposition may have been an expression of a strong belief in the notion of laissez faire; that is, if the system is to be operated by a private firm, the government should have as little direct involvement in the provision of the service as possible.

Table 14-6 shows that the results of the Hicksville survey were much the same as those for Davenport relative to the taxi but quite different with respect to the bus. As in Davenport, most respondents in each group were highly opposed to any public involvement in the provision of the shared-ride taxi service, although compared with the nonusers of public transportation, the bus users were significantly less strongly opposed to a publicly owned taxi system. Contrary to the case in Davenport, however, were the attitudes of the bus and taxi users toward the form of ownership of the bus system. In general, while being moderately opposed to private ownership, the bus users were only slightly partial to public ownership of the bus service. Both the nonusers of public transportation and the taxi users were somewhat neutral toward each of these alternatives, although in each group more persons were opposed to public ownership than were in favor of it. These two groups were highly against the notion of having a public entity purchase the buses and lease them to a private firm. The bus users also expressed considerable disagreement with this alternative although not to the same

TABLE 14-6

ATTITUDES TOWARD ALTERNATIVE METHODS OF PROVIDING BUS AND SHARED-RIDE TAXI SERVICE IN HICKSVILLE

Alternative	Nonusers of Public Transportation			Bus Users			Taxi Users		
	Percent in Favor	Percent Opposed	Median Scale Value	Percent in Favor	Percent Opposed	Median Scale Value	Percent in Favor	Percent Opposed	Median Scale Value
Private ownership									
Bus	44.7	39.3	4.17	29.5	52.3	3.00	39.5	43.0	3.90
Taxi	80.3	11.1	6.81	70.5	15.9	6.65	81.2	10.6	6.79
Public leasing of vehicles to private operators									
Bus	13.6	68.0	1.39	15.9	68.2	2.50	18.8	62.4	1.47
Taxi	6.9	85.3	1.17	9.3	74.4	1.30	7.1	85.7	1.15
Public ownership									
Bus	39.3	45.7	3.79	47.7	27.3	4.41	33.7	41.9	3.83
Taxi	10.8	80.4	1.18	27.3	59.1	2.00	15.3	77.6	1.22

degree. In general there appeared to be considerable uncertainty as to which sector--either public or private--held the responsibility for providing bus service in the Hicksville area.

Summary

The analyses presented in this chapter provided further evidence that most persons possessed a different image of each type of public transportation. Attitudes toward the shared-ride taxi system were definite. An overwhelming majority of the bus users, taxi users, and nonusers of public transportation clearly felt that the responsibility for this type of service should be relegated to private enterprise; consequently, there was very little support for any form of governmental involvement in the operation of the taxi system. Attitudes toward the bus service, however, varied between users and nonusers of public transportation and between study areas. In Davenport bus and taxi users were more inclined to regard the provision of bus transportation as a public service. Both groups, particularly the bus users, were in favor of partial subsidization and public ownership of the bus system; moreover, both groups attached a high priority to public transportation in general as an area in need of additional tax support. In contrast there was considerable lack of agreement among those in the nonuser group in Davenport and among the individuals in all three groups in Hicksville as to whether the provision of bus transportation was a private or a public responsibility. Thus, despite the fact that the issues of partial subsidization and public ownership of the bus system had been resolved at the governmental level in both

study areas, there still existed no strong support for this policy on the part of the populace.

CHAPTER 15

IMPLICATIONS OF THE RESEARCH

The intent of this research effort has been to clarify the roles performed by the bus and shared-ride taxi systems in two smaller urban areas. The results of this study have several important implications which concern the potential of privately owned demand-responsive transportation and the formulation of public policy in this area. These are touched upon in the following summary of the major conclusions and recommendations drawn from the study.

Conclusions

A shared-ride taxi service can be a major component of the total public transportation system in smaller urban areas. The shared-ride taxi is a versatile mode, capable of accommodating a diversity of trips. While sacrificing some of the privacy and speed of the private automobile, the shared-ride taxi nevertheless retains much of the auto's flexibility. Consequently, from an operational standpoint, all areas of the community are equally accessible to the service, particularly low-density areas which often cannot be economically served by the fixed-route, fixed-schedule transit. The shared-ride taxi is especially useful for trips between widely scattered origins and destinations which are often difficult to reach by bus. This last attribute of the shared-ride taxi was amply demonstrated by the system in Davenport.

The functions which a shared-ride taxi system performs can vary between urban areas, depending on the characteristics of each urban

environment. This trait is further testimony of the versatility and flexibility of the mode. In Davenport, a midwestern industrial center with a population of nearly 100,000 and a relatively low overall density, the shared-ride taxi system functioned primarily as a many-to-many system, a connector of widely dispersed locations, usually minor trip generators such as residences and small business and service establishments. In Hicksville, an unincorporated community located within the New York City SMSA, smaller and slightly more densely developed than Davenport, an important function of the shared-ride taxi system was that of a feeder service to the Long Island Railroad commuter rail network. In general the Hicksville system, which also frequently served the major shopping centers, operated both as a many-to-few and a many-to-many service.

The effective range of a shared-ride taxi system is not limited to small areas. Most of the existing, publicly owned demand-responsive transportation systems operate within areas encompassing between two and ten square miles (Arrillaga and Mouchahoir, 1974, p. 14). One of the largest many-to-many dial-a-ride systems, in operation in Haddonfield, New Jersey, serves an area of 10.9 square miles, employing twelve 17-passenger and seven 13-passenger vehicles (Arrillaga and Mouchahoir, 1974, p. 14). The Davenport shared-ride taxi system, however, operated quite well in a service area of 19.7 square miles, using approximately twenty 5-passenger Checker cabs. The average ride time on the Davenport system was 14 minutes, compared to 13 minutes on the Haddonfield system (Arrillaga and Mouchahoir, 1974, p. 14).

The market for shared-ride taxi service is not limited to the more elite segments of the population. A similar conclusion has been drawn from studies of taxicab usage in major metropolitan areas. In Davenport

and Hicksville the shared-ride taxi systems attracted the same types of people as the bus systems.

The functions of a shared-ride taxi system operating in a community without a bus service may differ from its roles when in competition with a lower-priced bus service. The bus and shared-ride taxi systems in Davenport and Hicksville were highly competitive in many respects. Both systems attracted the same types of people; in fact, many persons utilized both types of service. Except for the movement of masses of commuters during the peak hours, both modes also performed many similar tasks although not to the same extent. Nevertheless, when in competition with a lower-priced bus service, a shared-ride taxi system may assume the role of an auxiliary mode of transportation. In other words, the system will tend to attract persons who are less dependent upon public transportation and, therefore, use it relatively infrequently. This does not negate the importance of the shared-ride taxi service nor lessen its utility, since for certain trips the cab may be a highly useful if not an essential means of transportation.

Improvements in a shared-ride taxi service can produce substantial increases in ridership. An excellent example of this was the system in Davenport, which witnessed a 179 percent increase in annual ridership between 1967 and 1972 following the expansion of the fleet and the implementation of a service-oriented market strategy. Improvements in conventional transit systems often result in much smaller short-term increases in ridership.

The image of the shared-ride taxi system, although not inimical, was unfavorable from a public relation's standpoint. Improvements in the Davenport system appeared to be highly invisible to nonusers, who

very likely formed their impressions on the basis of outward appearances and the relatively high fare. Unbalanced promotion of the bus service by the local government may also have contributed to or reinforced this unsatisfactory view of the shared-ride taxi service.

Recommendations

In urban areas with a population less than at least 100,000 and possibly up to 250,000, consideration should be given to using shared-ride taxi service or some other variation of a privately owned demand-responsive transportation system as a replacement for fixed-route, fixed-schedule bus service during off-peak periods. Some smaller urban areas, those with a population under 50,000, could rely totally on a shared-ride taxi system for public transportation service. If a bus service is desirable during the rush hours, a contractual agreement could be arranged with a taxicab firm or, indeed, with any entrepreneur to provide the service. However, other solutions to the peak hour traffic problem, including car pools, express bus service, and employer-sponsored van pools, should always be evaluated.

A shared-ride taxi service can play a useful role in serving the commuter during the daily peak travel periods. A shared-ride taxi system can supplement an express transit service in areas where the aggregate demand for transportation between common origins and destinations is small. Car pooling by taxicab was practiced to a limited extent in Hicksville; in fact, a flat "package" fare was offered to groups of regular users such as commuters who lived in the same neighborhood and traveled together to work (A Preliminary Analysis of Two Shared-Ride Taxi Systems,

1973, p. 15). Therefore, in developing and implementing car pool and bus pool programs, the shared-ride taxi should not be ignored.

The taxicab should be a major element in short-range public transportation plans. Indeed, the local planning agency can become an important source of information for the management of a taxicab service. While developing both short- and long-range plans, the planner can pinpoint areas which are poorly served by public transportation, identify untapped markets and market opportunities, and conduct market analyses to determine what changes or improvements consumers would like to see made in the taxi service.

There is no reason to believe that a shared-ride taxi service cannot serve the needs of the transportation disadvantaged such as the poor, the handicapped, the elderly, etc.; consequently, efforts to improve the mobility of these people should include this mode as an alternative to conventional, fixed-route, fixed-schedule transit service. Often employed as an argument for the subsidization of mass transit systems is the inability of the transportation disadvantaged, particularly the poor, to afford the frequent use of higher-priced public transportation services. Rather than subsidize an uneconomical bus system, however, local elected officials should consider the alternative of entering into a contractual agreement with a private taxicab firm to offer its service to designated groups at reduced fares. Any such arrangement, however, should be designed to subsidize the user and not the system. Thus, in order to benefit from a program to assist the transportation disadvantaged, the management of the shared-ride taxi system should be required to seek the patronage of this market segment through marketing and innovation.

At the state and local government levels, a complete re-evaluation of current regulatory practices and policies affecting local public carriers is urgently needed. Special consideration should be given to relaxed regulation in the areas of entry control, fares, and methods of operation. Many existing regulations may not be in the best interests of consumers and/or operators. Moreover, in urban areas where the bus service is publicly owned, it is questionable as to whether the public sector should also dictate the cab fare structure and the permissible methods of operation, since the two modes can be highly competitive. To the extent that relaxed regulation fosters competition and innovation in the public passenger transport industry, the present unsatisfactory image of the taxi may be dispelled.

At the Federal level, the shared-ride taxi and other forms of local, privately owned, public carriage should also be considered as systems which are eligible for funds designed to aid communities in the implementation of plans and programs involving transportation. However, the purpose of such funds should be to subsidize particular groups of users rather than the systems themselves. On the other hand, federal financial and technical assistance in the development of automatic dispatching technology is desirable.

The role of a shared-ride taxi service or any other form of demand-responsive transportation in issues relating to land development and energy conservation should also be considered. As mentioned previously, a shared-ride taxi system performs an important function in linking widely scattered areas. Hence, such a service is well-suited to the prevailing low-density, dispersed form of development. It is doubtful that the existence of a shared-ride taxi operation could be used by

itself as an implementation device to induce or foster desirable patterns of development. On the other hand, this mode of public transportation could be used to serve various alternative forms of planned development such as cluster development. With regard to energy matters, to an individual, the substitution of the shared-ride taxi for the private automobile could have a consequential impact upon personal energy consumption if the former is used extensively. Because better utilization of fuel can be obtained when separate trips are consolidated into a single vehicle, a shared-ride taxi system could have some impact upon energy conservation in general and certainly should be considered as a component in an energy conservation program along with other forms of pooling.

Finally, additional research into taxicab usage in smaller urban areas is needed to further clarify the roles which this mode plays in such communities. Future research should also include other privately owned public carriers such as jitney, livery, and public limousine services.

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APPENDIXES

APPENDIX A

CUSTOMER DATA RECORD

CUSTOMER DATA RECORD

(For Each Request for Service)

Form No. 1 (1) City (2) Date: Month (3 4) Day (5 6) Year (7 8)

1. Service Request Number (9 10 11 12 13)

2. Time of Service Request _____a.m. _____p.m. (14 15 16 17)

3. Trip Origin _____
(Address of Residence or Name of Business, Institution, etc.)

a. Type (18) 1 = Residence 2 = Medical facility 3 = public facility 4 = Tavern 5 = Motel 6 = Business 7 = school 8 = frequent point

b. Zone (19 20 21) Zone if a = 1 - 7 Firm # if a = 8

4. Trip Destination _____
(Address of Residence or Name of Business, Institution, etc.)

a. Type (22) 1 = Residence 2 = Medical facility 3 = public facility 4 = Tavern 5 = Motel 6 = Business 7 = school 8 = frequent point

b. Zone (24 25 26) Zone if a = 1 - 7 Firm # if a = 8

5. Trip Type (28) 1 = People 2 = Goods 3 = People & Goods

****

PASSENGER TRIP

6. Level of Service (29) 1 = Shared Ride 2 = Premium Service (Single Fare)

7. Passenger Physically Handicapped? (30) 1 = Yes 2 = No 3 = Emergency 4 = Drunk

8. Wheel Chair? (31) 1 = Yes 2 = No

9. Number of People (32)

****

GOODS DELIVERY

10. Type of Goods (33 34) 1 = Telegram 2 = Groceries 3 = Money 4 = Mail 5 = Prescription Drugs 6 = Alcoholic Beverages 7 = Auto parts 8 = Animals 9 = Skycab 10 = Other parcels or packages

11. Number of Parcels (fares only) (35 36)

12. Approximate Weight of Goods Shipment (LBS) (37 38 39)

****

13. Dispatch Time _____a.m. _____p.m. (40 41 42 43)

14. Vehicle Assigned (44 45 46)

15. Method of Assignment (47) 1 = Computer 2 = Manual 3 = Flag 4 = Prearranged 5 = Stand

16. Driver's Identification Number (48 49 50)

17. Pick Up Time _____a.m. _____p.m. (51 52 53 54)

18. Delivery Time _____a.m. _____p.m. (55 56 57 58)

19. Fare _____ (59 60 61 62)

20. Extra Charge (63) 1 = Waiting 2 = Tour 3 = Long Distance Trip 4 = Packages 5 = Multiple destination 6 = Nurse Call 7 = Other

21. Extra Fare _____ (64 65 66 67)

22. Method of Payment (68) 1 = Cash by shipper 2 = Cash by receiver 3 = Billed 4 = COD 5 = Social Services

23. Cancellations (69) 1 = Cancel 2 = Noshow

APPENDIX B

VEHICLE DATA RECORD

VEHICLE DATA RECORD

Form No. 4 (1) City (2) Date: Month (3 4) Day (5 6) Year (7 8)

1. Vehicle Number (9 10 11)
2. Vehicle Capacity (Passengers): (12 13)
3. Driver's Identification Number: (14 15 16)
4. Driver's Initials: (17 18 19)
5. Beginning Mileage: (20 21 22 23 24 25 . 26)
6. Beginning Zone: _____
   Zone (27 28 29 30)
7. Time Vehicle Began Operation: _____a.m. _____p.m. (31 32 33 34)
8. Weather: (35) 1 = Light rain 2 = Heavy rain 3 = Light snow 4 = Heavy Snow 5 = Freezing rain 6 = Clear
9. Street Conditions: (36) 1 = Dry 2 = Wet 3 = Snow-covered 4 = Icy
10. Temperature at Midday: (+/-) (37 38 39 40)
11. Ending Mileage: (41 42 43 44 45 46 . 47)
12. Ending Zone: _____
    Zone (48 49 50 51)
13. Time Vehicle Ended Operation? _____a.m. _____p.m. (52 53 54 55)
14. Vehicle Down Time: Hours (56 57) Minutes (58 59)
15. Daily Receipts:
    a. Passenger: Cash (60 61 . 62 63) Charge (64 65 . 66 67)
    b. Goods: Cash (68 69 . 70 71) Charge (72 73 . 74 75)

APPENDIX C

BUS PASSENGER QUESTIONNAIRES

Transportation Research Center

The University of Tennessee
Knoxville



NASSAU COUNTY PUBLIC TRANSPORTATION STUDY
BUS PASSENGER QUESTIONNAIRE

Dear Passenger: Please complete the top sheet of this survey while you are riding in the bus. When you leave the bus, please give only the top sheet to the driver. Complete the rest of the survey after you return home. Thanks for your help.

For Office Use Only 0231	
9	____
13	____
17	____
21	_
22	___
25	___
28	_
29	_
30	_
31	__
33	__
35	__
37	_
38	_
39	__
41	_
42	_
43	___
46	_

1. At what time did you start this trip? _____ ___a.m. ___p.m.

2. At what time will you get to your destination? _____ ___a.m. ___p.m.

3. Purpose of trip? 1. ___Work 2. ___School 3. ___Shopping
   4. ___Social or Recreation 5. ___Medical 6. ___Personal Business

4. Where did you start this trip? (Nearest street intersection)
   Corner of _____St. and _____St.

5. What is your final destination? (Nearest street intersection)
   Corner of _____St. and _____St.

6. Have you already or will you change buses? 1. ___Yes 2. ___No

7. Will you use the bus again today? 1. ___Yes 2. ___No

8. Will you use the taxi today? 1. ___Yes 2. ___No

9. How many packages (such as sacks of groceries) are you carrying? _____

10. How many children are going with you on this trip? _____

11. How many cars are owned or used by members of your household? _____

12. Are you physically handicapped? 1. ___Yes 2. ___No

13. Do you have a driver's license? 1. ___Yes 2. ___No

14. How many blocks from your house to nearest bus stop? _____

15. Your sex? 1. ___Male 2. ___Female

16. Your age group? 1. ___Under 16 2. ___16-21 3. ___22-30
    4. ___31-44 5. ___45-64 6. ___Over 64

17. Employed? 1. ___Yes 2. ___No
    Student? 1. ___Yes 2. ___No
    Married? 1. ___Yes 2. ___No

18. Yearly household income? 1. ___0-$4,999 2. ___$5,000-$9,999
    3. ___$10,000-$14,999 4. ___$15,000-$20,000
    5. ___Over $20,000

Transportation Research Center

The University of Tennessee
Knoxville

NASSAU COUNTY PUBLIC TRANSPORTATION STUDY

BUS PASSENGER QUESTIONNAIRE

Dear Passenger:

The Transportation Research Center at the University of Tennessee is studying bus and taxi service in smaller urban areas. The purpose of this study is to learn how important the bus and taxi are to you in meeting your transportation needs.

Please complete the attached questionnaire, fold it so that the address on the back shows, and drop it in any mail box. No postage stamp is necessary.

You will notice that we are not asking for your name and address in order to keep this questionnaire as impersonal as possible.

Thanks for your help.

Kenneth W. Heathington, Ph.D., P.E.
Director Transportation Research Center
University of Tennessee

Transportation Research Center

The University of Tennessee
Knoxville

NASSAU COUNTY PUBLIC TRANSPORTATION STUDY

9 0232 12

BUS PASSENGER QUESTIONNAIRE

CARD 1/13

1. Fill in this table with the number of trips YOU made last week by bus, taxi, car, and rail (Long Island Railroad) to each of these places.

Going to a place counts as one trip. Returning from it counts as another trip.

Ignore the numbers in Parentheses

PLACE	BY BUS	BY TAXI	BY CAR	BY RAIL
Rail stations	(14-15)	(16-17)	(18-19)	
Work	(20-21)	(22-23)	(24-25)	(26-27)
School, nursery, or day-care center	(28-29)	(30-31)	(32-33)	(34-35)
Store for shopping	(36-37)	(38-39)	(40-41)	(42-43)
Social visits or meetings such as friend's or relative's house	(44-45)	(46-47)	(48-49)	(50-51)
Places for recreation (theater, bowling alleys, etc.)	(52-53)	(54-55)	(56-57)	(58-59)
Doctor's office, clinic, and hospital	(60-61)	(62-63)	(64-65)	(66-67)
Places for personal business (bank, post office , pay bills, etc.)	(68-69)	(70-71)	(72-73)	(74-75)
Restaurants, taverns, and drive-ins	(14-15)	(16-17)	(18-19)	(20-21)

CARD 2/13

2. Are you a regular user of the local bus service?

1. ___Yes 2. ___No _ (22)

If you are NOT a regular user, please skip to Question 9.

3. How many years has it been since you started using the bus regularly?

1. ___Less than 1 year 5. ___7-10 Years _ (23)
2. ___1-2 Years 6. ___11-20 Years
3. ___3-4 Years 7. ___21-30 Years
4. ___5-6 Years 8. ___Over 30 years

4. When you started using the bus regularly, did you have a driver's license?

1. ___Yes 2. ___No _ (24)

5. What was your age group when you started using the bus regularly?

1. ___Under 16 4. ___31-44 _ (25)
2. ___16-21 5. ___45-64
3. ___22-30 6. ___Over 64

6. Before you started using the bus regularly, which one of these did you use in its place?

1. ___Taxi 4. ___Walked _ (26)
2. ___Drove a Car 5. ___Other? _____
3. ___Rode in a car _____

7. Why did you start riding the bus? You may check more than one.

1_____The bus was the only thing I could afford to use _ (27)
2_____I did not know how to drive a car _ (28)
3_____Someone else in the family needed the car _ (29)
4_____I lived near a bus stop _ (30)
5_____My place of work was near a bus stop _ (31)

(Continued on next page)

6_____I no longer had someone to drive me in their car _ (32)

7_____I changed jobs and my new job was near a bus stop _ (33)

8_____I moved and my new home was near a bus stop _ (34)

9_____I was no longer able to drive _ (35)

10_____I no longer liked to drive in heavy traffic _ (36)

11_____I did not like the taxi service _ (37)

12_____I no longer wanted to use the taxi service _ (38)

13_____Other reasons? Please explain _____ _ (39)

_____

Of the ones you have just checked, CIRCLE the single MOST IMPORTANT one. _ _ (42)

8. Do you ride the bus as often now as you did when you first started using it?

1. ___Yes 2. ___No _ (43)

9. Why do you use the bus now instead of the taxi? You may check more than one.

1_____I live near a bus route _ (44)

2_____Many of the places that I go to are near a bus route _ (45)

3_____I know some of the people who ride the bus with me _ (46)

4_____I can't afford to use the taxi _ (47)

5_____The bus drivers are more friendly _ (48)

6_____I do not have to wait as long for the bus as I do for the taxi _ (49)

7_____I can save time by taking the bus instead of the taxi _ (50)

8_____It is easier for me to get in and out of a bus than a taxi _ (51)

9_____The bus is more comfortable than the taxi _ (52)

(Continued on next page)

10.____The buses are in better shape than the taxis _ (53)

11.____The bus drivers are safer drivers than the taxi drivers _ (54)

12.____I sometimes have to carry packages and it is easier to carry them on the bus _ (55)

13.____I sometimes have children with me and it is easier to take them on the bus _ (56)

14.____Other reasons? Please explain _____ _ (57)

_____

Of the ones you have just checked, CIRCLE the single MOST IMPORTANT one. _ _ (60)

10. Check how often you use the local taxi.

1. ___I use the taxi but not as much as I use the bus _ (61)
2. ___I use the taxi about as much as I use the bus
3. ___I use the taxi more than I use the bus
4. ___I do not use the taxi at all

11. If you do use the taxi, when do you use it instead of the bus? You may check more than one.

1.____When the buses are not running _ (62)

2.____When I have to get someplace at a certain time _ (63)

3.____When the place where I am going is not on a bus route _ (64)

4.____When I don't want to wait outside in the weather for the bus _ (65)

5.____When I would have to change buses to get to my destination _ (66)

6.____When I don't know which bus to take _ (67)

7.____When I miss my bus and can't wait for the next one _ (68)

8.____When I'm carrying a lot of packages _ (69)

9.____When I've got children with me _ (70)

10.____Other? Please explain _____ _ (71)

_____

12. How long have you lived at your present address? _ (73)

1_____Less than 6 months 5_____6-10 years

2_____6 months - 1 year 6_____11-20 years

3_____1-2 years 7_____21-40 years

4_____3-5 years 8_____Over 40 years

13. How long have you lived in Nassau County? _ (74)

1_____Less than 6 months 5_____6-10 years

2_____6 months - 1 year 6_____11-20 years

3_____1-2 years 7_____21-40 years

4_____3-5 years 8_____Over 40 years

14. Do you live in the Town of Oyster Bay?

1_____Yes 2_____No _ (75)

15. Do you live in Hicksville?

1_____Yes 2_____No _ (76)

16. How many persons are in your household counting yourself?

_____ _ _ (78)

17. How many persons in your household have a driver's license counting yourself if you have one?

_____ _ _ (80)

APPENDIX D

TAXI PASSENGER QUESTIONNAIRES

Transportation Research Center — The University of Tennessee, Knoxville

0001



NASSAU COUNTY PUBLIC TRANSPORTATION STUDY
TAXI PASSENGER QUESTIONNAIRE

TO BE COMPLETED BY TAXI DRIVER	Pickup Time _____	___a.m.	___p.m.	13 _ _ _ _
	Delivery Time _____	___a.m.	___p.m.	17 _ _ _ _

For Office Use Only 9 _ _ _ _

Dear Passenger: Please complete the top sheet of this survey while you are riding in the taxi. When you are finished, please give only the top sheet to the driver. Complete the rest of the survey after you return home. Thanks for your help.

1. Purpose of trip? 1. ___Work 2. ___School 3. ___Shopping 4. ___Social or Recreation 5. ___Medical 6. ___Personal Business — 21 _

2. Where did you get on the taxi? (Please give an address) _____ — 22 _ _ _

3. Where will you get off? (Please give an address) _____ — 25 _ _ _

4. Will you use the taxi again today? 1. ___Yes 2. ___No — 28 _

5. Will you use the bus today? 1. ___Yes 2. ___No — 29 _

6. How many packages (such as sacks of groceries) are you carrying? _____ — 30 _ _

7. How many children are going with you on this trip? _____ — 32 _ _

8. How many cars are owned or used by members of your household? _____ — 34 _ _

9. Are you physically handicapped? 1. ___Yes 2. ___No — 36 _

10. Do you have a driver's license? 1. ___Yes 2. ___No — 37 _

11. How many blocks from your house to nearest bus stop? _____ — 38 _ _

12. Your sex? 1. ___Male 2. ___Female — 40 _

13. Your age group? 1. ___Under 16 2. ___16-21 3. ___22-30 4. ___31-44 5. ___45-64 6. ___Over 64 — 41 _

14. Employed? 1. ___Yes 2. ___No Student? 1. ___Yes 2. ___No Married? 1. ___Yes 2. ___No — 42 _ _ _

15. Yearly household income? 1. ___0 - $4999 2. ___$5000 - $9999 3. ___$10,000 - $14,999 4. ___$15,000 - $20,000 5. ___Over $20,000 — 45 _

Transportation Research Center

The University of Tennessee
Knoxville

NASSAU COUNTY PUBLIC TRANSPORTATION STUDY
TAXI PASSENGER QUESTIONNAIRE

Dear Passenger:

The Transportation Research Center at the University of Tennessee is studying bus and taxi service in smaller urban areas. The purpose of this study is to learn how important the bus and taxi are to you in meeting your transportation needs.

Please complete the attached questionnaire, fold it so that the address on the back shows, and drop it in any mail box. No postage stamp is necessary.

You will notice that we are not asking for your name and address in order to keep this questionnaire as impersonal as possible.

Thanks for your help.

Kenneth W. Heathington, Ph.D., P.E.
Director Transportation Research Center
University of Tennessee

Transportation Research Center

The University of Tennessee
Knoxville

0002

9 – – 12

CARD 1
13

NASSAU COUNTY PUBLIC TRANSPORTATION STUDY
TAXI PASSENGER QUESTIONNAIRE

1. Fill in this table with the number of trips YOU made last week by bus, taxi, car, and rail (Long Island Railroad) to each of these places.

   Going to a place counts as one trip. Returning from it counts as another trip.

Ignore the numbers in Parentheses

PLACE	BY BUS	BY TAXI	BY CAR	BY RAIL
Rail stations	(14-15)	(16-17)	(18-19)	
Work	(20-21)	(22-23)	(24-25)	(26-27)
School, nursery, or day-care center	(28-29)	(30-31)	(32-33)	(34-35)
Store for shopping	(36-37)	(38-39)	(40-41)	(42-43)
Social visits or meetings such as friend's or relative's house	(44-45)	(46-47)	(48-49)	(50-51)
Places for recreation (theater, bowling alleys, etc.)	(52-53)	(54-55)	(56-57)	(58-59)
Doctor's office, clinic, and hospital	(60-61)	(62-63)	(64-65)	(66-67)
Places for personal business (bank, post office , pay bills, etc.)	(68-69)	(70-71)	(72-73)	(74-75)
Restaurants, taverns, and drive-ins	(14-15)	(16-17)	(18-19)	(20-21)

CARD 2
13

2. Are you a regular user of the local taxi service?

1. ___Yes 2. ___No _ (22)

If you are NOT a regular user, please skip to Question 10.

3. How many years has it been since you started using the taxi regularly?

1. ___Less than 1 Year 5. ___7-10 Years _ (23)
2. ___1-2 Years 6. ___11-20 Years
3. ___3-4 Years 7. ___21-30 Years
4. ___5-6 Years 8. ___Over 30 Years

4. When you started using the taxi regularly, did you have a driver's license?

1. ___Yes 2. ___No _ (24)

5. What was your age group when you started using the taxi regularly?

1. ___Under 16 4. ___31-44 _ (25)
2. ___16-21 5. ___45-64
3. ___22-30 6. ___Over 64

6. Before you started using the taxi regularly, which one of these did you use in its place?

1. ___Bus 4. ___Walked _ (26)
2. ___Drove a Car 5. ___Other? _____
3. ___Rode in a Car _____

7. Were you a regular user of the local BUS service before you started using the taxi regularly?

1. ___Yes 2. ___No _ (27)

8. Are you a regular user of the local BUS service now?

1. ___Yes 2. ___No _ (28)

9. Why did you start using the taxi? You may check more than one.

1_____ I could not afford a car _ (29)

2_____ I did not know how to drive _ (30)

3_____ Someone else in the family needed the car _ (31)

4_____ I worked at night when the buses were not running _ (32)

5_____ I changed jobs and my new job was not near a bus stop _ (33)

6_____ I moved and my new home was not near a bus stop _ (34)

7_____ The bus route that I used was dropped _ (35)

8_____ I did not like the bus service _ (36)

9_____ The bus fares were raised _ (37)

10_____ I no longer wanted to use the bus _ (38)

11_____ I no longer felt safe standing on a street corner waiting for a bus _ (39)

12_____ I no longer liked to drive in heavy traffic _ (40)

13_____ I was no longer able to drive _ (41)

14_____ I no longer had someone to drive me in their car _ (42)

15_____ Other reasons? Please explain _____ _ (43)

_____

_____

Of the ones you have just checked, CIRCLE the single MOST IMPORTANT one. _ _ (46)

10. Why do you use the taxi now instead of the bus? You may check more than one.

1_____ It is not safe to stand on a street corner and wait for a bus _ (47)

2_____ I do not live near a bus route _ (48)

3_____ Many of the places that I go to are not near a bus route _ (49)

4_____ There are no buses running at the time _ (50)

5_____ I do not like to ride with a lot of other people _ (51)

6_____ I missed my bus _ (52)

7_____ The taxi drivers are more friendly _ (53)

8_____ I do not have to wait as long for the taxi as I do for the bus _ (54)

9_____ I can save time by taking the taxi instead of the bus _ (55)

10_____ I do not like to wait outside in the weather for the bus _ (56)

11_____ I do not always know which bus to take _ (57)

12_____ I do not like to have to change buses _ (58)

13_____ It is easier for me to get in and out of a taxi than a bus. _ (59)

14_____ The taxi is more comfortable than the bus _ (60)

15_____ The taxis are in better shape than the buses _ (61)

16_____ The taxi gives me more freedom to travel when I want to than the bus _ (62)

17_____ The taxi drivers are safer drivers than the bus drivers _ (63)

18_____ I sometimes have to carry packages and it is easier to carry them in a taxi _ (64)

19_____ I sometimes have children with me and it is easier to take them in a taxi _ (65)

20_____ Other reasons? Please explain _____ _ (66)

_____

Of the ones you have just checked, CIRCLE the single MOST IMPORTANT one. _ _ (69)

11. How long have you lived at your present address?

1_____Less than 6 months
2_____6 months - 1 year
3_____1-2 years
4_____3-5 years
5_____6-10 years
6_____11-20 years
7_____21-40 years
8_____Over 40 years

_ (70)

12. How long have you lived in Nassau County?

1_____Less than 6 months
2_____6 months - 1 year
3_____1-2 years
4_____3-5 years
5_____6-10 years
6_____11-20 years
7_____21-40 years
8_____Over 40 years

_ (71)

13. Do you live in the Town of Oyster Bay?

1_____Yes 2_____No

_ (72)

14. Do you live in Hicksville?

1_____Yes 2_____No

_ (73)

15. How many persons are in your household counting yourself?

_____

__ (75)

16. How many persons in your household have a driver's license counting yourself if you have one?

_____

__ (77)

APPENDIX E

HOUSEHOLD SURVEY QUESTIONNAIRE



HICKSVILLE AREA PUBLIC TRANSPORTATION STUDY

Household Survey

1 2
I 2

Household Sample Number 3 – 5

Person Number 6 7

Interview Address _____

Zone Number 8 – 10

Date of Interview _____ 11 – – – – 16

Interviewer Identification and Certification:

I hereby certify that the information on this form has been obtained by me from the respondent and is accurate and complete.

Signature of Interviewer _____

Interviewer's Number 17 — 19

(2)

1. Fill in this table with the number of trips YOU made last week by bus, taxi, car, and rail (Long Island Railroad) to each of these places.

Going to a place counts as one trip. Returning from it counts as another trip. CARD 1/20

PLACE	BY BUS	BY TAXI	BY CAR	BY RAIL
Rail station	(21-22)	(23-24)	(25-26)	
Work	(27-28)	(29-30)	(31-32)	(33-34)
School, nursery, or day-care center	(35-36)	(37-38)	(39-40)	(41-42)
Store for shopping	(43-44)	(45-46)	(47-48)	(49-50)
Social visits or meetings such as friend's or relative's house	(51-52)	(53-54)	(55-56)	(57-58)
Places for recreation (theaters, sporting events, bowling alleys, etc.)	(59-60)	(61-62)	(63-64)	(65-66)
Doctor's office, clinic, hospital	(67-68)	(69-70)	(71-72)	(73-74)
Places for personal business (bank, post office, pay bills, etc.)	(21-22)	(23-24)	(25-26)	(27-28)
Restaurants, taverns, and drive-ins	(29-30)	(31-32)	(33-34)	(35-36)

CARD 2*/20

*1/1 2/5 ---/10 ---/15 ---/19

(3)

2. Are you now or have you ever been a regular user of the local BUS service?

1 ____ Yes 2 ____ No 37

If YES, please continue this question.
If NO, skip to question 3 on page 6.

A. How many years has it been since you started using the bus regularly?

1 ____ Less than 1 year
2 ____ 1-2 years
3 ____ 3-4 years
4 ____ 5-6 years
5 ____ 7-10 years
6 ____ 11-20 years
7 ____ 21-30 years
8 ____ Over 30 years
38

B. When you started using the bus regularly, did you have a driver's license?

1 ____ Yes 2 ____ No 39

C. What was your age group when you started using the bus regularly?

1 ____ Under 16
2 ____ 16-21
3 ____ 22-30
4 ____ 31-44
5 ____ 45-64
6 ____ Over 64
40

D. Before you started using the bus regularly, which one of these did you use in its place?

1 ____ Taxi
2 ____ Drove a car
3 ____ Rode in a car
4 ____ Walked
5 ____ Other? _____
41

(4)

E. Why did you start riding the bus? You may check more than one.

1 ____ The bus was the only thing I could afford to use 42

2 ____ I did not know how to drive a car 43

3 ____ Someone else in the family needed the car 44

4 ____ I lived near a bus stop 45

5 ____ My place of work was near a bus stop 46

6 ____ I no longer had someone to drive me in their car 47

7 ____ I changed jobs and my new job was near a bus stop 48

8 ____ I moved and my new home was near a bus stop 49

9 ____ I was no longer able to drive 50

10 ____ I no longer liked to drive in heavy traffic 51

11 ____ I did not like the taxi service 52

12 ____ I no longer wanted to use the taxi 53

13 ____ Other reasons? Please explain _____ 54

_____

Of the reasons which you have just checked, CIRCLE the single MOST IMPORTANT one. 56 57

(5)

F. Do you ride the bus as often now as you did when you first started using it?

1 ____ Yes 2 ____ No 58

If NO, why not? You may check more than one.

1 ____ I bought a car 59

2 ____ I found someone to drive me in their car 60

3 ____ I changed jobs and my new job was not near a bus stop 61

4 ____ I moved and my new home was not near a bus stop 62

5 ____ The bus route that I used was dropped 63

6 ____ The bus fare was raised 64

7 ____ I no longer felt safe standing on a street corner waiting for the bus 65

8 ____ I got tired of having to wait out in the weather for the bus 66

9 ____ I got tired of having to walk to the bus stop 67

10 ____ The bus service was getting worse 68

11 ____ Other? Please explain _____ 69

_____

Of the reasons which you have just checked, CIRCLE the single MOST IMPORTANT one. 71 72

1/I - - - 5 - - - - 10 - - - - 15 - - - - 3/20

(6)

3. Are you now or have you ever been a regular user of the local TAXI service?

1 ____ Yes 2 ____ No 21

If YES, please continue with this question.
If NO, skip to question 4 on page 8.

A. How many years has it been since you started using the taxi regularly?

1 ____ Less than 1 year
2 ____ 1-2 years
3 ____ 3-4 years
4 ____ 5-6 years
5 ____ 7-10 years
6 ____ 11-20 years
7 ____ 21-30 years
8 ____ Over 30 years
22

B. When you started using the taxi regularly, did you have a driver's license?

1 ____ Yes 2 ____ No 23

C. What was your age group when you started using the taxi regularly?

1 ____ Under 16
2 ____ 16-21
3 ____ 22-30
4 ____ 31-44
5 ____ 45-64
6 ____ Over 64
24

D. Before you started using the taxi regularly, which one of these did you use in its place?

1 ____ Bus
2 ____ Drove a car
3 ____ Rode in a car
4 ____ Walked
5 ____ Other?_____
_____
25

E. Were you a regular user of the local BUS service before you started using the taxi regularly?

1 ____ Yes 2 ____ No 26

F. Are you a regular user of the local BUS service now?

1 ____ Yes 2 ____ No 27

(7)

G. Why did you start using the taxi? You may check more than one.

1 ____ I could not afford a car 28

2 ____ I did not know how to drive 29

3 ____ Someone else in the family needed the car 30

4 ____ I worked at night when the buses were not running 31

5 ____ I changed jobs and my new job was not near a bus stop 32

6 ____ I moved and my new home was not near a bus stop 33

7 ____ The bus route that I used was dropped 34

8 ____ I did not like the bus service 35

9 ____ The bus fares were raised 36

10 ____ I no longer wanted to use the bus 37

11 ____ I no longer felt safe standing on a street corner waiting for a bus 38

12 ____ I no longer liked to drive in heavy traffic 39

13 ____ I was no longer able to drive 40

14 ____ I no longer had someone to drive me in their car 41

15 ____ Other reasons? Please explain_____ 42

_____

Of the reasons which you have just checked, CIRCLE the single MOST IMPORTANT one. 43 44

(8)

4. If you had to ride either the bus or the taxi because you had no other way to travel, which one would you choose?

1 ____ Bus 2 ____ Taxi 45

A. If you chose the BUS, why? You may check more than one.

1 ____ I live near a bus stop 46

2 ____ Many of the places that I go to are near a bus stop 47

3 ____ The bus costs less to use than the taxi 48

4 ____ The bus drivers are friendlier than the taxi drivers 49

5 ____ I would not have to wait as long for the bus as I would for the taxi 50

6 ____ I can save time by taking the bus instead of the taxi 51

7 ____ It is easier for me to get in and out of a bus than a taxi 52

8 ____ The bus is more comfortable than the taxi 53

9 ____ The buses are in better shape than the taxis 54

10 ____ The bus drivers are safer drivers than the taxi drivers 55

11 ____ I know some of the people who ride the bus 56

12 ____ It is easier to carry packages on the bus than on the taxi 57

13 ____ It is easier to take children on the bus than on the taxi 58

14 ____ Other reasons? Please explain _____

_____ 59

Of the reasons which you have just checked, CIRCLE the single MOST IMPORTANT one. 60 61

(9)

B. If you chose the TAXI, why? You may check more than one.

1 ____ I do not live near a bus stop 62

2 ____ Many of the places that I go to are not near a bus stop 63

3 ____ I do not know very much about the bus service 64

4 ____ The taxi drivers are friendlier than the bus drivers 65

5 ____ I would not have to wait as long for the taxi as I would for the bus 66

6 ____ I can save time by taking the taxi instead of the bus 67

7 ____ I do not like to wait outside in the weather for the bus 68

8 ____ I do not like to have to change buses 69

9 ____ It is easier for me to get in and out of a taxi than a bus 70

10 ____ The taxi is more comfortable than the bus 71

11 ____ The taxis are in better shape than the buses 72

12 ____ The taxi drivers are safer drivers than the bus drivers 73

13 ____ The taxi gives me more freedom to travel when and where I want to than the bus 74

14 ____ It is not safe to stand on a street corner and wait for a bus 75

15 ____ It is easier to carry packages in a taxi than on the bus 76

16 ____ It is easier to take children in a taxi than on the bus 77

17 ____ Other reasons? Please explain _____ 78

_____

Of the reasons which you have just checked, CIRCLE the single MOST IMPORTANT one. 79 80

1 - - - 5 - - - - 10 - - - - 15 - - - - 4/20

(10)

5. Compare the BUS service now with 5 years ago.

1 ____ Very much better now
2 ____ Much better now
3 ____ Slightly better now
4 ____ About the same
5 ____ Slightly worse now
6 ____ Much worse now
7 ____ Very much worse now

21

6. Compare the TAXI service now with 5 years ago.

1 ____ Very much better now
2 ____ Much better now
3 ____ Slightly better now
4 ____ About the same
5 ____ Slightly worse now
6 ____ Much worse now
7 ____ Very much worse now

22

7. How would you rate the present BUS service?

1 ____ Very good
2 ____ Good
3 ____ Adequate
4 ____ Poor
5 ____ Very poor

23

8. How would you rate the present TAXI service?

1 ____ Very good
2 ____ Good
3 ____ Adequate
4 ____ Poor
5 ____ Very poor

24

(11)

9. Indicate how important you think the local BUS service is to each group of people shown below. Do this by checking one of the boxes for each group.

People	1. Very Important	2. Fairly Important	3. Fairly Unimportant	4. Not Important At All	
Workers with low incomes	☐	☐	☐	☐	25
Workers with moderate incomes	☐	☐	☐	☐	26
Workers with high incomes	☐	☐	☐	☐	27
The unemployed	☐	☐	☐	☐	28
People with no car	☐	☐	☐	☐	29
Families with only one car	☐	☐	☐	☐	30
Large families	☐	☐	☐	☐	31
Small families	☐	☐	☐	☐	32
The elderly	☐	☐	☐	☐	33
Children	☐	☐	☐	☐	34
Housewives	☐	☐	☐	☐	35
The handicapped	☐	☐	☐	☐	36
Downtown shoppers	☐	☐	☐	☐	37
New residents	☐	☐	☐	☐	38
Out-of-town businessmen	☐	☐	☐	☐	39

(12)

10. How important is the BUS service to YOU?

1 ____ Very important
2 ____ Fairly important
3 ____ Fairly unimportant
4 ____ Not important at all

40

11. Suppose the bus service was discontinued.

A. How much would that hurt downtown business?

1 ____ Quite a bit
2 ____ Some, but not too much
3 ____ Very little
4 ____ Not at all

41

B. Would it cause more traffic congestion?

1 ____ Definitely would
2 ____ Probably would
3 ____ Might or might not
4 ____ Probably would not
5 ____ Definitely would not

42

C. Would it cause more air pollution?

1 ____ Definitely would
2 ____ Probably would
3 ____ Might or might not
4 ____ Probably would not
5 ____ Definitely would not

43

(13)

12. Indicate how important you think the local TAXI service is to each group of people shown below. Do this by checking one of the boxes for each group.

People	1. Very Important	2.Fairly Important	3. Fairly Unimportant	4. Not Important At All	
Workers with low incomes	☐	☐	☐	☐	44
Workers with moderate incomes	☐	☐	☐	☐	45
Workers with high incomes	☐	☐	☐	☐	46
The unemployed	☐	☐	☐	☐	47
People with no car	☐	☐	☐	☐	48
Families with only one car	☐	☐	☐	☐	49
Large families	☐	☐	☐	☐	50
Small families	☐	☐	☐	☐	51
The elderly	☐	☐	☐	☐	52
Children	☐	☐	☐	☐	53
Housewives	☐	☐	☐	☐	54
The handicapped	☐	☐	☐	☐	55
Downtown shoppers	☐	☐	☐	☐	56
New residents	☐	☐	☐	☐	57
Out-of-town businessmen	☐	☐	☐	☐	58

(14)

13. How important is the TAXI service to YOU?

1 ____ Very important
2 ____ Fairly important
3 ____ Fairly unimportant
4 ____ Not important at all

59

14. Suppose the taxi service was discontinued.

A. How much would that hurt downtown business?

1 ____ Quite a bit
2 ____ Some, but not too much
3 ____ Very little
4 ____ Not at all

60

B. Would it cause more traffic congestion?

1 ____ Definitely would
2 ____ Probably would
3 ____ Might or might not
4 ____ Probably would not
5 ____ Definitely would not

61

C. Would it cause more air pollution?

1 ____ Definitely would
2 ____ Probably would
3 ____ Might or might not
4 ____ Probably would not
5 ____ Definitely would not

62

1/1 - - - 5 - - - - 10 - - - - 15 - - - - 5/20

(15)

15. Each set below contains a pair of items, A and B. For each pair check the item, A or B, which you feel should have more of your tax dollars than is now being spent. Check an A or B for every pair. (Each pair appears only once.) 1/21

A ____ Streets and highways 22

B ____ Water and sewage

A ___ Police protection 23

B ____ Streets and highways

A ____ Public transportation 24

B ____ Water and sewage

A ____ Parks and recreation areas 25

B ____ Police protection

A ____ Pollution control 26

B ____ Water and sewage

A ____ Pollution control 27

B ____ Welfare

A ____ Schools 28

B ____ Streets and highways

A ____ Police protection 29

B ____ Pollution control

A ____ Pollution control 30

B ____ Public transportation

A ____ Parks and recreation areas 31

B ____ Water and sewage

(16)

(15-1 Continued)

A ____ Public transportation
B ____ Police protection — 32

A ____ Streets and highways
B ____ Parks and recreation areas — 33

A ____ Police protection
B ____ Welfare — 34

A ____ Public transportation
B ____ Streets and highways — 35

A ____ Pollution control
B ____ Schools — 36

A ____ Streets and highways
B ____ Pollution control — 37

A ____ Public transportation
B ____ Parks and recreation areas — 38

A ____ Welfare
B ____ Parks and recreation areas — 39

A ____ Schools
B ____ Police protection — 40

A ____ Pollution control
B ____ Parks and recreation areas — 41

A ____ Streets and highways
B ____ Welfare — 42

(17)

(15-1 Continued)

A ____ Water and sewage
B ____ Schools — 43

A ____ Welfare
B ____ Public transportation — 44

A ____ Police protection
B ____ Water and sewage — 45

A ____ Water and sewage
B ____ Welfare — 46

A ____ Welfare
B ____ Schools — 47

A ____ Public transportation
D ____ Schools — 48

A ____ Parks and recreations areas
B ____ Schools — 49

$\frac{1}{1}$ - - - 5 - - - - 10 - - - - 15 - - - - $\frac{6}{20}$

(18)

16. Indicate how much YOU agree or disagree with each of these statements about the local BUS service:

If you strongly disagree with the statement, you would circle the number (1)

If you strongly agree with the statement, you would circle the number (7)

If you do not have strong feelings one way or the other, circle one of the numbers between (1) and (7) to show your opinion

A. Bus service should pay for itself from fares charged users.

Disagree 1 2 3 4 5 6 7 Agree 21

B. Bus service should be supported in part by fares and in part by local taxes.

Disagree 1 2 3 4 5 6 7 Agree 22

C. Bus service should be free with the entire cost paid from local taxes.

Disagree 1 2 3 4 5 6 7 Agree 23

D. The bus service should be privately owned.

Disagree 1 2 3 4 5 6 7 Agree 24

E. The public should buy the buses and lease them to a private company to operate.

Disagree 1 2 3 4 5 6 7 Agree 25

F. The bus service should be provided by the public and not by a private company.

Disagree 1 2 3 4 5 6 7 Agree 26

(19)

17. Indicate how much YOU agree or disagree with each of these statements about the local TAXI service. Do this in the same way as you did in the previous question.

A. Taxi service should pay for itself from fares charged users.

Disagree 1 2 3 4 5 6 7 Agree 27

B. Taxi service should be supported in part by fares and in part by local taxes.

Disagree 1 2 3 4 5 6 7 Agree 28

C. Taxi service should be free with the entire cost paid from local taxes.

Disagree 1 2 3 4 5 6 7 Agree 29

D. The taxi service should be privately owned.

Disagree 1 2 3 4 5 6 7 Agree 30

E. The public should buy the taxi cabs and lease them to a private company to operate.

Disagree 1 2 3 4 5 6 7 Agree 31

F. The taxi service should be provided by the public and not by a private company.

Disagree 1 2 3 4 5 6 7 Agree 32

(20)

18. To conclude, may we ask you a few questions about yourself:

A. How long have you lived at your present address?

_____ Years 33 34

B. How long have you lived in Hicksville?

1 ____ Less than 6 months
2 ____ 6 months - 1 year
3 ____ 1-2 Years
4 ____ 3-5 Years
5 ____ 6-10 Years
6 ____ 11-20 Years
7 ____ 21-40 Years
8 ____ Over 40 years

35

C. How many persons are in your household counting yourself?

_____ 36 37

D. How many of them have a driver's license counting yourself if you have one?

_____ 38 39

E. How many cars are owned or regularly used by members of your household?

_____ 40 41

F. Do you have a driver's license?

1 ____ Yes 2 ____ No 42

G. Are you physically handicapped?

1 ____ Yes 2 ____ No 43

H. What is your sex?

1 ____ Male 2 ____ Female 44

I. And your marital status?

1 ____ Married 2 ____ Single 3 ____ Other 45

(21)

(18 continued)

J. Please check your age group

1 ____	Under 16	4 ____	31-44	
2 ____	16-21	5 ____	45-64	
3 ____	22-30	6 ____	Over 64	46

K. What kind of work do you do? (For example: TV repairman, sewing machine operator, spray painter, civil engineer, junior high English teacher, high school student, housewife, unemployed, etc.)

_____ 47 48

THANK YOU FOR YOUR COOPERATION.

TO BE COMPLETED BY THE INTERVIEWER:

This address was selected from:

1 ____	A list of bus users	
2 ____	A list of taxi users	
3 ____	A city directory	50

VITA

David Paul Middendorf was born in Greensburg, Indiana, on October 22, 1949. After graduating from Greensburg Community High School, he attended Purdue University where he received the degree of Bachelor of Science in Civil Engineering with Highest Distinction in June 1971. Upon completion of his undergraduate work, he entered the Graduate School of Purdue University and earned the degree of Master of Science in Civil Engineering in August 1972, majoring in urban transportation planning.

In addition to his formal education, Mr. Middendorf has worked for the Chicago Area Transportation Study, the Louisville and Jefferson County Air Board, and as a consulting engineer. He was project director for the New Castle (Indiana) Bus Transit Study and the Morristown (Tennessee) Downtown Parking Study.

Mr. Middendorf is a member of Chi Epsilon, Tau Beta Pi, and Phi Kappa Phi honor societies. He is an associate member of the American Society of Civil Engineers, a student member of the Institute of Traffic Engineers, and a supporting member of the Transportation Research Board. He is also registered as an Engineer-in-Training in Indiana.

Publications

Heathington, Kenneth W., and Middendorf, David P. New Castle Feasibility Study and Preliminary Planning for Bus Transit. 1972.

Heathington, Kenneth W.; Davis, Frank W., Jr.; Middendorf, David P.; and Brogan, James D. "An Example of Demand-Responsive Transportation Systems in the Private Sector." New Transportation Systems. Transportation Research Record 522. Washington: Transportation Research Board, 1974, pp. 47-55.

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