DEMAND-RESPONSIVE TRANSPORATION SYSTEMS IN THE PRIVATE SECTOR

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Two privately owned demand-responsive transportation systems were investigated to determine the economic feasibility and marketability of these systems and the roles that they play in small- to medium-sized urban areas. The 2 systems are operated by innovative taxicab companies that offer door-to-door service in 6-passenger automobiles on a shared-ride basis. This paper summarizes the results of preliminary analyses of some of the basic information collected on the daily operations of these systems. The 2 companies differ in terms of fleet size, service area, fare structure, types of service offered, market strategies, and goals. Those differences are reflected in ridership, level-of-service, and economic characteristics. Preliminary results reveal the systems to be economically viable, marketable, and important components of the total public transportation system.

•EFFORTS to increase ridership on public transit systems have centered on improvements to existing systems. Among the more common solutions are fare reductions, fare subsidies for certain socioeconomic and age groups, new rolling stock, route and schedule modifications including service extensions, construction of pedestrian shelters at access points to the system, and improved informational services. In addition, a number of advertising and motivational devices have been employed to influence automobile drivers to use the bus or subway for certain trips. These are positive inducements for increasing the use of the transit system, but many negative ones have recently come into prominence. The latter usually consist of methods of restricting the use of the automobile, augmenting the cost of automobile usage, or otherwise inconveniencing the automobile user. The positive approach usually results in a slight increase in ridership although never to the extent that the transit system becomes a profitable enterprise or that it significantly reduces traffic congestion, traffic accidents, air pollution, or other problems attributed to automobile usage. The negative approach has not been implemented to any large degree. Neither approach recognizes the diversity of individual needs relative to transportation or carefully considers the actual and potential markets for alternative public transportation services.

Some think that a consumer-oriented approach to the planning of public transportation systems is needed. This approach requires the planner to identify the transportation needs of population groups and then to design a system or several systems to satisfy those needs within the limits imposed by available resources. Some transportation planners and a few public officials are beginning to realize that, in many small- and medium-sized urban areas, fixed-route and fixed-schedule bus systems have been rendered obsolete by present-day, low-density development patterns and, therefore, no longer adequately meet the needs of the majority of the public. In fact, this mode of transportation may no longer adequately serve the needs of captive riders. As a result, a considerable amount of research effort has been expended lately in analyzing a rather old concept: demand-responsive transportation.

Demand-responsive transportation is usually associated with, but is by no means restricted to, the notion of small vehicles providing door-to-door service on a shared-ride basis. There is some agreement among transportation planners that this type of service is more marketable and could more adequately serve a wider segment of the

population in low- and medium-density urban areas than the conventional fixed-route and fixed-schedule bus system. However, a lack of information regarding the actual public response to a demand-responsive system has been a major obstacle to a thorough evaluation of the potential of this concept despite the fact that several market surveys and research projects have indicated that such a response would be favorable. If both a conventional bus and a demand-responsive system were in operation in a given urban area, one could begin to answer some interesting and important questions concerning the ridership patterns and market characteristics of each. For example, what population groups are attracted to each type of service? Is each system used more frequently for certain trip purposes than for others? How frequently is each system used for specific trip purposes? To what extent is each type of transit service a primary or secondary mode of transportation? The urgent need to answer these and other related questions, the gradual shift toward a consumer-oriented approach to public transit planning, and some disenchantment with contemporary modal-choice models have served to magnify the need for more research on choices of, attitudes toward, and preferences for alternative modes of transportation.

A number of taxicab companies in small- and medium-sized cities and in suburbs of large metropolitan areas offer transportation on a shared-ride basis, seemingly unaware of the research having been conducted in this area. Many of these companies combine goods delivery with passenger service, and some are contemplating the implementation of computer-dispatching. The existence of these privately owned, shared-ride, and demand-responsive transportation systems seems to indicate that the concept of demand-responsive, for-hire transportation has been and is economically feasible.

In addition to the shared-ride transportation systems, conventional fixed-route and and fixed-schedule bus systems exist in many urban areas. As a result, researchers are now afforded an excellent opportunity to determine the roles of each of these systems, to study the various markets that each attracts, to identify the needs, attitudes, and preferences of these markets relative to public transportation, to determine the most important variables involved in the process of choosing among alternative modes of public transportation, and to formulate more reliable, behavior-oriented demand or modal-split models for alternative modes of public transportation.

This paper reports on a comprehensive investigation of the economic and service characteristics of 2 privately owned, demand-responsive transportation systems. These systems—one in Davenport, Iowa, and the other in Hicksville, New York—consist of innovative taxicab companies that offer door-to-door, shared-ride service at fares somewhat lower than those charged by conventional single-ride cab systems. In addition, each study area is served by one or more conventional fixed-route and fixed-schedule bus systems, and thus comparisons can be made of the demand characteristics of the 2 forms of public transportation.

STUDY AREAS

The 2 urban areas whose public transportation systems are being studied are representative of vastly different urbanized areas and are dissimilar in terms of population composition, economic base, travel patterns, land use patterns, and residential densities. This constitutes an important advantage in that it enables one to ascertain the applicability of the demand-responsive transportation concept to widely varied economic, cultural, and political environments. This section contains a brief profile of each study area and of the demand-responsive transportation systems that serve them. Table 1 gives some of the population characteristics.

Davenport, Iowa, is 1 of a cluster of 4 incorporated communities commonly known as the Quad Cities, which are located in the states of Iowa and Illinois and have a population of approximately 300,000 people. Situated along the Mississippi River, the area is a major midwestern trading and industrial center and is often referred to as the farm implement capital of the world. Davenport, which is the largest of the 4 communities in terms of population, experienced an approximate 11 percent growth in population between 1960 and 1970.

Table 1. Population characteristics.

Characteristic	Davenport	Hicksville
Area, miles^2	19.7	6.8
1970 population		
Total	98,500	48,100
Persons/mile^2	5,000	7,100
Nonwhite, percent	7	1
Over 64 years, percent	11	6
Under 19 years, percent	37	39
Labor force employed	96	96
Professional, managers, or technical workers, percent	23	62
Sales, clerical, or skilled workers, percent	57	
Service, farm, or unskilled workers, percent	20	38
Median family income, dollars	10,800	13,900
Median value of homes, dollars	17,800	27,500

Hicksville, New York, is an unincorporated community located on Long Island and within the New York City Standard Metropolitan Statistical Area. It was at one time the terminus of a branch of the Long Island commuter railroad system and is still noted as a major transportation hub. The local railroad station handles the largest number of riders of any station on the island. Although the county in which it is located has undergone a rapid and extensive transformation from open space to urban land use since World War II, Hicksville itself experienced a 4.6 percent decrease in population between 1960 and 1970 as a result of commercial expansion and population relocation.

Although both demand-responsive transportation systems under analysis use 6-passenger automobiles to provide on-call, door-to-door service on a shared-ride basis, in many respects they are as dissimilar to each other as the urban areas they serve. For example, both systems charge for services on a zonal fare basis, but each has developed its own rate structure. The 2 systems also differ in terms of service offered, market strategy, ridership levels, travel patterns, and other trip characteristics.

TAXI SYSTEMS

The present demand-responsive or shared-ride cab system in Davenport was established in 1967. The company operates 20 Checker cabs and employs more than 40 drivers. Drivers are encouraged to lease their vehicles on a weekly basis at a rate of $240 per week. The company provides insurance, vehicle maintenance and cleaning, licensing and dispatching services, and technical assistance; the driver pays the cost of fuel. The lease arrangement is designed to allow the lessee to retain the same vehicle during an extended period of time and to hire other individuals to operate the vehicle during second and third shifts on a commission basis. This arrangement fosters pride in equipment and provides the opportunity for drivers to increase their weekly income. The company's rate structure is based on a zonal system consisting of a central zone that encompasses the downtown business area and from which additional zones radiate. Consequently, fares are computed on the basis of distance from the central business district and, because of this geographical orientation, the fare for a short crosstown trip can be substantially higher than that for a much longer trip having its origin or destination in the downtown business area.

The system in Davenport employs the concept of shared riding in which a customer may have to share the vehicle with passengers with whom he has no affinity and who may have different origins or destinations. No specified maximum or minimun intervals of time for waiting or riding are guaranteed although the company strives to provide as high a level of service as is consistent with the prevailing conditions of the cab system and the street network. Users may request direct origin-to-destination service

(no intermediate pickups or deliveries) for a somewhat higher fare. In addition, cruising is not permitted and is precluded by the present lease arrangement that requires the drivers to pay for their own gasoline. "Flagging" a vehicle is not common although drivers are permitted to serve such a form of request.

The privately owned demand-responsive transportation system in Hicksville has been in operation since 1961. The company's fleet consists of approximately 30 Dodge passenger cars driven by 100 full- and part-time drivers. Drivers lease their vehicles on a daily basis for a fee that is composed of a mileage and an hourly dispatching rate. Fuel costs are borne by drivers, and all other expenses including maintenance, cleaning, insurance, and licensing are borne by the cab company. The fare structure is based on a combination zone-mileage plan consisting of 6 overlapping zones, each of which has a cab stand serving as a focal point. Consequently, the determination of the fares for various interzonal and intrazonal movements can be quite complex, and, in a few instances, the actual fare charged is negotiable. The company, of course, uses the shared-ride concept although, as in Davenport, the customer can obtain nonstop or direct origin-to-destination service for a higher fare.

RIDERSHIP CHARACTERISTICS

Davenport

Table 2 gives a summary of daily passengers on both the demand-responsive and the bus transit systems in Davenport for those days on which system operations data were collected. The difference between the number of requests for shared-ride taxi service and the number of daily person trips handled by this system is an expression of the degree of group riding. This study makes a distinction between group riding and shared riding. If a request for service involves more than one individual, the resulting trip is defined as a group ride. Although this concept is perhaps not so important as that of shared riding in the analysis of demand-responsive transportation systems, it does have an advantage for patrons of the shared-ride taxi service in Davenport in that the fare depends not on the number of persons in the group but on a zone-based charge that is subdivided among the members of the group. Whether this advantage has indeed influenced the practice of group riding in Davenport cannot be accurately determined at this time. However, preliminary results indicate that on weekdays an average of only 11 percent of all requests for shared-ride taxi service involves 2 or more persons. A higher degree of group riding was observed on Saturday, May 12, and Sunday, May 20, when 18.5 percent and 22 percent respectively of all requests for service involved groups of 2 or more individuals.

The demand-responsive transportation system carried an average of 1,269 person trips on weekdays or approximately 48 percent of the average number of weekday trips handled by the local bus transit system. The demand for both forms of public transportation on Saturday (May 12, 1973) was remarkably consistent with weekday demands. Ridership decreased on the shared-ride taxi system on Sunday (May 20). Fixed-route and fixed-schedule bus service is completely curtailed on Sundays.

Figure 1 shows the absence of sharp morning and afternoon peaks corresponding to the morning and afternoon rush hours. Many intraurban bus systems and almost all urban streets and highways are characterized by heavy use during the morning and afternoon rush hours and light use during other periods. The demand-responsive transportation system in Davenport, however, experiences a reasonably constant level of use throughout much of the day and has the heaviest use during the noon hour. Relatively minor peaks occur during the morning and after the afternoon rush hours. One of the future tasks of this research effort is to fully establish the reasons underlying these observed hourly demand patterns.

A comparison of the percentages given in Table 3 for residence-oriented and motel- or hotel-oriented trips seems to imply that the demand-responsive transportation system is used primarily by residents. This is firmly supported by the percentages given in Table 4, which indicate that the most frequent unidirectional movement on the average weekday is between 2 residences. The shared-ride taxi service is apparently used quite extensively for social visiting. Even trips to and from business establishments are highly oriented toward residences.

Table 2. Daily ridership.

City	Date	Demand-Responsive System		Bus Transit Person Trips
		Requests for Passenger Service	Person Trips	
Davenport	Tuesday, 4-10-73	1,150	1,303	2,516
	Wednesday, 4-18-73	988	1,137	2,622
	Thursday, 4-26-73	964	1,108	2,587
	Friday, 5-4-73	1,271	1,528	2,826
	Weekday average	1,093	1,269	2,638
	Saturday, 5-12-73	988	1,278	2,422
	Sunday, 5-20-73	514	680	No service
Hicksville	Wednesday, 4-10-73	755	858	
	Thursday, 5-3-73	832	943	
	Friday, 5-18-73	856	971	
	Weekday average	814	924	
	Saturday, 6-2-73	471	528	

Figure 1. Hourly distribution of average weekday person trips.

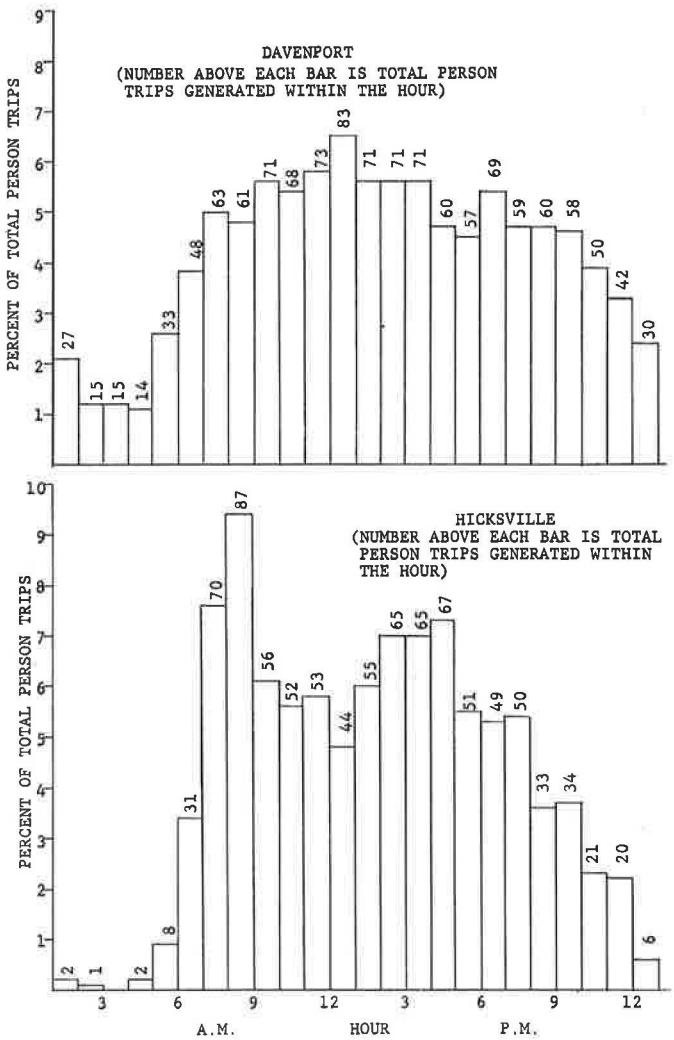

Table 3. Average weekday person trips by type of origin and destination.

City	Trip Generator	Origin		Destination	
		Number	Percent	Number	Percent
Davenport[a]	Residence	695	52.8	793	60.2
	Business	351	26.6	309	23.4
	Tavern	108	8.2	52	4.0
	Medical facility	72	5.5	87	6.6
	Motel or hotel	51	3.9	20	1.5
	Public facility	29	2.2	40	3.0
	School	12	0.9	17	1.3
Hicksville[b]	Residence	397	42.9	444	48.0
	Public facility	327	36.4	276	29.9
	Business	155	16.8	164	17.7
	Medical facility	22	2.4	25	2.7
	Tavern	12	1.3	8	0.9
	Motel	12	1.3	7	0.8
	School	0	0.0	0	0.0

[a]Based on data collected on 4-26-73 and 5-4-73.
[b]Based on data collected on 4-18-73, 5-3-73, 5-18-73.

Table 4. Dominant weekday origin-destination person trip flow on demand-responsive systems.

City	From	To	Number	Percent
Davenport[a]	Residence	Residence	348	26.4
	Business	Residence	265	20.1
	Residence	Business	211	16.0
	Tavern	Residence	69	5.3
	Residence	Medical Facility	68	5.2
	Medical Facility	Residence	56	4.2
	Business	Business	47	3.6
	Residence	Public Facility	26	2.0
Hicksville[b]	Public Facility	Residence	234	25.3
	Residence	Public Facility	200	21.6
	Business	Residence	120	12.9
	Residence	Business	109	11.8
	Residence	Residence	68	7.4
	Public Facility	Public Facility	43	4.6
	Public Facility	Business	37	4.0
	Business	Public Facility	22	2.4

[a]Based on data collected on 4-26-73 and 5-4-73.
[b]Based on data collected on 4-18-73, 5-3-73, 5-18-73.

Table 5. Average daily ride, wait, and deviation time in minutes.

City	Date	Wait Time[a]	Ride Time[b]	Deviation Time[c]
Davenport	Wednesday, April 18	16.7	10.3	2.2
	Thursday, April 26	16.1	10.3	3.1
	Friday, May 4	21.2	11.1	7.8
	Saturday, May 12	24.0	11.7	3.8
	Sunday, May 20	20.5	10.4	3.6
Hicksville	Wednesday, April 18	10.8	9.6	3.7
	Thursday, May 3	9.7	9.4	2.9
	Friday, May 18	9.9	8.8	4.4
	Saturday, June 2	8.7	9.6	5.6

[a]Includes radio-dispatched trips only.
[b]Includes all shared-ride taxi trips.
[c]Includes prearranged trips only.

Table 6. Income and mileage.

City	Day	Miles Operated	Miles/ Vehicle	Miles/ Vehicle/ Hour	Revenue/ Vehicle (dollars)	Revenue/ Vehicle/ Hour (dollars)	Revenue/ Vehicle/ Mile (dollars)
Davenport	Tuesday	2,988	175.8	8.55	84.23	4.10	0.47
	Wednesday	3,359	186.6	11.28	74.63	4.51	0.39
	Thursday	3,128	195.0	10.80	84.29	4.53	0.43
	Friday	3,729	219.4	10.93	97.07	4.84	0.44
	Saturday	3,162	243.2	12.07	101.78	5.05	0.41
	Sunday	1,460	146.0	11.15	63.92	4.85	0.43
	Weekday avg	3,301	194.2	10.38	85.05	4.49	0.43
	Weekend avg	2,311	194.6	11.61	82.85	4.95	0.42
Hicksville	Wednesday	3,740	155.8	12.39	69.02	5.49	0.44
	Thursday	3,083	154.2	9.80	80.55	5.12	0.52
	Friday	3,119	148.5	10.76	82.11	5.95	0.55
	Saturday	2,363	138.9	11.66	56.76	4.78	0.40
	Weekday avg	3,314	152.8	10.99	77.22	5.52	0.50

Of the 110 traffic zones in Davenport, an average of 83 zones generated at least 1 passenger trip on weekdays. The largest generator of demand-responsive transportation trips was the central business district, which produced an average of 219 daily person trips and attracted an additional 158 trips, 18 and 13 percent respectively of the total daily demand. The next most productive zones are the 4 zones clustered around the CBD; hence, the demand for shared-ride taxi service tends to be highly concentrated spatially.

Hicksville

The total demand for shared-ride taxi service on the average weekday in Hicksville is slightly less than three-fourths of the average weekday demand in Davenport (Table 2). However, the seemingly large disparity between ridership levels in the 2 study areas is not quite so striking when one considers that the population of Hicksville is approximately one-half that of Davenport. Consequently, based on population size, Hicksville appears to serve a larger proportion of its population. Saturday ridership in Davenport remained at weekday levels, but the demand in Hicksville fell to 57 percent of the weekday average.

The hourly distribution of shared-ride taxi trips in Hicksville (Fig. 1) exhibits a slightly different demand pattern from that in Davenport. The most notable dissimilarity is the peak system use between 7:00 and 9:00 a.m. The principal role of the cab service during this period is one of collecting and distributing commuters journeying to or from the area's 3 commuter rail stations. After the morning peak period, hourly ridership fluctuates, is lowest during the noon hour, and increases sharply during the early afternoon to an obtuse secondary peak that extends for a 3-hour period.

Residences were the most common type of origin and destination in Hicksville, but they produced and attracted less than half of all person trips (Table 3). The lesser importance of the residence as a trip generator in Hicksville can be explained by the public facility category, which includes the Long Island Railroad station. This single facility produces and attracts more than a third of the total demand for demand-responsive transportation. Even on Saturday, June 2, 38 percent of the cab system's business was oriented to this terminal.

Trips between public facilities (primarily the commuter rail station) and residences account for nearly half of all daily person trips made on the demand-responsive system (Table 4). The number of shared-ride taxi trips between residences is relatively small, indicating that the cab system is used more for commuting, personal business, and shopping than for social visiting.

The Hicksville zone that contains the commuter rail station and a large shopping area dominates all other zones in terms of trip generating potential, producing 41 percent and attracting 32 percent of all daily shared-ride taxi trips. In general, demand-responsive trip origins and destinations tend to be more highly concentrated spatially in Hicksville than in Davenport. Of the 87 zones within the cab system's service area, 50 generated at least 1 trip and 15 of those zones accounted for 75 percent of all person trips.

LEVEL-OF-SERVICE CHARACTERISTICS

In both Davenport and Hicksville, 3 mutually exclusive types of request for service are recognized: radio dispatched, "flagged," and prearranged. The most common is the radio-dispatched service in which the customer telephones a request for transportation but does not state a specific pickup time. By definition, then, radio-dispatched trips have associated with them a period of waiting. In flagged service, the customer hails a standing or moving cab and obviously has no wait time. In prearranged service, the user requests in advance to be picked up at a specific time. The difference between the requested and the actual vehicle arrival time is the deviation time. Average daily wait, ride, and deviation times for each date on which system operations were monitored are given in Table 5.

The user of the demand-responsive transportation system in Davenport must wait for a vehicle, on the average, between 16 and 24 minutes. Because of the number of cabs operating on the street network, the level of the demand for service, and traffic conditions in general, the wait varies considerably by hour or day. The average individual wait times for all radio-dispatched trips during a 1-hour period fluctuated between 6 and 31 minutes. In general, mean hourly wait times tend to be lower than the average daily wait time in the morning and higher in the afternoon.

Demand-responsive system users in Hicksville spend considerably less time waiting for cab service and are subjected to less uncertainty with regard to the expected arrival time of a vehicle. Mean hourly wait times typically vary between the extremes of 4 and 12 minutes. They tend to be lower than the average daily wait time during the morning and higher during the afternoon and early evening.

Both cab systems are usually punctual for prearranged trips. The vehicle can be expected to arrive at the customer's origin 5 minutes before or after the requested time of boarding in about two-thirds of the cases in Davenport and three-fourths of the cases in Hicksville.

The mean hourly ride time, which is the average travel time for all trips made within a 1-hour period, generally varies between 6 and 14 minutes in Davenport and between 5 and 13 minutes in Hicksville. These average hourly ride times tend to be at or above the average daily ride time between 7:00 a.m. and 5:00 p.m. in Davenport and between 3:00 p.m. and 9:00 p.m. in Hicksville. The highest ride times typically occur during periods of heavy traffic congestion.

On the average, use of the demand-responsive transportation system involves approximately 30 minutes in Davenport and 20 minutes in Hicksville between the time service is requested and the time the trip is completed (wait time plus ride time). The shared-ride taxi service thus appears to offer little advantage over a fixed-route and fixed-schedule bus system that operates on 30-minute headways. The extent to which the measured wait and ride times are considered to be unfavorable by users and nonusers remains to be determined.

ECONOMIC CONSIDERATIONS

The demand-responsive transportation systems in Hicksville and Davenport operate on 2 different market philosophies. The Hicksville operation seeks to maximize return on investment through higher fare levels and strict attention to cost control. Thus, it has followed a strategy of periodic fare increases and relatively stable ridership. The Davenport operation, on the other hand, seeks to provide a low-cost transportation service to a rapidly growing market segment. As a consequence, ridership on the Davenport system has increased from 174,000 in 1967 to 485,000 in 1972. (Public bus ridership decreased from 1,472,399 to 740,000 in this same period.)

The taxi fleet maintained in daily operation is approximately 76 percent in Davenport and 69 percent in Hicksville. A vehicle is driven approximately 13.5 hours a day in Hicksville and 18.4 hours a day in Davenport, but a driver operates a vehicle an average of 10.9 hours a day in Davenport and 9.5 hours a day in Hicksville. Hicksville increases vehicle use by leasing vehicles to second-shift drivers, while Davenport leases its cabs for a flat fee each week, thus encouraging the lessee to hire a driver for the second shift. This results in an average vehicle use of 1.43 shifts in Hicksville and 1.65 shifts in Davenport.

The Davenport passenger pays an average fare of $1.25 per trip but, in a group ride, the average fare per person is reduced to $1.03. The Hicksville passenger pays an average fare of $1.83 per trip or $1.79 per passenger. In Davenport, the fare is independent of each additional person in the group; the cost per person is equal to the zone fare divided by the number of people in the group. In Hicksville, an incremental charge is added for each additional person, resulting in a charge per person that is equal to the base fare plus the incremental charge for each additional person divided by the number of people in the group. Consequently, group riding does not have as significant an advantage in Hicksville as it does in Davenport.

Table 6 gives the effect of the 2 market strategies. On an average weekday in Davenport, each vehicle travels an average of 10.38 mph and produces $4.49 each hour or $0.43 each mile. Hicksville's system generates less revenue per vehicle but more revenue per vehicle-hour since it operates each vehicle only 13.5 hours per day. The higher profitability of the Hicksville system is explained by the high income per mile and per hour. In fact, the income per mile is 16 percent higher and the revenue per hour is 22.9 percent higher in Hicksville than in Davenport. Since these differences are on the basis of gross revenue, the profit margins in Hicksville are many times greater than in Davenport.

SUMMARY

This discussion has illustrated the applicability of the concept of demand-responsive transportation to different economic, cultural, and political environments. Not only do the 2 communities of Davenport and Hicksville differ in terms of geographic location, population composition, size, density of development, economic base, and political structure, but the 2 privately owned demand-responsive transportation systems differ in several important aspects. Although each system operates under the semblance of a taxicab company and provides on-call, door-to-door, shared-ride transportation, each is characterized by its own fleet size, fare structure, driver leasing arrangements, types of service offered, market strategy, and goals. These differences between study areas and between cab companies are reflected in dissimilarities in ridership, levels of service, and economic characteristics of the 2 demand-responsive transportation systems. These 2 companies are economically strong, have been in operation for a considerable period of time, and have never received capital or operating subsidies. Their ridership has consistently grown while that on fixed-route and fixed-scheduled buses has declined.